



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

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

FINAL REPORT

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TABLE OF CONTENTS

Status Page i

Table of contents ii

List of Tables vi

List of Figures viii

List of Plates x

List Of Abbreviations And Acronyms xii

EIA Preparers xvi

Executive summary xvii

CHAPTER ONE 1

INTRODUCTION 1

1.1: Background 1

1.2: Objectives of the EIA 2

1.3: The Project 3

Project Premises 3

1.4: Legal and Administrative Framework 4

1.4.1: Legislations guiding Environmental management in Nigeria 4

1.4.2: Legislations guiding Environmental management in Delta State 7

1.4.3: International Laws and Regulations 8

1.4.4: SPDC Policies and Principles 10

1.5: Declaration 13

1.6: Structure of this EIA Report 13

1.7: Terms of Reference 13

1.8: Statistical Analysis 25

1.9: Quality Assurance and Quality Control 25

1.10: Quantification and Evaluation of Impacts 25

1.11: Determination of Appropriate Remedial Measures 25

1.12: Monitoring Plan 26

1.13: Report Writing 26

CHAPTER TWO 27

PROJECT JUSTIFICATION 27

2.1: Project Background 27

2.2: Need for the Project 28

2.3: Value of the Project 28

2.4: Project Schematics 29

2.5: Project Screening 29

2.6: Relationship to Other Projects 30

2.7: Project Alternatives/Options 31

2.8: Sustainability 32

2.8.1: Economic Sustainability 32

2.8.2: Technical Sustainability 33

2.8.3: Environmental Sustainability 33

CHAPTER THREE 34

PROJECT DESCRIPTION 34

| | |
|---------------------------------------------------------|-----|
| 3.1: Introduction..... | 34 |
| 3.2: Project Objectives | 34 |
| 3.3: Project Location..... | 35 |
| 3.4: Proposed Project Scope | 36 |
| 3.5: Project Activities Description..... | 38 |
| 3.6: Details of Main Project Activities: | 38 |
| 3.6.1: Design Considerations: | 38 |
| 3.6.2: Conceptual and Detailed Design..... | 38 |
| 3.6.3: Central Processing Facility (CPF) | 39 |
| 3.6.4: Planned Facilities | 39 |
| 3.6.5: Field Logistics Base..... | 42 |
| 3.6.6: Pipelines..... | 43 |
| 3.7: Pre-construction Activities and Land take..... | 44 |
| 3.8: Construction Phase | 44 |
| 3.9: Operation and Maintenance | 48 |
| 3.10: Decommissioning/Abandonment..... | 50 |
| 3.11: Project Schedule | 51 |
| CHAPTER FOUR..... | 60 |
| DESCRIPTION OF THE ENVIRONMENT | 60 |
| 4.1: Introduction..... | 60 |
| 4.1.1: Quality Assurance/Quality Control (QA/QC) | 60 |
| 4.1.2: Sample Collection and Handling | 60 |
| 4.1.3: Laboratory Analyses | 60 |
| 4.1.4: Statistical Analysis..... | 60 |
| 4.1.5: Data Coding and Manipulation..... | 61 |
| 4.1.6: Scope of Work | 61 |
| 4.2: Meteorology, Air Quality and Noise Studies..... | 63 |
| 4.2.1: Meteorology – Historical Background | 63 |
| 4.2.2: Air Quality and Noise | 68 |
| 4.3: Soil and Land Use..... | 73 |
| 4.3.1: Soil quality..... | 73 |
| 4.3.2: Land Use and Agriculture..... | 91 |
| 4.4: Surface Water Quality | 92 |
| 4.5: Hydrobiology | 108 |
| 4.6: Fish and Fisheries | 118 |
| 4.7: Vegetation..... | 120 |
| 4.8: Wildlife | 132 |
| 4.9: Geology and Hydrogeology..... | 135 |
| 4.9.1: Geology and Geomorphology..... | 135 |
| 4.9.2: Hydrogeology | 135 |
| 4.9.3: Aquifer Characteristics | 136 |
| 4.10: Description of the Socioeconomic Environment..... | 143 |
| 4.11: Health Studies | 170 |
| 4.12: Consultation and Stakeholder Engagement | 180 |

| | |
|-----------------------------------------------------------------------------------------------|-----|
| 4.12.1: Objectives | 181 |
| 4.12.2: Identification and involvement of key stakeholders | 182 |
| 4.12.3: EIA HSE Workshop..... | 182 |
| 4.12.4: Issues and Concerns..... | 182 |
| 4.12.5: Future Consultations | 183 |
| CHAPTER FIVE | 185 |
| ASSOCIATED AND POTENTIAL ENVIRONMENTAL IMPACTS | 185 |
| 5.1: Assessment Methodology/ Analysis Tools..... | 185 |
| 5.1.1: Introduction..... | 185 |
| 5.1.2: Basis for Screening | 186 |
| 5.1.3: Environmental Screening Process | 186 |
| 5.2: Scoping | 186 |
| 5.3: Impacts Identification | 188 |
| 5.4: Impact Quantification And Determination Of Significance | 192 |
| 5.4.1: Discussion of Ranking in Table 5.6..... | 197 |
| 5.5: Impact Prediction and Analysis | 199 |
| 5.5.1: Emissions to Air..... | 200 |
| 5.5.2: Impacts on Soil/Land Use and Groundwater | 205 |
| 5.5.2.1: Soil/Landuse | 205 |
| 5.5.2.2: Impacts on Groundwater..... | 207 |
| 5.5.3: Effects on Ecosystem..... | 208 |
| 5.5.3.1: Observed Impacts of Existing Activities and Facilities on the Host Environment | 208 |
| 5.5.3.2: Associated Potential Impacts of the proposed Otumara Node AGS Project | 213 |
| 5.5.4: Impacts on Wildlife and Forestry | 216 |
| 5.5.4.1: Impact of the Proposed Project on Forestry and Wildlife | 216 |
| 5.5.5: Impacts on Water | 217 |
| 5.5.6: Noise and Vibration Impacts | 218 |
| 5.5.7: Impacts on Resource Utilization..... | 221 |
| 5.5.8: Risk Assessment | 223 |
| 5.5.9: Social & Health Impacts | 226 |
| CHAPTER SIX..... | 229 |
| MITIGATION OF IMPACTS | 229 |
| 6.1: Introduction..... | 229 |
| 6.2: Mitigation Measures | 229 |
| CHAPTER SEVEN | 238 |
| ENVIRONMENTAL MANAGEMENT PLAN..... | 238 |
| 7.1: Introduction..... | 238 |
| 7.2: SPDC's Corporate HSE Programme | 238 |
| 7.3: Monitoring Focal Point..... | 240 |
| 7.4: Environmental Audits | 241 |
| 7.5: Responsibilities And Training | 241 |
| 7.6: Oil and Gas Contingency Planning..... | 255 |
| 7.7: Consultation..... | 255 |
| 7.8: Future Commitments | 255 |

| | |
|----------------------------------------------------|-----|
| 7.9: Waste Management..... | 256 |
| 7.9.1: Sources and Characteristics of Wastes | 256 |
| 7.9.2: Solid Waste Management | 258 |
| 7.9.3: Aqueous Waste Management | 259 |
| 7.9.4: Gaseous Waste Management | 260 |
| 7.9.5: Non-operational Gas Flares | 261 |
| Chapter Eight | 263 |
| CONCLUSIONS AND RECOMMENDATIONS | 263 |
| REFERENCES | 264 |
| GLOSSARY AND DEFINITION OF TERMS..... | 271 |
| APPENDICES | 279 |

LIST OF TABLES

| | |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| Table 1.1: Data Requirements and Environmental Indicators (Biophysical Aspect) | 16 |
| Table 1.2: Sampling Specifications and Parameters for Laboratory Analysis for Biophysical Samples..... | 19 |
| Table 1.3: List of Study Communities and Local Governments..... | 23 |
| Table 1.4: Socio-economic Data Needs | 23 |
| Table 1.5: Health Data Needs | 24 |
| Table 2.1: Constructability Workshop Result..... | 30 |
| Table 2.2 Installation Selection Workshop Result..... | 30 |
| Table 2.3.: Project Options Considered | 31 |
| Table 3.1: Potential Waste Expected From The Otumara AGS Project | 59 |
| Table 4.1: Sampling Stations and Codes | 62 |
| Table 4.2.1a: Ambient Temperature, Relative Humidity, Wind Speed and wind Direction within the Study Fields (August. 2012)..... | 66 |
| Table 4.2.1b: Ambient Temperature, Relative Humidity, Wind Speed and wind Direction within the Study Fields (January. 2013)..... | 66 |
| Table 4.2.2a: Measured Air Quality/Noise Parameters at the Monitoring Points (August, 2012 - Wet Season)..... | 68 |
| Table 4.2.2b: Measured Air Quality/Noise Parameters at the Monitoring Points (January, 2013 - Dry Season)..... | 69 |
| Table 4.2.3: Summary Comparison of the Mean Field Concentrations of Air Quality Indicators | 71 |
| Table 4.2.4: Nigerian Ambient Air Quality Standard. | 72 |
| Table 4.2.5: World Health Organisation (WHO) Guidelines For Maximum Exposure To The Major Pollutants And Some Possible Effects If These Recommendations Are Exceeded..... | 72 |
| Table 4.2.6: Natural Atmospheric Concentration of Some Greenhouse gases | 72 |
| Table 4.2.7: Evolution of Atmospheric Concentrations of Key Greenhouse gases influenced by Human Activities | 73 |
| Table 4.3.1a: Physicochemical Analysis Of Soil At Otumara During The Wet Season..... | 74 |
| Table 4.3.1b: Physicochemical Analysis Of Soil At Otumara During The Dry Season..... | 77 |
| Table 4.3.2: Summary of physicochemical properties of soil in Otumara field | 80 |
| Table 4.3.3a: Soil Microbial Population during The Dry Season | 88 |
| Table 4.3.3b: Soil Microbial Population During The Wet Season | 89 |
| Table 4.3.4: Various Land Uses in Otumara Project Area..... | 91 |
| Table 4.4.1a: Details of the Wet Season Physico-Chemical Results of Surface waters within Otumara | 92 |
| 4.4.1b: Details of the Dry Season Physico-Chemical Results of Surface waters within Otumara | 93 |
| Table 4.4.2: Summary of the Physico-Chemical Results of Surface waters within Otumara..... | 94 |
| Table 4.4.3a: Surface water microbial population in the Dry season | 98 |
| Table 4.4.3b: Surface water microbial population in the wet season..... | 99 |
| Table 4.4.4a: Physicochemical properties of sediment in Otumara during the dry season..... | 103 |
| Table 4.4.4b: Physicochemical properties of sediment in Otumara during the wet season | 104 |
| Table 4.4.5: Summary of the physicochemical and microbiological properties of Otumara area | 105 |
| Table 4.4.6a Sediment microbial population density during the dry season..... | 107 |
| Table 4.4.6b: Sediment Microbial Population Density during The Wet Season | 108 |
| Table 4.5.1: List of Phytoplankton Species | 109 |
| Table 4.5.2: List of Zooplankton Species | 113 |
| Table 4.5.3: Macroinvertebrates Species Composition..... | 115 |
| Table 4.6.1: List of Some Fin and Shell Fish from the study area..... | 119 |
| Table 4.7.1a: Checklist of plant species present at Otumara Field | 129 |
| Table 4.7.1b: Results of Phytochemical Screening..... | 131 |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| | |
|------------------------------------------------------------------------------------------------------------------------------------|-----|
| Table 4.8.1: Checklist of Mammals found in the project site | 133 |
| Table 4.8.2: Checklist of Birds (Aves) found in the project site..... | 133 |
| Table 4.8.3: Checklist of Reptiles found in the project site | 134 |
| Table 4.9.1: Stratigraphic sequence of the Niger Delta Basin with aquifer prospectivity | 135 |
| Table 4.9.2a: Physico-chemical qualities of Otumara Borehole Samples (Wet Season 2012)..... | 137 |
| Table 4.9.2b: Physico-chemical qualities of Otumara Borehole Samples (Dry Season 2013)..... | 138 |
| Table 4.9.3: Summary of Physico-chemical qualities of Otumara Borehole water Samples | 139 |
| Table 4.9.4a: Groundwater microbial population in the Dry season | 142 |
| Table 4.9.4b: Groundwater microbial population in the wet season..... | 142 |
| Table 4.10.1: List of common local deities and festivals in the Project communities..... | 143 |
| Table 4.10.2: Population of the state and LGA..... | 144 |
| Table 4.10.3: Population of Otumara AGS Project Communities | 145 |
| Table 4.10.4: Working experience of respondents..... | 154 |
| Table 4.10.5: Income distribution of the respondents..... | 155 |
| Table 4.10.6: Expenditure Profile of households in the area | 155 |
| Table 4.10.7: Status of Infrastructural Amenities and Quality of Life in Otumara AGG Solution Project Communities | 164 |
| Table 4.10.8: Perceived Fears entertained by respondents about proposed project..... | 169 |
| Table 4.10.9: Expectations and Priority Needs of SPDC's Otumara AGG Solution Project Communities | 169 |
| Table 5.1: Identified Phases of Project Development and their Activities | 187 |
| Table 5.2 (a): Impactable Environmental Components and Associated Impact Indicators for all phases of the project development..... | 188 |
| Table 5.2 (b): Checklist of Associated and Potential Impacts | 189 |
| Table 5.3: SPDC Risk Matrix | 191 |
| Table 5.4: ISO Criteria and Rating for Identification of Significant Environmental Impacts. | 191 |
| Table 5.5: Significant Impacts of the Proposed Project..... | 193 |
| Table 5.6: Operational Gas Flares And Typical Gaseous Emission Sources And Quantities | 203 |
| Table 5.7: Typical Exhaust Gas Compositions..... | 203 |
| Table 5.8: Green House Gas Emission Scenario in 2012 and 2017..... | 205 |
| Table 5.9: Typical Noise Levels for relevant Construction Equipment*..... | 218 |
| Table 5.10: HAZID Assessment | 224 |
| Table 6.1: Summary of Significant Impacts and Mitigative Measures for the Identified Potential and Associated Impacts | 230 |
| Table 7.1: Environmental Management Plan (EMP) of Otumara AGS Project | 241 |
| Table 7.2: Anticipated Residuals from site preparation and construction. | 257 |
| Table 7.3: Classified Waste Treatment/ Disposal Options | 257 |
| Table 7.4: Analysis of Oil Spill Records in Otumara/ Saghara/ Escravos Beach Fields (2007-2012) | 260 |
| Table 7.5: Green House Gas Emission Scenario in 2012 and 2017..... | 261 |

LIST OF FIGURES

Fig. 1.1: Map of Nigeria Showing Otumara Project Area 2

Fig. 1.2: Map of Delta State showing Otumara AG Solution Project Area 3

Fig. 2.1: Schematic for Otumara AGS Project Facilities 29

Fig. 2.2: Schematic for Otumara AGS Project Pipelines 29

Fig 2.3 Otumara Saghara Location Map 31

Fig 3.1: Map of Nigeria Showing Otumara Project Area 35

Fig 3.2: Map of Delta State showing project location 36

Fig 3.3: Project Activities and schedule 51

Fig. 3.4: CPF Facility Layout in Otumara Flowstation 52

Fig 3.5 Proposed CPF Imposed on Otumara Flowstation 53

Fig 3.6: Central Processing Facility – 3D Model 54

Fig 3.7 FLB superimposed on Otumara Field location 55

Fig 3.8: Field Logistics Base – 3D Model 56

Fig 3.9: Pictorial View of Otumara Showing Proposed FLB Location 57

Fig 3.10: Superimposed FLB on Otumara location 58

Fig. 4.2.1: Average Relative Humidity for Warri Synoptic Station 64

Fig. 4.2.2: Wind rose of 11 (1995-2006) year historical data of wind speed and direction for Warri synoptic station 65

Fig. 4.2.3: Average Monthly Rainfall distribution for Warri Synoptic Stations 67

Fig. 4.2.4: Average Monthly Temperatures for Warri Synoptic Station 67

Fig. 4.2.5: Diagram showing the size distribution in micrometres of various types of atmospheric particulate matter 70

Fig. 4.3.1: Soil Parameters Concentration as Compared to DPR Limits 90

Fig. 4.5.1: Percentage Composition of Phytoplankton Divisions in the Wet Season 110

Fig. 4.5.2: Percentage Composition of Phytoplankton Divisions in the Dry Season 110

Fig. 4.5.3: Spatial variation in the total density of phytoplankton 111

Fig. 4.5.4a: Percentage Composition of Wet season Zooplanktonic Organisms 112

Fig. 4.5.4b: Percentage Composition of Dry season Zooplanktonic Organisms 112

Fig. 4.5.5: Spatial variation in the total density of Zooplankton 114

Fig. 4.5.6a: Percentage Composition of Wet Season Macrobenthic Fauna 115

Fig. 4.5.6b: Percentage Composition of Dry Season Macrobenthic Fauna 115

Fig. 4.5.7: Spatial variation in the total density of benthic macroinvertebrates 118

Fig. 4.5.8: Spatial variation in the total density of benthic macroinvertebrates 118

Fig. 4.8.1: Map of Niger Delta showing Protected Areas 132

Fig 4.9.1: Average typical Litholog of the boreholes of the study areas 136

Fig 4.9.2: Groundwater flow direction in the study area Otumara 137

Fig. 4.10.1: Marital status of the Households in the study area 146

Fig. 4.10.2: Family size in surveyed Otumara community 146

Fig. 4.10.3: Age Structure of sampled respondents at Otumara Community 147

Fig. 4.10.4: Age-sex structure of Delta State population (2006) 148

Fig. 4.10.5: Educational attainment of respondents 149

Fig. 4.10.6: Power Structure and Governance in Communities/Settlements 150

Fig. 4.10.7: Primary occupation of respondents in Otumara community 153

Fig. 4.10.8: Weekly expenditure profile of families in surveyed Otumara community 156

Fig. 4.10.9: Annual savings of respondents 156

Fig. 4.10.10: Size of land owned by respondents 157

Fig. 4.10.11: Housing ownership and type in Otumara community 163

| | |
|--------------------------------------------------------------------------------------------|-----|
| Fig. 4.10.12: Benefits expected from SPDC’s AGG Solution Project..... | 169 |
| Fig. 4.11.1: Sources of drinking water..... | 171 |
| Fig. 4.11.2: Time spent to fetch water in the Otumara AGS communities..... | 171 |
| Fig. 4.11.3: A comparison of the prevalence of childhood malnutrition | 178 |
| Fig. 5.1: Otumara and Saghara Gas Flare Records (scf/d)..... | 202 |
| Fig. 5.3: Otumara Flowstation Gas Production and Lift Gas Consumption (1993-2013) | 204 |
| Fig 5.4 Model showing the deposition of sediments at the mouth of the Escravos river. | 211 |
| Fig. 7.1: Otumara and Saghara Gas Flare Records (scf/d)..... | 261 |

LIST OF PLATES

Plate 4.3.1: A Panoramic View of the Various Land Uses in Otumara Area 91

Plate 4.5.1: *Cardisoma armatum* (rainbow crab)..... 116

Plate 4.5.2: *Uca tangeri* (Fidler crab) 116

Plate 4.5.3: *Balanus* sp (attached to wellhead base) 117

Plate 4.5.4: *Thais* sp (attached to mangrove root)..... 117

Plate 4.6.1: Local trap for shell fishes (Shrimps and crabs)..... 119

Plate 4.6.2: Smoked shrimps caught by local fishermen (ready for sale) 120

Plate 4.7.1 120

Plate 4.7.2: showing (L-R) the transition zones at VG18 and 8 respectively. 122

Plate 4.7.3: Showing vegetation zones, and types, present in the Otumara area. 123

Plate 4.7.4 showing tall Mangrove (above); and the short mangroves (below)..... 125

Plate 4.7.5: Showing the dwarf mangrove vegetation at Otumara and a pile of twigs harvested from it for fuel wood. 126

Plate 4.7.6: Showing a section of the fresh water swamp forest..... 127

Plate 4.7.7: Showing a disturbed patch of the Palm dominated swamp vegetation; *Tabanaemontana pachysiphon*. 128

Plate 4.7.8: Showing a *Phoenix reclinata* swamp with *Avicennia germinans*, Oil palm and *Acrostichum aureum* associations at VGC 3, near Madagho– ajeda. 129

Plate 4.10.1: Destroyed market structures at Ugborodo 152

Plate 4.10.2: Fishing gears used in the Otumara study environment, bagged periwinkles 154

Plate 4.10.3: Sign post showing Otseyen Primary School, Ugbeogungun 158

Plate 4.10.4: Primary school structures for the Ekperi Primary School, Ugborodo Community 159

Plate 4.10.5: Two giant generators supplied by SPDC and DESOPADEC at Ugbeogungun community .. 159

Plate 4.10.6: Boat and concrete jetties at Ugbeogungun community 160

Plate 4.10.7: Modern Town Halls for Ugbeogungun and Ugborodo communities 161

Plate 4.10.8: Water receptacle for rain water harvesting. Community members travelling long distance to fetch water in jerrycans..... 161

Plate 4.10.9: Modern housing in Ugborodo constructed by NDDC and RDC 162

Plate 4.10.10: Typical housing in Otumara AGS community 163

Plate 4.10.11: Private modern Housing in Ugbeogungun..... 163

Plate 4.11.1: Water sources in the host communities..... 172

Plate 4.11.2: Water sources in the host communities..... 172

Plate 4.11.3: Discarded drums of drilling chemicals used to collect rain water in Ajudaibu community. .. 173

Plate 4.11.4: The jetty-type toilet is the commonest toilet in the host communities 174

Plate 4.11.5: Raised house in a host community..... 175

Plate 4.11.6: One of the houses built in Ogidigben by the Itsekiri Regional Development Council..... 175

Plate 4.11.7: Firewood is the commonest source of fuel for domestic use 176

Plate 4.11.8: Refuse dump site at the bank of the river at Otumara..... 176

Plate 4.11.9: PHC Ajudaibo..... 180

Plate 4.11.10: Cottage hospital in Ogidigben being renovated..... 180

Plate 4.12.1: Members of Otumara Community (Ugborodo, Ugbeogungun and Deghele)..... 183

Plate 4.12.2: The elderly and women leaders in Ugbeogungun Community..... 183

Plate 4.12.3: Engagement session in the home of the Olaraja of Ogidigben community 184

Plate 4.12.4: Engagement session with some elders and members of the youth taskforce at Madangho Community 184

Plate 5.1: Bush cleared area prior to dredging in Opukushi field (Macgill, 1996). 197

Plate 5.2: Grab dredger in action in Opukushi field..... 198

Plate 5.3: Showing an *Acrostichum* community cut off from the adjoining Swamp – *Acrostichum* Marsh transition zone by dredge spoil associated Plantation farm at VG 15..... 209

Plate 5.4: Top Left: Slot mesh on HIGH SALT MARSH; Top Right: Slot mesh on LOW SALT MARSH, C= dense *Acrostichum-Avicennia* belt, b = sparsely vegetated low marsh; Bottom: the nearness of the well heads and slot mesh to the coast line. 209

Plate 5.5: Shows a cleared area (about 100 ft wide) adjoining the dredge plantation at VG 15..... 210

Plate 5.6: Showing the invasive Nuisance Palm at several locations in Otumara. 212

LIST OF ABBREVIATIONS AND ACRONYMS

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

| | |
|-------------------|----------------------------------------------------------------------|
| FID | Final Investment Decision |
| FLB | Field Logistics Base |
| FMEnv | Federal Ministry of Environment |
| Ft | Feet |
| FYIP | Forcados Yokri Integrated Project |
| GEM | Gender Empowerment Measure |
| GHF | Gas Handling Facility |
| GIIP | Gas Initially in Place |
| GW | Groundwater |
| HAZID | Hazard Identification |
| HAZOP | Hazard Operability |
| HDI | Human Development Index |
| HIA | Health Impact Assessment |
| HNO ₃ | Nitric Acid |
| HPI | Human Poverty Index |
| HSE | Health, Safety, Environment |
| HSE | Health, Safety and Environment |
| HSE-MS | Health, Safety and Environment Management System |
| IA | Impact Assessment |
| IFC | International Finance Corporation |
| ISO | International Organisation for Standardisation |
| IUCN | International Union for Conservation of Nature and Natural Resources |
| Km | Kilometres |
| LGA | Local Government Area |
| m/s | meter per second |
| m ³ | meter cube |
| m ³ /d | meter cube per day |
| MAC | Mid Arm Circumference |
| MEDEVAC | Medical Emergency Evacuation Response |
| mg/l | milligram per liter |
| Mm | Millimeter |
| MMbbl | Million Barrel |
| MMboe | Million Barrel of oil Equivalent |
| MMscf/d | Million Standard cubic feet of gas per day |
| MMstb | Million stock tank barrel |
| MoU | Memorandum of Understanding |
| Na | Sodium |
| NAG | Non Associated Gas |
| NDPC | Niger Delta Peace Coalition |

| | |
|------------------------------|------------------------------------------------------------|
| NDT | Non Destructive Test |
| NERC | National Electricity Regulatory Commission |
| NFA | No Further Activity |
| NGC | Nigerian Gas Company |
| NGO | Non-Governmental Organisation |
| NH ₄ ⁺ | Ammonium ion |
| NIWA | National Inland Waterways Authority |
| NPF | Nigeria Police Force |
| ° | Degree |
| °C | Degree Celsius |
| OML | Oil Mining License |
| P | Phosphorus |
| Pb | Lead |
| pH | Hydrogen ion concentration |
| PMoU | Project Memorandum of Understanding |
| PO ₄ ⁻ | Tetraoxophosphate (VI) ion |
| Ppm | Parts Per Million |
| PRA | Participatory Rural Appraisal |
| Q1 | Quarter one |
| Q4 | Quarter four |
| QA/QC | Quality Assurance/Quality Control |
| QRA | Quantitative Risk Assessment |
| RF | Recovery Factor |
| RoW | Right of Way |
| SCD | Sustainable Community Development |
| SD | Sustainable Development |
| SED | Sediment |
| SIA | Social Impact Assessment |
| SMART | Specific, Measurable, Achievable, Realistic and Time-based |
| SPDC | Shell Petroleum Development Company of Nigeria Limited |
| SPDC | The Shell Petroleum Development Company of Nigeria Ltd |
| SS | Soil Sample |
| SS | Suspended Solids |
| SSAGS+ | Southern Swamp Associated Gas Solution Plus Project |
| SSIOGP | Southern Swamp Integrated Oil & Gas Project |
| SW | Surface Water |
| SWL | Static Water Level |
| Tcf | Trillion cubic feet |
| TDS | Total Dissolved Solid |
| TDS | Total Dissolved Solids |
| THC | Total Hydrocarbon |
| THC | Total Hydrocarbon Content |

| | |
|------|------------------------------|
| ToR | Terms of Reference |
| Tscf | Trillion standard cubic feet |
| TSP | Total Suspended Particulates |
| TSS | Total Suspended Solid |
| TSS | Total Suspended Solids |
| UR | Ultimate Recovery |
| VAR | Value Assurance Review |
| VEG | Vegetation |
| VOC | Volatile Organic Carbon |
| WHO | World Health Organisation |
| % | Percentage |
| ‰ | Parts per thousand |
| µg/l | Microgram per liter |
| µS | Micro Siemen |

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EXECUTIVE SUMMARY

ES1: BACKGROUND

The Shell Petroleum Development Company of Nigeria Limited (SPDC), on behalf of the Joint Venture partners (Nigerian National Petroleum Corporation, Nigerian Agip Oil Company, and Total), plans to embark on Otumara Associated Gas Solution Project to meet the business objectives of Domestic Gas supply and gas flares down. At present, most of the associated gas produced at the Otumara flow station is being flared. Produced associated gas is currently used as fuel gas for the pumps and generators, for lift gas, and the excess flared.

The SPDC Business Plan forecast for Otumara showed that substantial Further Oil Development (FOD) activities may commence in the field, and will need disposal of AG and probably more lift gas. In view of this, it is considered that a pre-investment in AG pipeline from Otumara to Nigerian Gas Company (NGC) will be required by installing a 12''x 12 km pipeline to the Nigeria Gas Company NGC to accommodate 20 mmscf/day.

ES2: EIA OBJECTIVES

The objectives of the EIA study are to:

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

ES3: LEGAL AND ADMINISTRATIVE FRAMEWORK

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

Environment (1989), National Oil Spill Detection and Response Agency (NOSDRA), 2006 and National Environmental Standards Regulatory and Enforcement Agency (NESREA), 30th July, 2007.

Other regulations include Forestry Law CAP 51, 1994, Land Use Act of 1978, The Bendel State Town and Country Planning Laws Cap 165 (as applicable to Delta State) of 1975, Delta State Environmental Protection Agency Edict No 5 of 1997, Delta State Ecology Law, 2006, Bendel State Forestry Law Cap 59, 1976 (now applicable to Delta State), Delta State Revenue Edict, 1997, Delta State Waste Management Law, 2004 and Delta State Internal Revenue Consolidation Law, 2009. Other regulations are the National Inland Waterways Authority Act No 13 of 1997, International Laws and Regulations (World Bank Guidelines on Environmental Assessment {EA} (1991), International Union for Conservation of Nature and Natural Resources (IUCN) Guidelines, Convention on the Migratory Species of Wild Animals (Bonn Convention), Convention of Biological Diversity, Convention Concerning the Protection of the World Cultural and National Heritage Sites (World Heritage Convention), Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal and United Nations Framework Convention on Climate Change (1992)), Associated Gas Re-Injection Act No. 99 of 1979 (CAP 26), Nigerian Ports Authority Act No 38 of 1999, Endangered Species (Control of International Trade and Traffic) Act 11 of 1985, and the Environmental Impact Assessment (EIA) Process – A Manual for EIA Execution in SPDC, SPDC 99-201, 2000. This document sets down the guidelines for an enhanced, cost effective and improved EIA process in SPDC, which fully incorporates Social Impact Assessment (SIA), Health Impact Assessment (HIA) and effective consultation with all the Stakeholders in the EIA.

ES4: 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 drilling 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.

ES5: PROJECT OBJECTIVE

The objectives of the Otumara Field AGS project are:

- Align with government's aspirations by contributing to SPDC's plan to meet its assigned DOMGAS contributory quota and thus deliver 100 MMscf/d gas to the Western domestic gas market.
- Implement the drive for reliability and standardization of major facilities using industry standards.
- Achieve Flares down and thus minimize impact on the environment and enhance the socio-economic development of the host communities in the area through sustainable development of the project over its life cycle.
- Provide Lift Gas for Secondary Recovery
- Maintain Reputation
- Maintain LTO

- Secure Developed reserves
- Enable Maturation/booking of undeveloped reserves and
- Alignment with Stakeholders aspiration

RELATIONSHIP TO OTHER PROJECTS

SPDC's oil production is gathered in a number of flowstations for oil and gas separation before pumping oil to the terminal for dehydration and export, and flaring the AG at the flow stations. SPDC, in its major effort to usefully exploit AG, had undertaken AG production forecasts up to the year 2014. Based on the production forecasts, five (5) main AG production areas had been identified for development in the Western Division of SPDC's operations in Nigeria. These are:

- Escravos Beach Uplifted Well drilling Project;
- Saghara Field Associated Gas Solution Project;
- Otumara Field Associated Gas Solution Project;
- Southern Swamp Associated Gas Solution Project and
- Forcados Yokri Integrated Project

ES6: SUSTAINABILITY OF THE PROJECT

ECONOMIC SUSTAINABILITY

The Otumara Node fields, namely Otumara and Saghara have proven reserves of natural gas. These reserves of gas can economically and commercially support the project following the high demand for natural gas in the domestic and international market. Part of this demand will be met from some of the fields in this node. The project will therefore contribute substantially to the revenue accruing to Nigeria.

SPDC policy on employment of indigenous contractors will be applied in the project. Skilled and unskilled indigenous labour will be hired in the construction phase and possibly in the future maintenance and running of the AG facility.

The main contractors employed in this development shall be required to award minor contracts to local indigenous contractors for jobs in which they have the required expertise. Such jobs will include but not limited to bush clearing, fencing, labour supply, catering, leasing, fabrication, surveillance, etc. Efforts will be made also to upgrade the technical and managerial capacities of such indigenous contractors.

TECHNICAL SUSTAINABILITY

The Otumara Field AG Solution Project is technically sustainable because of SPDC's track record of strict adherence to Nigerian National (and International) engineering codes and standards. Only proven technologies that are economically viable with minimal environmental, social and health impacts shall be utilised in the execution of the Otumara AG Solution project.

ENVIRONMENTAL SUSTAINABILITY

The aim is to ensure that current use of the environment and its natural resources does not damage prospects for use by future generations. SPDC shall comply with all statutory regulations and its own corporate guidelines on Environmental Sustainability, continuously striving for performance

improvement. Elimination of routine gas flaring is a positive step in the direction of sustainable development and will thus support transition to environmental sustainability. Adequate incentives are therefore needed to ensure that the cost of enhancing environmental performance does not inhibit business growth.

ES7: PROJECT ALTERNATIVES/OPTIONS

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

- No Project Option
- Build on New location
- Build on existing location

Option 3 build on existing location was adopted over the other options. A summary of the advantages and disadvantages of each option is contained in chapter 2. However, option 3 had the following advantages. It required land acquisition and therefore more money to the communities, it offered employment and contract opportunities. Other advantages included no land take, no negative impact on project schedule, minimal vegetation clearing and improved environmental performance. The only disadvantage was increased pressure on existing facility in view of influx of people.

ES8: PROPOSED PROJECT SCOPE

The Otumara field Associated Gas (AG) Solution Project is mainly a facility upgrade of the existing Otumara flowstation with addition of new facilities and laying of pipelines using the existing SPDC Right of Way (RoW). The scope of works has been divided into a facilities and pipeline scope. It will involve the following:

Facilities Scope

This has been further sub-divided into the following:

1. Otumara Central Processing Facility (CPF)
 - Gas Processing Module- Nominal 30 mmscf/day
 - Gas Turbine Driven Compression Module - Nominal 20 mmscf/day
 - Power Generation/Utility modules- Circa 6.5 MW ISO
 - Flare Relief Systems
 - Blow Down Systems.
2. Otumara Flow station Brown Field works
 - Piping Modifications and tie-ins to integrate the new CPF.
 - Site preparation and civil works including dredging, piling, concreting and shoring works.
3. Design and Construction of a 44-room Field Logistic Base (FLB)
 - Design of the FLB
 - Additional Land Acquisition (11.5ha)
 - Site preparatory works (Dredging, Sand filling, Shoring, Piling)

- Construction of various infrastructures (Staff/Security Accommodations, Offices, Workshops, Utilities, Jetty, Bridges, Fences, Roads, Walkways, Landscaping).
4. Laying of ~30km, 11KV overhead electrical power line to communities (Ugboegungu, Deghelle, Ugborodo) and Saghara field
- Clearing of RoW
 - Installation of foundations piles and electric poles
 - Laying, Pulling, Stringing of overhead cables
 - Installation of terminal points, 500KVA transformers and Feeder Pillars

Pipeline Scope

- i. Corrosion Inhibition Lines - 2" x 5km (From Otumara CPF to Saghara Manifold)
- ii. Test Line - 4" x 5km (from Saghara Manifold to Otumara F/S)
- iii. Bulk line - 6" x 5km (from Saghara Manifold to Otumara F/S)
- iv. Gas Export line - 12" x 12km (from Otumara CPF to NGC)
- v. Flowlines – 15km (Re-routing of 7nos Otumara wells from Saghara F/S to Otumara F/S).
- vi. Manifolds and Pigging facilities (launcher and receiver)
- vii. Cathodic protection system
- viii. 21km Fibre Optic cable for data transmission

River Crossing

The Gas pipeline- 12" x 12 km from Otumara CPF to NGC will cross one major river (Escravos River).

ES9: PROPOSED PROJECT ACTIVITIES

The activities to be carried out for the Otumara field AG Solution Project will include the following aspects:

- Land and Marine transportation of heavy equipment
- Piling of civil foundation for new facilities at the Central Processing Facility (CPF), Flowstation and FLB sites.
- Lifting of equipment and materials during construction
- Excavation on the RoW for laying pipelines.
- Piping tie-ins, Welding, minor fabrication and testing at site.
- River crossing of pipelines by dredging
- Dredging of Otumara creek to allow passage of the barges/vessels that will convey fabricated modules from Warri to Otumara.
- Sand filling of the proposed FLB location
- Electrification of three host communities
- Bulkline and flowline installations

ES10: PROJECT SITE DESCRIPTION

The Otumara flowstation is located on OML 43 North-West of Warri on swamp piled platform on the Otumara river. A journey from Warri by air to Otumara takes approximately 25 minutes while boat transportation takes about 3hour to get to the flowstation. The flowstation is a three bank

station of which the third bank is yet to be commissioned. The produced crude is pumped with gas driven crude oil export pumps to Otumara tie-in manifold via the 10” oil trunkline.

Major part of the separated gas is compressed by the third party gaslift barge (Exterran) for gaslifting of Otumara and Saghara wells. The remaining gas is used as instrument and fuel gas while any excess gas is flared through two horizontal flare units located in a bunded area outside the flowstation.

There are two overhead tanks within the facility, a major overhead tank close to the water Treatment plant and another located on top of the pump house roof inside the flowstation. The major overhead tank receives water from the WTP and feeds the hydrant ring mains for fire fighting and utilities. The second overhead tank on top of the pump house roof has been decommissioned.

ES11: PROJECT SCHEDULE

The current activity schedule for the Otumara AG Solutions Project is shown in the Figure below. First gas is expected from the node by last quarter of 2014.

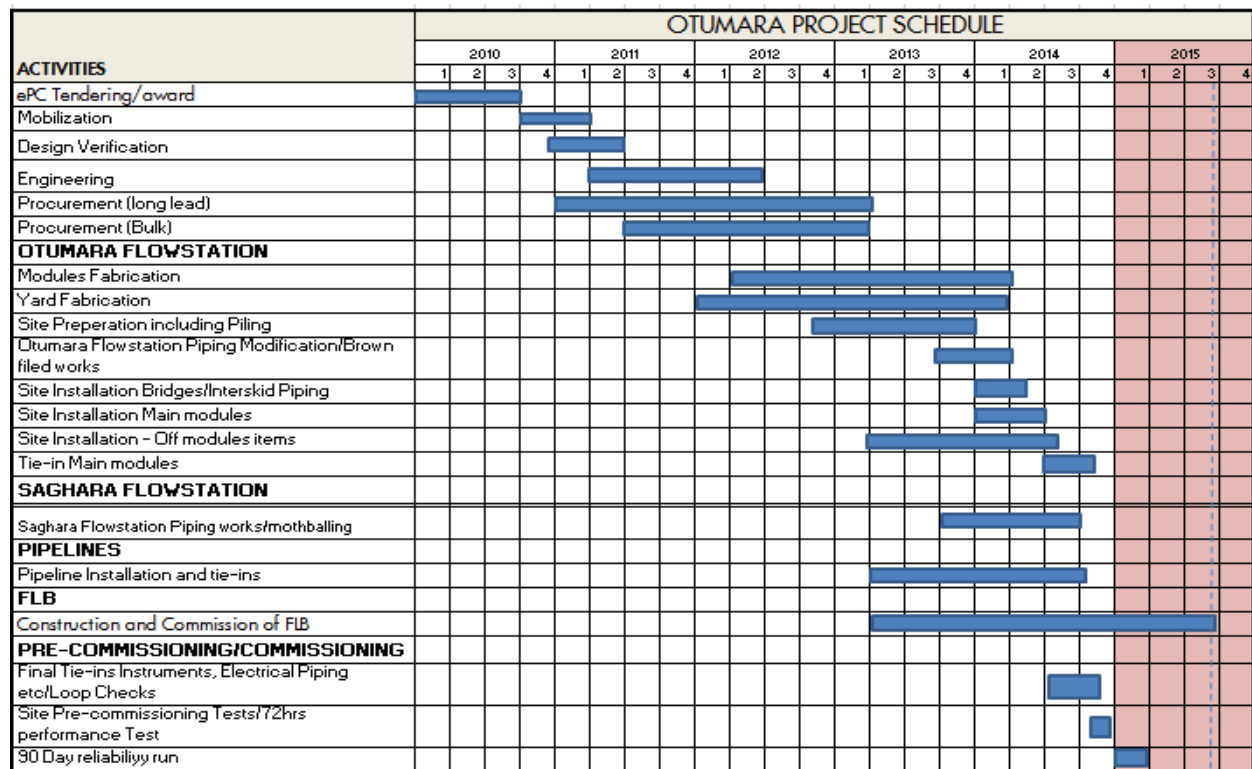


Fig. ES.1: Project Activities and schedule

OPERATION AND MAINTENANCE

The pipelines and their associated facilities will be operated in accordance with operational procedures developed through SPDC extensive experience. Fully trained and qualified personnel who are conversant with SPDC's HSE policy guidelines will manage the eventual facilities.

The CPF at Otumara will be fully manned and the control room shall be designed for fully attended operation. However, the design of the CPF shall be based on unmanned philosophy with

automatic operation and minimal intervention requirements for maintenance and operations. The maintenance and operational crew will be housed in a 44-bed Field Logistics Base.

ES12: ENVIRONMENTAL DESCRIPTION

One of the comments by the FMEnv for the Otumara AGS project, following the FMEnv Panel Review in which the Project was giving Provisional approval in 2010 was that most of the data used were over five years old. Thus SPDC decided to embark and produce a two season EIA instead of simply ground truthing as originally requested.

Thus the purpose of this environmental description is to provide qualitative and quantitative baseline information on the existing status of the project area against which future departures as a result of the emplacement of the proposed project facilities will be weighed. The field data were gathered between August 15 and 20, 2012, representing the Wet Season and from January 15 - 21 2013, for the Dry Season.

CLIMATE AND AIR QUALITY

Measured mean wind speed within the field ranged between 0.8 and 1.4 m/sec, with the highest in the coastal areas. The prevailing wind direction was predominantly Southwesterly. Measured mean temperatures within the field ranged from 27.8°C to 31.5°C, while relative humidity ranged from 55% to 76.1%. Historical data show that the region experiences rainfall throughout the year. On the average, the region receives annual rainfall of over 2,472mm; however it is not uncommon to record total annual rainfall of over 3,200mm, for a very wet year. The monthly variation was a minimum of 20 mm in January and a maximum of 355 mm in July.

Air quality studies indicated that concentrations of NO_x as NO₂ exceeded Regulatory limits at 12 locations while SO_x as SO₂ exceeded Regulatory limits at 8 sampling locations though the averaging times for the samples were relatively short (5 – 10 mins). It is equally probable that these concentrations may remain at these levels over longer periods.

SOIL

The soil of the project area varied in colour ranging from brown superficial (7.5YR 5/3) to light brown (7.5YR 6/3) at the subsurface level. The pH values obtained in the project area during the wet season ranged from 3.3 to 6.7 at the surface soil level and from 3.7 to 6.8 at the sub-surface soil level. During the dry season, pH ranged from 3.70 – 5.80 with a mean of 4.67, whereas at the control it was 4.77 in the surface and 5.29 in the sub-surface. The exchange acidity (EA) was lower in the dry season (0.3 – 5.0 meq/100g with a mean of 1.7 meq/100g) than the wet season (0.9 – 6.8 meq/100g with a mean of 3.7 meq/100g). The EA of the control during the dry season (1.0 meq/100g at the surface and 0.6 meq/100g at the sub-surface) was similarly lower than that of the wet season (4.5 meq/100g at the surface and 2.3 meq/100g at the sub-surface), which are within the values recorded in the main sampling points. EC was several order higher in the dry season (100 – 12510 μS/cm with a mean of 2377 μS/cm) than the wet season (190 -6650 μS/cm with a mean of 1225 μS/cm). The organic carbon (TOC) content of the soils of the Otumara area during the wet season ranged from 1.63 to 5.44 % at the surface and from 1.51 to 4.13 % at the subsurface soil level. During the dry season, TOC ranged from 0.17 - 4.15% with a mean of

2.06%, higher values were recorded for the control, 3.89% at the surface and 3.47% at the subsurface. Similarly, higher TOC values were recorded during the wet season ranging from 1.82 – 5.44% with a mean of 3.53%.

The Available Phosphorus content of the soils of Otumara project area during the wet season ranged from 10.8 – 85.2 mg/kg at the surface soil level and from 9.8 – 78.4 mg/kg at the subsurface soil level. For the controls, phosphorus was 33.2 mg/kg in the surface and 32.4 mg/kg in the subsurface. Phosphorus was lower during the dry season. The Total Nitrogen content of Otumara area soil during the dry season ranged from 0.02 – 0.50% with a mean of 0.24%, whereas at the controls, total nitrogen was 0.39% at the surface and 0.42% at the subsurface. During the wet season, total nitrogen ranged from 0.35 – 1.05% with a mean of 0.69%, whereas at the control, it was 0.72% at the surface and 0.64% at the subsurface. The concentration of Sulphate in the soil of the Otumara area during the wet season ranged from 80 to 2004 mg/kg at the surface soil level, and from 80 to 1628 mg/kg at the subsurface soil level. The control station had sulphate concentration of 104 mg/kg in the surface and 80 mg/kg in the subsurface. Results obtained during the dry season were not significantly different from that of the wet season.

The concentration of chloride in the soil of Otumara area during the wet season ranged from 71 to 2192 mg/kg at the surface soil level and from 83 to 2096 mg/kg at the sub surface soil level. The control had chloride concentration of 86 mg/kg at the surface and 68 mg/kg at the subsurface. The concentration of chloride was higher in the dry season than the wet season. During the wet season, sodium concentration ranged from 0.08 to 9.91 meq/100g at the surface soil level and from 0.06 to 9.11 meq/100g at the subsurface soil level. Potassium concentration ranged from 0.11 to 5.15 meq/100g at the surface soil level and from 0.08 to 5.09 meq/100g at the subsurface soil level. Calcium concentration ranged from 1.50 to 15.6 meq/100g at the surface soil level, and from 1.30 to 14.8 meq/100g at the subsurface soil level. Magnesium concentration ranged from 0.76 to 9.80 meq/100g at the surface level and from 0.67 to 9.89 meq/100g at the subsurface soil level. The order of hierarchy of occurrence of exchangeable cations of the Otumara project area was calcium > sodium > magnesium > potassium.

Hydrocarbon related parameters studied include Total Hydrocarbon Content (THC), Total Petroleum Hydrocarbon (TPH), Polycyclic Aromatic Hydrocarbon (PAH), Benzene, Toluene, Ethylene, and Xylene (BTEX), and Phenol.

During the wet season, the THC of the soil of the Otumara project area ranged from 54.5 to 183.5 mg/kg at the surface soil level and from 50.2 to 144.5 mg/kg at the subsurface soil level. The Total Petroleum Hydrocarbon Content of the soil of Otumara area ranged from 0.036 to 0.304 mg/kg at the surface soil level, and from 0.038 to 0.296 mg/kg at the subsurface soil level.

The concentration of PAH in the soil of Otumara project area during the wet season ranged from 0.039 to 0.188 mg/kg at the surface soil level, and from 0.033 to 0.783 mg/kg at the subsurface soil level.

During the wet season, the concentration of Benzene in Otumara area soil varied from below the detectable limit of the analytical equipment (<0.001 mg/kg) to 0.006 mg/kg at the surface soil level. The subsurface soil level concentration also varied from below the detectable limit of the analytical equipment to 0.005 mg/kg.

Toluene concentration varied from below detectable limit of the analytical equipment, to 0.002 mg/kg at the surface soil level. The subsurface soil level concentration of Toluene varied from below detectable limit of the analytical equipment to 0.003 mg/kg.

Ethyl Benzene concentration varied from below the detectable limit of the analytical equipment to 0.008 mg/kg at the surface soil level, while the subsurface soil level concentration varied from below detectable limit of the analytical equipment to 0.002 mg/kg.

Xylene concentration varied from below detectable limit of the analytical equipment to 0.003 mg/kg at the surface soil level, and from 0.001 to 0.003 mg/kg at the subsurface soil level. The concentration of phenol in the soils of Otumara area ranged from 0.001 mg/kg to 0.005 mg/kg at the surface soil level, and from 0.001 mg/kg to 0.004 mg/kg at the subsurface soil level.

In both wet and dry seasons, iron concentration was markedly higher than the concentrations of the other heavy metals in the soil of Otumara area. During the wet season, the concentration of iron ranged from 189.3 to 207.5 mg/kg at the surface soil level, and from 190.4 to 206.1 mg/kg at the subsurface soil level. Similar values were reported during the dry season. Copper concentration ranged from 1.41 to 6.97 mg/kg at the surface soil level, and from 1.39 to 7.10 mg/kg at the subsurface soil level. Manganese concentration ranged from 3.41 to 3.67 mg/kg at the surface soil level, and from 3.27 to 3.66 mg/kg at the subsurface soil level. Zinc concentration ranged from 6.04 to 15.9 mg/kg at the surface soil level, and from 6.00 to 15.6 mg/kg at the subsurface soil level. Cadmium concentration ranged from 0.20 to 6.55 mg/kg at the surface soil level, and from 0.04 to 6.50 mg/kg at the subsurface soil level. Chromium concentration ranged from 1.39 to 1.61 mg/kg at the surface soil level, and from 1.44 to 1.58 mg/kg at the subsurface soil level. Lead concentration ranged from 0.72 to 5.43 mg/kg at the surface soil level, and from 0.98 to 5.33 mg/kg at the subsurface soil level. Nickel concentration ranged from 0.82 to 6.45 mg/kg at the surface soil level, and from 0.73 to 6.47 mg/kg at the subsurface soil level. Vanadium concentration ranged from 0.72 to 4.79 mg/kg at the surface soil level, and from 0.57 to 4.68 mg/kg at the subsurface soil level. Barium concentration ranged from 0.001 to 0.008 mg/kg at the surface soil level, and from 0.001 to 0.004 mg/kg at the subsurface soil level. The concentration of Mercury was below the detectable limit of the analytical equipment (i.e <0.001).

During the wet season, the total heterotrophic bacteria count of the soil of Otumara area ranged from 5.3×10^5 to 9.9×10^5 cfu/g soil at the surface soil level, and from 4.9×10^5 to 9.3×10^5 cfu/g soil at the subsurface soil level. The hydrocarbon utilizing bacteria count ranged from 0.9×10^3 to 4.2×10^3 cfu/g soil at the surface soil level, and from 0.5×10^3 to 4.0×10^3 cfu/g soil at the subsurface soil level. The dominant bacterial isolates were *micrococcus sp.*, *Bacillus*, *Enterobacter sp.*, *Staphylococcus*, *Pseudomonas* and *Nocardia*. The fungi count ranged from 0.9×10^5 to 2.1×10^5 cfu/g soil at the surface soil level, and from 0.5×10^5 to 2.0×10^5 cfu/g soil at the subsurface

soil level. The hydrocarbon utilizing fungi count ranged from 0.5×10^3 to 1.6×10^3 cfu/g at the surface soil level, and from 0.3×10^3 to 1.2×10^3 cfu/g at the subsurface soil level. The dominant fungi isolates were *Aspergillus*, *Mucor sp.*, *Penicillium*, *Rhizopus*, and *Trichoderma*.

SURFACE WATER PHYSICO-CHEMISTRY

All the water samples in Otumara field were moderately acidic to moderately alkaline in nature. The conductivity values recorded in this study ranged from 3039 $\mu\text{S}/\text{cm}$ to 20860 $\mu\text{S}/\text{cm}$, with the mean value being higher in the dry than in the wet season. These values are characteristic of brackish water environment, with salinity values ranging from 1.37 ‰ to 9.66 ‰. The turbidity values in this study ranged from 6.3 NTU in the control to 14.5 NTU in the wet season. The high level of TDS (10165 mg/l - 10430 mg/l) recorded in this study is characteristic of brackish water environment and followed the same trend with electrical conductivity (EC). The DO values recorded in this study ranged from 4.3 in the dry season to 7.36 mg/l with a mean of 6.94 mg/l in the dry season, and fell within the FMEnv regulatory limit. Sodium ranged between 102 and 170 mg/l, potassium (26.4 – 143.9 mg/l), calcium (31.6 – 59.2 mg/l) and magnesium (31.2 – 61.2 mg/l). These values are characteristic of brackish water environment and not different from values obtained for the control station for both the wet and dry seasons. The order of dominance is as follows: $\text{Na} > \text{K} > \text{Mg} > \text{Ca}$. Chloride values ranged between 3700 and 17900 mg/l, and the values in the control were as high as 17900 mg/l because of its nearness to the coast and brackish nature. The nutrients were low, reflecting oligotrophic condition.

The levels of Total Hydrocarbon (THC), Total Petroleum Hydrocarbon (TPH), Polycyclic Aromatic Hydrocarbon (PAH), BTEX (Benzene, Toluene, Ethylbenzene and Xylene) and Phenol recorded in this study were low, indicating an environment not polluted by petroleum hydrocarbons. The THC values ranged between 0.02 and 1.05 mg/l, TPH values ranged between 0.001 and 0.022 mg/l, while PAH values ranged from 0.001 to 0.013 $\mu\text{g}/\text{l}$. The BTEX and Phenol values ranged from 0.00 to 0.008 $\mu\text{g}/\text{l}$ and 0.001 to 0.003 $\mu\text{g}/\text{l}$ respectively. These values are below the regulatory limits, especially for TPH.

Natural waters contain very small quantities of essential metals including zinc (Zn), copper (Cu), Cadmium (Cd), lead (Pb), iron (Fe), Nickel (Ni), chromium (Cr), manganese (Mn), barium (Ba), vanadium (V) and mercury (Hg). The concentrations of heavy metals in the water samples were generally low ranging from 0.00 mg/l (Hg) to 1.69 mg/l (Fe). All heavy metals had mean values less than the regulatory limits, except for Fe and Pb which had values greater than the regulatory limits of DPR (WHO) and FMEnv.

SURFACE WATER MICROBIOLOGY

During the dry season, total coliform ranged from 8 – 20 MPN/100ml with a mean of 14 MPN/100ml while fecal coliform ranged from 4 – 11 MPN/100ml, whereas, at the control station, total coliform was 11 MPN/100ml and fecal coliform was 9 MPN/100ml. The control station values fell within the range of the main samples. Similarly, during the wet season, total coliform ranged from 11 – 20 MPN/100ml with a mean of 15 MPN/100ml while fecal coliform ranged from 6 – 11 MPN/100ml, whereas, at the control station, total coliform was 11 MPN/100ml and fecal coliform was 7 MPN/100ml.

During the dry season, THB in the surface water was in the range of $5.1 - 9.1 \times 10^4$ cfu/ml with a mean of 6.69×10^4 cfu/ml. The control had a population of 4.8×10^4 cfu/ml. Hydrocarbon utilizing bacteria (HUB) ranged from $0.8 - 2.8 \times 10^2$ cfu/ml, with a mean of 1.51×10^2 cfu/ml. Hence, HUB accounted for about 1% of the THB. In the wet season, THB ranged from $6.9 - 9.2 \times 10^4$ cfu/ml with a mean of 7.9×10^4 cfu/ml. The control had a THB population of 5.5×10^4 cfu/ml and HUB population of 0.8×10^2 cfu/ml. Bacteria species isolated from the surface water include *Bacillus* sp, *Micrococcus* sp, *Pseudomonas* sp, *E. coli*, *Enterobacter* sp, *Serratia* sp, *Staphylococcus* sp, *Alcaligenes* sp and *Norcadia* sp. Total fungi (TF) during the dry season ranged from $0.7 - 1.4 \times 10^4$ cfu/ml with a mean of 1.0×10^4 cfu/ml. The THF of the control fell within the range of the main samples.

Hydrocarbon utilizing fungi (HUF) during the dry season was scanty occurring in only few locations with a population of $0 - 1.0 \times 10^2$ cfu/ml having a mean of 0.3×10^2 cfu/ml. Thus, hence the proportion of HUF relative to the TUF was less than 1% suggesting no hydrocarbon input from petroleum sources. In the wet season, TF population ranged from $0.4 - 1.8 \times 10^4$ cfu/ml, with a mean of 1.1×10^4 cfu/ml. Hydrocarbon utilizing fungi (HUF) ranged from $0 - 1.2 \times 10^2$ cfu/ml, with a mean of 0.2×10^2 cfu/ml. HUF accounted for about 1% of the TF. The control sample had a population of THF of 0.9×10^4 cfu/ml and HUB population of 0 cfu/ml. Fungi species isolated from the study area include *Mucor* sp, *Rhizopus* sp, *Aspergillus flavus*, *Aspergillus clavatus*, *Penicillium* sp.

SEDIMENT PHYSICO-CHEMISTRY

The pH ranged from 4.89 – 5.54 with a mean of 5.34 in the dry season. The pH of the control point was 5.54. The pH data during the wet season had higher variability ranging from 4.2 – 6.8 with a mean of 5.34, whereas the control sample also has a pH of 6.8. The variation in the pH was within the DPR intervention value of 5.5-6.5. Exchange acidity (EA) ranged from 0.9 – 2.8 meq/100g, with a mean of 1.3 meq/100g in the dry season, whereas the control point has an EA of 1.0. However, during the wet season, the EA was slightly lower ranging from 0.4 – 2.0 meq/100g with a mean of 1.0 meq/100g and the control point also had an EA of 1.0 meq/100g.

Electrical conductivity (EC) during the dry season ranged from 2100 – 10680 μ S/cm with a mean of 5381 μ S/cm, whereas the control site had an EC of 8940 μ S/cm. The wet season EC was comparable to that of the dry season ranging from 2030 – 10350 μ S/cm, whereas the control point had an EC of 2030 μ S/cm. The control points in both seasons were within the ranges reported for the main samples. Exchangeable cations studies in this project include calcium, magnesium, sodium, and potassium. During the dry season, sodium ranged from 8.64 – 10.89 meq/100g with a mean of 9.98 meq/100g, whereas 10.21 meq/100g was recorded at the control site. Likewise, during the wet season significantly lower concentration of sodium was recorded, ranging from 4.16 – 7.07 meq/100g with a mean concentration of 6.59 meq/100g, but the control had a concentration of 4016. Calcium concentration was slightly higher than sodium concentration, whereas magnesium concentration was comparable to sodium, but potassium was several orders lower than sodium.

Nitrogen related parameters studied include total nitrogen, ammonium, nitrite and nitrate. Total nitrogen in the sediments during the dry season ranged from 0.08 – 0.67% with a mean of 0.52, whereas the control had 0.58%. The data obtained in the wet season exhibited higher variability, ranging from 0.34 – 1.09%, with a mean of 0.87%, but the control was 0.34%. During the dry season, nitrate ranged from 2.9 – 14.1 mg/kg with a mean of 8.5 mg/kg, but the control points had higher concentration, 10.4 mg/kg. Roughly, nitrate levels of 2 ppm are very low and 20 ppm is considered high. The wet season values were similar to that of the dry season without significant differences. Nitrite was slightly lower than nitrate, while ammonium is several orders lower. Other anions determined included phosphate, chloride and sulphate. Being a brackish environment, chloride and sulphate are more dominant. During the dry season, chloride ranged from 124 – 156 mg/kg with a mean of 136 mg/kg, but the control was 135 mg/kg.

Significantly higher concentration was recorded during the wet season ranging from 695 – 2636 mg/kg, with a mean of 1783 mg/kg, but the control was 695 mg/kg. The increased tidal flooding might have resulted in the higher salinity during the wet season. Sulphate exhibited a similar pattern like chloride, being significantly higher during the wet season. During, the dry season, sulphate ranged from 122 – 1252 mg/kg with a mean of 446 mg/kg, while the control was 320 mg/kg. During the wet season, sulphate ranged from 1044 – 6120 mg/kg with a mean of 2808 mg/kg, whereas the control was 1522 mg/kg.

Hydrocarbon related parameters studied includes THC, TPH, PAH, BTEX and phenol. THC in the sediments during the dry season ranged from 26.9 – 83.2 mg/kg with a mean of 60.0 mg/kg, but the control was 71.6 mg/kg. The wet season THC values ranged from 58.9 – 170.6 mg/kg with a mean of 101.7 mg/kg whereas the control was 62.5 mg/kg. Notwithstanding the relatively high THC values, TPH, was significantly lower occurring in traces generally <1.0 mg/kg. This value was several orders lower than the DPR intervention value of 5000 ppm. Other hydrocarbon related parameters including BTEX, PAH and phenol similarly occurred in traces (<1 mg/kg) during both wet and dry seasons. Notwithstanding, the TOC was high ranging from 0.67 – 5.62 % (mean = 4.36 %) in the dry season and 1.68 – 5.73 % (mean = 4.51%) in the wet season. This therefore suggests that organic matter is largely responsible for the THC and not petroleum sources.

Heavy metals were also studied. Iron was the most abundant metal in the study area. During the dry season, iron ranged from 125.4 – 140.6 mg/kg with a mean of 131.8 mg/kg, but the control was 140.6 mg/kg. The wet season value was slightly higher ranging from 197.6 – 211.6 mg/kg with a mean of 207.0 mg/kg, but the control was 197.6 mg/kg. Some metals including lead, copper, manganese, and zinc occurred in the range of 20 – 30 mg/kg. Next in concentration are nickel and vanadium which occurred in the range of 1 – 19 mg/kg, while some metals such as mercury and barium occurred in traces <1 mg/kg. The texture of the sediment was determined. Sand ranged from 89.5 – 92.4 % with a mean of 90.8%, clay ranged from 4.5 – 8.4 % with a mean of 2.9 %, while silt accounted for the remainder.

SEDIMENT MICROBIOLOGY

The population of total heterotrophic bacteria (THB) during the dry season was in the range of $2.4 - 3.7 \times 10^5$ cfu/g with a mean of $2.9. \times 10^5$ cfu/g. Hydrocarbon utilizing bacteria (HUB) ranged

from $0.3 - 1.3 \times 10^3$ cfu/g with a mean of 0.6×10^3 cfu/g. At the dry season control, THB of was 2.7×10^5 cfu/g and HUB is 0.7×10^5 cfu/g. During the wet season, THB ranged from $2.0 - 3.7 \times 10^5$ cfu/g with a mean of 2.8×10^5 cfu/g. HUB ranged from $0.1 - 1.2 \times 10^3$ cfu/g with a mean of 0.6×10^3 cfu/g. Thus, the HUB accounted for <1% of the heterotrophic population, suggesting non-pollution from petroleum sources.

Predominant bacteria species isolated from the surface water include *Bacillus* sp, *Micrococcus* sp, *Pseudomonas* sp, *E. coli*, *Enterobacter* sp, *Klebsiella* sp, *Staphylococcus* sp, and *Norcardia* sp. Similarly, total fungi (TF) during the dry season ranged from $0.1 - 2.1 \times 10^5$ cfu/g with a mean of 0.8×10^5 cfu/g. Hydrocarbon utilizing fungi (HUF) population ranged from $0.1 - 0.8 \times 10^3$ cfu/g with a mean of 0.3×10^3 cfu/g. During, the wet season, TF ranged from $0.1 - 3.1 \times 10^5$ cfu/g, with a mean of 1.1×10^5 cfu/g. HUF ranged from $0.1 - 1.0 \times 10^3$ cfu/g with a mean of 0.3×10^3 cfu/g. The control station had a TF population of 0.2×10^5 cfu/g and HUF population of 0.1×10^3 cfu/g. Fungi species isolated from the study area include *Aspergillus* sp and *Penicillium* sp.

GROUNDWATER QUALITY

The results of this study have revealed that the groundwater in most part of the area is high in dissolved constituents and not suitable for drinking and other domestic purposes. Since pH values in the area show slightly acidic to slightly alkaline groundwater, polyvinyl chloride (PVC) pipes and other non-corrosive materials should be used for borehole construction in the area because acidic waters can be very aggressive. The effects of salt water intrusion in the coastal parts of the Niger Delta Sedimentary Basin are felt in this study. The high Chloride (over 250mg/l) noticed at most locations as well as High TDS and Ca/Mg are indicative of salt water encroachment in the area.

Total coliform in the dry season was in the range of 11 – 17 MPN/100ml with a mean of 14 MPN/100ml, while fecal coliform was in the range of 7 – 10 MPN/100ml. Coliform was higher during the wet season, ranging from 18 – 20 MPN/100ml, while fecal coliform ranged from 9 – 11 MPN/100ml. The control borehole water had a total coliform population of MPN/100ml and fecal coliform population of 3 MPN/100ml. During the dry season, THB ranged from $2.0 - 6.8 \times 10^4$ cfu/ml with a mean of 4.3×10^4 cfu/ml. The result obtained during the wet season was similar to that of the dry season. It ranged from $4.7 - 5.8 \times 10^4$ cfu/ml with a mean of 5.2×10^4 cfu/ml. The control is within the same order, 3.5×10^4 cfu/ml.

Hydrocarbon utilizing bacteria (HUB) during the dry season ranged from $0.4 - 1.0 \times 10^2$ cfu/ml with a mean of 0.7×10^2 cfu/ml. Thus, HUB accounted for nearly 1% of the heterotrophic population in both seasons, indicating non pollution from petroleum sources. Microbes isolated from the study area include *Staphylococcus* species, *Alcaligenes* sp, *Enterobacter aerogenes*, *Citrobacter freundii*, and *Micrococcus* sp. The population of total fungi (TF) in the wet and dry seasons were in the order of 10^4 cfu/ml, whereas hydrocarbon utilizing fungi (HUF) was scanty and virtually absent in the dry season, but it is generally in the order of 10^2 cfu/ml in the wet season. Fungi species isolated from the study area include *Aspergillus flavus*, *Aspergillus clavatus*, *Penicillium* sp.

HYDROBIOLOGY

The ecological aspect of this study includes phytoplankton, zooplankton, macroinvertebrates and fisheries study. The area is rich in plankton; 38 taxa of phytoplankton (distributed into five divisions, the Bacillariophyta (diatoms), Dinophyta (dinoflagellates) Chlorophyta (green algae) and Euglenophyta); 29 taxa of zooplankton with Cladocera dominating, 25 benthic taxa, distributed into three phyla (Annelida, Arthropoda and Mollusca). Common fin fishes in the area include but not limited to *Sarotherodon galilea*, *Ethmalosa fimbriata*, *Chrysichthys* sp; while the shell fish in this area are mainly shrimps of the genera *Panaeus* and *Macrobrachium*.

VEGETATION

The vegetation cover of the study area is influenced by the topography: Otumara is closer to the coastline and on a much lower terrain than Escravos. A total of 56 Species belonging to 34 families were encountered. Four basic kinds of vegetation cover are present - Salt Marsh, Fresh water, Mangrove swamp and Phoenix swamp, but the Salt Marsh was most prominent in Otumara. The marsh is a mosaic of the low and high salt marsh interspersed by bare salt flats. The three kinds of red Mangrove vegetation are present, while several sub types of the fresh water swamp forest were identified based on species dominance patterns. Dominant species of the Salt Marsh ecosystem include *Paspalum vaginatum*, *Acrostichum aureum*, and *Avicennia germinans*. Phoenix swamp had *Phoenix reclinata*, *Avicennia germinans*, *Elaeis guineensis*; Mangrove swamp, *Rhizophora racemosa*, *Rhizophora harrisonii*, and *Rhizophora mangle*, and the Fresh water swamp – *Fleroya ledermanii*, *Alstonia boonei*, *Anthocleista djalensis*.

The vegetation cover is affected by dredging and dumping of spoils along the numerous slots at Otumara. There is no widespread disease condition; only pockets of infections as are expected in plant communities. Phytochemistry reveals that the level of heavy metal in the leaves of plants sampled across the study area. Heavy metal pollutants of concern include Cadmium, Nickel, Copper, and Zinc. Among the projects to be carried out, the proposed 44-bed field logistics base at Otumara, on a 200m x 100m area of high marsh – mud flat mosaic, along with its associated dredging for land fill, is of major concern having the potential to greatly disturb the ecosystem.

Generally, any dredging activity by Oil and gas companies should strongly be avoided in the interest of the very sensitive ecosystem especially as it affects Otumara. The presence of Oil and gas exploratory activities in the area is remotely responsible for the uncontrolled lumbering of red mangrove. While crude oil bunkering activities should be discouraged, the eradication of illegal refineries in the Saghara/Otumara axis, by the Military, should be done with regard for the integrity of the ecosystem. Finally, environmental management and monitoring plan should include the eradication of the invasive *Nypa* palm.

WILDLIFE

Otumara field is in a protected area. The wildlife diversity and distribution pattern observed in the Otumara field reflects the uniqueness of this area in terms of terrain and vegetation cover. The wildlife composition and species diversity in the Otumara area is low. This is traceable to the predominance of the High and low salt marsh in the Otumara axis which does not support land animals; hence the predominance of amphibians generally. Amongst the reptiles, the slender

snouted crocodile, the African dwarf Crocodile and python species were common across the entire area. There are fewer snakes in Otumara. The Mona monkey was the only species reported in the Otumara node.

GEOLOGY AND GEOMORPHOLOGY

The study area (Otumara) is part of the geologic sequence of the Quaternary and Tertiary formations of the Niger Delta consisting of three main geological formations – the Benin formation (the topmost unit), the Agbada and the basal unit, the Akata formations. Lithological units of the study area are generally composed of sands, silty sands and clays.

The land surface of the study area is characterized by low lying plains typical of the modern Niger Delta. These plains have swamps that are commonly flooded during the peak of the rainy season. The area slopes imperceptibly in the south direction towards the Atlantic Ocean and is drained by a network of Escravos River and the adjoining creeks, mangrove swamps, marshes and slots.

Three new boreholes were drilled. The drilled wells penetrated only a fraction of the total aquifer thickness, the maximum depth being 15m. The deposits encountered during the drilling, consist of clay and silty sand on the surface and silt to sand at the subsurface. The topsoil is mostly dark, averaging about 1m in thickness with highly porous sand underlain. The ground water flow direction is southerly towards the Escravos River and the adjoining creeks.

GROUNDWATER QUALITY

The results of this study have revealed that the groundwater in most part of the area is high in dissolved constituents and not suitable for drinking and other domestic purposes. Since pH values in the area show slightly acidic to slightly alkaline groundwater, polyvinyl chloride (PVC) pipes and other non-corrosive materials should be used for borehole construction in the area because acidic waters can be very aggressive.

The effects of salt water intrusion in the coastal parts of the Niger Delta Sedimentary Basin are felt in this study. The high Chloride (over 250mg/l) noticed at most locations as well as High TDS and Ca/Mg are indicative of salt water encroachment in the area.

SOCIAL IMPACT ASSESSMENT

Ugborodo, Ugbeogugun and Deghele are the three major host communities. With the exception of a few migrants of Yoruba, Ilaje, Urhobo, Isoko and Ijaw origin living along dotted settlements in the area, the Itsekiris are the landowners and major ethnic group in the project environment. The settlement pattern of the habitations in the area is rural nucleated cluster type, many also characteristically nodal, established along water courses (rivers, creeks and creeklets). Christianity is predominantly practised but the residents still have strong affinity to their traditional customs, beliefs and culture religious beliefs. Governance system is typical of well developed hierarchical structure that is gender and age sensitive, which have in-built mechanism to provide social cohesion, security and conflict prevention and resolution.

The population of the communities shows a skewed distribution in favour of lower age-cohorts of persons below 18 years old, with child dependency ratio of 31.23%, disaggregated into 16.37% (males) and 14.86% (females) and old age dependency of 5.06%. The sex-ratio is approximately 2:1 with a modal educational level of primary school attainment.

The modal educational attainment amongst the population in the communities is primary educational level. About 67% of the sampled population have post primary education and 10% have some forms of tertiary education. The local economy was consistently dominated by fishing, farming and petty trading that generated daily income levels just enough to cover household daily expenditure requirements; typical of the occupational status of rural fishing communities of Niger Delta region. The general quality of life measured in terms of housing types, productive and household asset ownership, and presence of functional social infrastructure in the communities was noted to be very low, suggesting high level of poverty among the residents of the communities.

Perception rating concerning the proposed project showed fairly low fears with respect to impact on health and environment; and high level of expectations of improved local economies and provision of quality and functional social infrastructures in the communities.

HEALTH IMPACT ASSESSMENT

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

Most members of the project communities were able to meet their total daily per capita water requirement albeit mainly from a variety of potentially contaminated surface sources. Tanker supply by SPDC, and sachet water were the main sources of drinking water. Significant health threat is associated with the use contaminated surface water source. In addition, surface water bodies provide favourable breeding grounds for vectors of important diseases including Malaria, Filariasis and Schistosomiasis. Regrettably, underground water sources in some of the communities were salty and showed evidence of faecal contamination.

Extensive faecal contamination of water bodies in the project communities is not surprising considering that the jetty or over-hung toilets that discharge faeces directly to surface water is the predominant method of faecal disposal. Access to adequate quantities of potable water is therefore a challenge in the project communities. Increase in population that may arise as a consequence of the project may further compromise access to potable water. The concentrations of suspended particulate matter (SPM) in the ambient air of the study communities were significantly lower than the Federal Ministry of Environment's stipulated limit. The Otumara AGS project should contribute significantly to better air quality when the flare out is achieved.

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

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

CONSULTATION PROGRAMME

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

ES13: ASSOCIATED AND POTENTIAL ENVIRONMENTAL IMPACTS

The identified phases of the Otumara AGS Project were divided into Premobilization/Mobilization, Construction, Commissioning, Operation, Maintenance and decommissioning/ abandonment. The Pre-mobilization and Mobilization Phase included the following activities land acquisition, land survey, Right of Way clearance, tree felling/destumping, civil works, facility construction, dredging/sweeping, piling and dredge waste disposal. Activities in Construction Phase included pipeline/bulkline construction, laying of optic fiber cables, Trenching and backfilling, welding, NDT testing, Coating/Wrapping, Hydrostatic testing, River crossing, waste/Spoil disposal, Community electrification, transportation of Modules and equipment, water transportation, CPF Installation and FLB construction, installation, tie- in and precommissioning of facilities and un loading and installation of CPF/Modules. Operation phase included the following activities commissioning, maintenance and Pigging while activities during the decommissioning and abandonment included cutting/Lifting, waste disposal and Restoration.

Potential Impacts during Premobilization/Mobilization phase

Significant negative impacts arising from the Premobilization/Mobilization phase include the increase of water related diseases due to poor sanitation practices when more pressure is put on already poor state of housing. Other impacts include loss of vegetation through cutting of line traces, increased erosion potential due to removal of vegetation canopies and road paving loss of economic trees and ecologically important vegetation (mangroves and rain forests), loss of habitats for wildlife, loss of farmlands, fishponds and gin distilleries and shrines along the pipeline routes. Other negative impacts in this phase will include Increase in cases of sexually transmitted disease and other disease strains resulting from migrant workers and accidents to workers especially for local labour not sufficiently skilled for the type of work.

Piling during this phase may result in impairment of hearing due to noise and vibrations. Dredging will lead to increased levels of suspended solids in water, shoreline erosion, disturbance of riverbed topography and re-suspension of fine sediments and bottom materials. Other impacts from dredging will include disaggregation of benthic habitat, loss of benthic organisms and loss of juvenile fishes due to gill damage from silt particles. Dredge Spoil disposal will smother epifauna and impair surface drainage especially in wetland areas and cause pollution of drinking water sources when domestic waste is discharged directly into the river. Significant positive impacts were income to local workers that may be employed for the bush clearing activities, improved quality of life resulting from increased project spending which will stimulate economic activity in the area and increased infrastructures in the communities as part of the projects' CD initiatives.

Potential Impacts during Construction phase

Significant negative impacts during the construction phase will include production of intertidal swamps, which will increase surface water sediment loading and suspended solids. Other negative impacts will include irreversible soil compaction which may alter the topography of the RoW and salt water intrusion into ground water, through ELPS (hydraulic seepage around the circumference of the pipe). Exposure to radioactivity and release of chemicals, impairment of vision, improper disposal of lay barge deck drainage will contaminate surface water and sediment. Discharge of untreated hydrotest water into the receiving environment, disaggregation of benthic habitats resulting in loss of benthic organisms, shoreline erosion and improper disposal of backfill residue will alter the morphology of the area and impede drainage

Water related disease might increase due to poorer sanitation practices when more pressure is put on already poor state of housing. Increase in cases of sexually transmitted disease (HIV AIDS) and other disease strains may result through migrant workers. The size and number of barges conveying equipment, materials & personnel and the associated waves may endanger small canoes/boats and curtail fishing activities. Welding activities will release toxic fumes, contamination of water may result from the use of paints, corrosion inhibitor, leaks and spills of diesel fuel and lubricants into water.

Significant positive impacts in this phase will include increased income to local workers increased project spend which will stimulate economic activity in the area construction of more

infrastructures in the communities as part of the projects' CD initiatives giving rise to improved socio-economic activities.

Potential Impacts during Operation and Maintenance phase

Significant negative impacts from operation and maintenance phase will include the discharge of untreated effluents from flow stations /CPF into water, leaks and spills of TEG during storage handling and decanting. Others will include disposal of domestic wastewater and sewage from the logistic centre and domestic and industrial solids from the logistic centre.

Potential Impacts during decommissioning/abandonment phase

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

ES14: MITIGATION MEASURES

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

Mitigation Measures for Premobilization/mobilization Phase

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

Other actions include organising awareness session on communicable diseases related to water and sexual behaviour such as HIV/AIDS awareness sessions, ensure the provision and enforcement of the use of appropriate PPEs on site provision of adequate First Aid and functional medevac system on site, ensure that approved detailed Job Hazard Analysis (JHA) is provided by the contractor and that all the controls and barriers are adhered to and ensuring that daily tool box meetings are held. Others include the use of silt curtains to prevent migration of plant matter, debris treatment of all waste water to DPR standards prior disposal, provision of mobile toilets for its work-force regularly monitoring of the quality of effluent to ensure that it meets regulatory standards, the adherence to its waste management procedure carry-out shore protection in areas susceptible to shoreline erosion, use sheet piling of the area affected use the suction dredging to minimize

disturbance to riverbed topography, deploy the most appropriate silt curtains, to minimize loss of benthic organisms adherence to journey management guidelines and sensitization of boat captains, use suction dredging and silt curtain to reduce turbidity, limit widening of Otumara creek or any other creek to be used for Barge movement,, to a width that will cause minimal shoreline erosion.

Other activities include ensuring that dredge spoil is deposited at least 10 metres into the buffer zone or Cap spoil with clean sand, ensure no hydraulic connection between the sea and the coastal forest by using cofferdams and sheet piling for the shoreline approach ensure proper scheduling of supply boat movements so as not to interfere significantly with artisanal fishing and commercial boat activities, ensure proper scheduling of supply boat movements so as not to interfere significantly with artisanal fishing and commercial boat activities, consult with the relevant Local Government and give adequate notice to the communities, of impending work and route plan, Institute good marine journey management system in-line with SPDC policy, enforce the use of appropriate PPE, dispose dredge spoils in an environmentally-friendly manner.

Mitigation Measures for Construction Phase

Mitigative actions for the activities during construction phase include some of the actions mentioned during the premobilization/mobilization phase. Others for this phase include the use low pressure tracked equipment for construction, provision of radiation counter to workers for monitoring individual radiation levels, ensure that the activities are carried out in accordance with standard procedures ensure waste management specifications and guidelines (especially with regards to the discharges into the environment) shall be complied with, ensure minimal disturbance to the river bed during pipeline crossing, ensure that appropriate containment (drip pans) and clean up procedures are adopted, incorporate into the design and install in TEG plant, an auto transfer device for charging and topping of the glycol and install glycol plant without the initial charge, and thereafter fill in glycol charge and ensure best engineering of pipeline design, construction and installation. Automatic leak detection facilities shall be installed for pipelines.

Mitigation Measures for Operation Phase

Mitigative actions for this phase may include some of the actions discussed during the premobilization/mobilization and construction phases. Other actions shall include the provision of effluent and waste water treatment facilities of adequate capacity, treatment of effluent to DPR standards prior discharge at the Otumara logistics Base, establishment of effective gas leak monitoring programme for the pipelines and regular audit of waste management practices of the contractor, recovery of dumped wastes as much as possible, and vigorously adhering to SPDC waste management practices.

Mitigation Measures for Decommissioning/ Abandonment Phase

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

ES15: ENVIRONMENTAL MANAGEMENT PLAN

The Environmental Management Plan (EMP) provides a delivery mechanism to address significant negative impacts, enhance project benefits, deliver on commitments made publicly in the EIA and introduce standards of good practice to be adopted for all project works. The EMP also addressed the conditions for which the EIA was approved. The plan is a document covering all aspects of the Otumara AGS Project. The EMP lists actions to ensure effective mitigation of potential environmental, social and health impacts (identified in the EIA), action parties, parameters to be monitored and frequency. In sections 5 of the ES potential impacts resulting from all the activities of the various phases have been enumerated. In section 6 mitigation actions have been proposed. Thus what are left are parameters/methods for monitoring, monitoring frequencies and responsible parties. These are included in Table 7.1.

Parameters/methods for monitoring include, site inspection reports, monthly and quarterly compliance monitoring reports, security plans/reports, community engagement records/ reports, compensation records/reports, employment records, contractor records, Project Memorandum of Understanding (PMoU) records, Sessions on health awareness, with records, records of daily tool box meetings, Job Hazard Analyses Records, evidence of functional MEDEVAC procedures, Safety plans/records and Impact Mitigation Exercises both conducted internally (by SPDC) and externally by the regulators. Monitoring frequency may range from daily such as tool box meetings/pep talks to yearly IMM. The responsible parties are SPDC personnel (Project Manager, Project Engineer, Environmental Adviser and HSE adviser) and the regulators.

ES16: CONCLUSIONS AND RECOMMENDATION

The results of the study showed that the air quality of Otumara field will substantially improve as a result of Mothballing of the Flowstation. Thus, the project will enhance air quality and reduce Nigeria's contribution to global warming potential.

All construction activities will take place on the existing RoW, hence no additional land will be required. Since no dredging is involved, the ecology of the project area will not be significantly compromised. The project will provide employment opportunities for young people during all phases of the development. The extension of electric power to the communities will enhance socioeconomic activities in the project area.

Based on the foregoing, we pray that this EIA Report be approved for implementation.

CHAPTER ONE INTRODUCTION

1.1: Background

The Shell Petroleum Development Company of Nigeria Limited (SPDC), on behalf of the Joint Venture partners (Nigerian National Petroleum Corporation, Nigerian Agip Oil Company, and Total), plans to embark on the Otumara Node (Otumara & Saghara flow stations) Associated Gas Solution (AGS) Project to meet the business objectives of Domestic Gas supply and gas flares down by 2014. At present, produced AG is currently used as fuel gas for the pumps and generators, for lift gas, and the excess flared. The proposed project is mainly a facility upgrade of the existing Otumara flowstation through the installation of new facilities in order to harvest AG from the Otumara field in Delta State of Nigeria (Figs. 1.1 and 1.2).

The SPDC Business Plan 2005 (BP05) forecast for Otumara showed that substantial Further Oil Development (FOD) activities may commence in the field as early as 2009, and will need disposal of AG and probably more lift gas. In view of this, it is considered that a pre-investment in AG pipeline from Otumara to Escravos beach will be required, by installing a 12''x 12 km pipeline to the Nigerian Gas Company manifold at Escravos beach to accommodate 30 mmscf/day. Future re-development will also require the retention of the existing 15 mmscf/d gas lift compressor.

The new facilities/activities at the Otumara flowstation are;

- Otumara Central Processing Facility (CPF) of 20 mmscf/d nominal capacity;
- Gas processing Module- Nominal 30 mmscf/day;
- Gas Compression - Nominal 20 mmscf/day;
- Power generation/utility modules- Circa 6.5 MW ISO;
- Flare systems relief;
- Blow down systems;
- Modifications and tie-ins to integrate the new facilities;
- Site preparation and civil works including all dredging, piling and shoring works;
- Design, construction and commissioning of a 44-bed FLB;
- Decommission, preserve and mothball Saghara flow station, and convert to a free-flow manifold; and
- Community electrification

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

1.2: Objectives of the EIA

The objectives of the EIA are to:

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

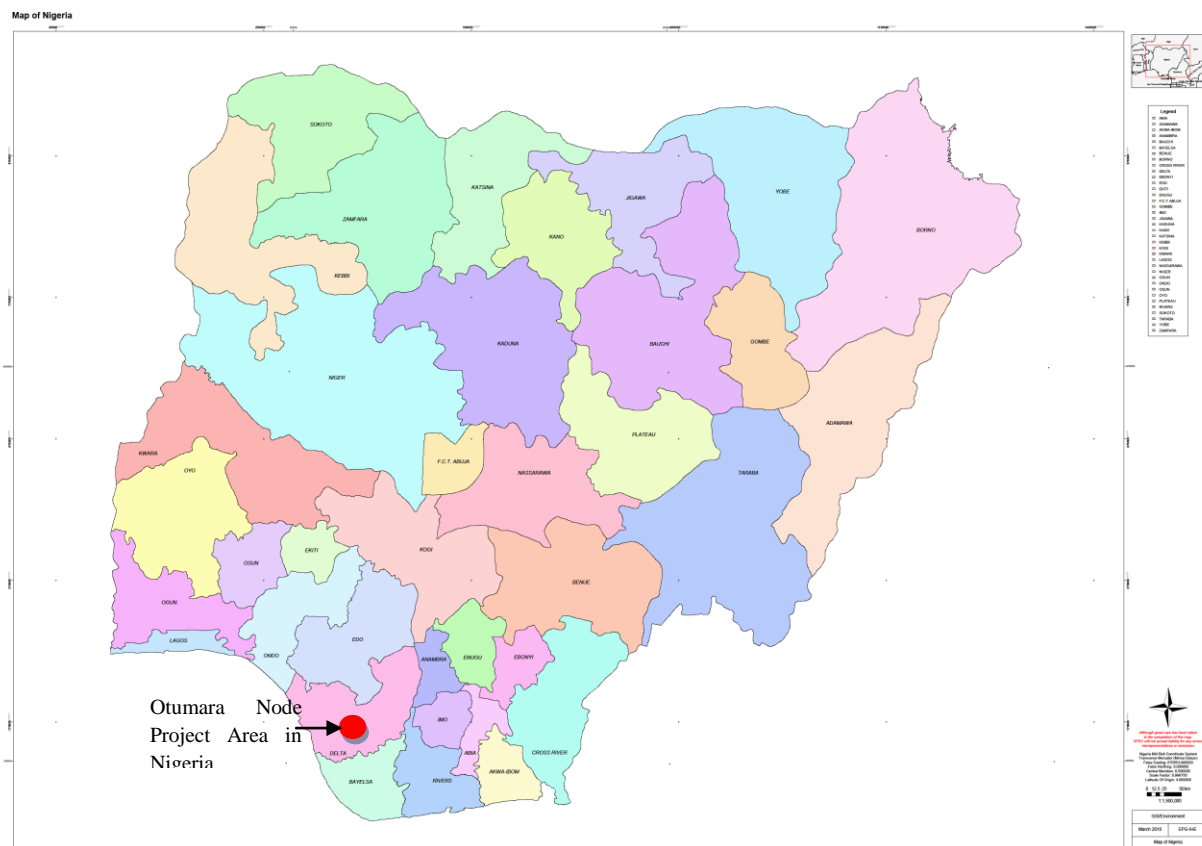


Fig. 1.1: Map of Nigeria Showing Otumara Project Area.

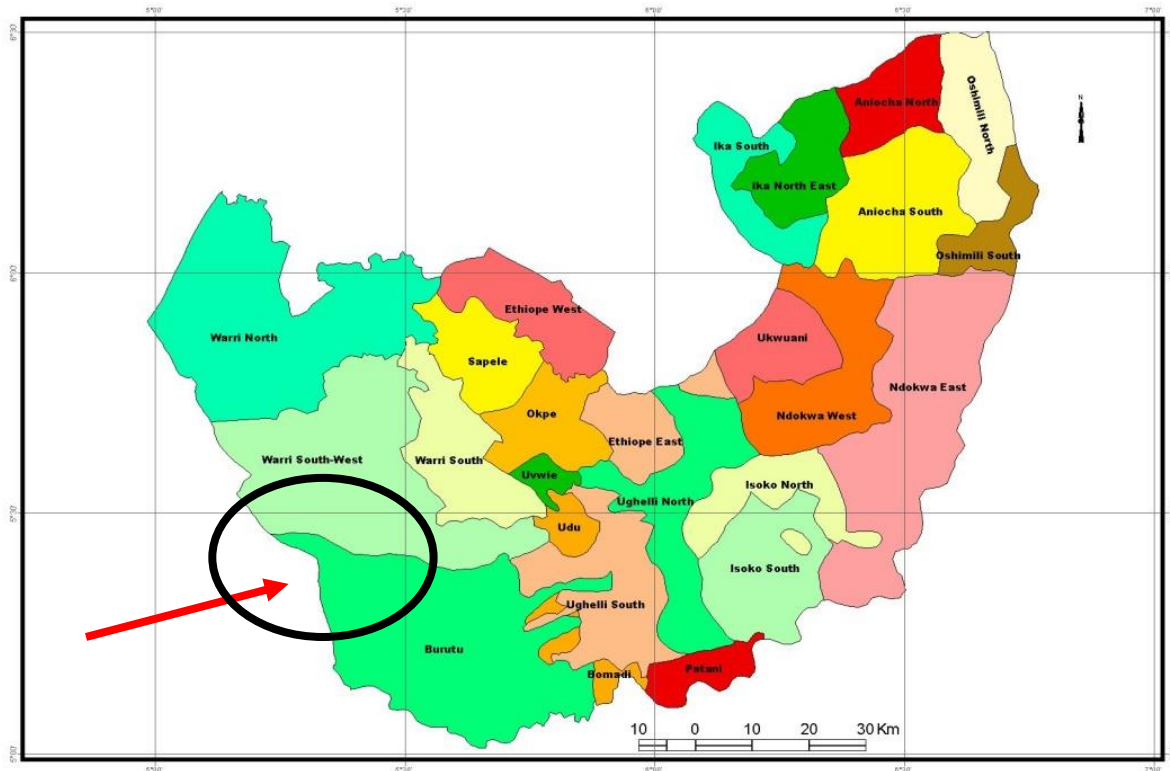


Fig. 1.2: Map of Delta State showing Otumara AG Solution Project Area

1.3: The Project

The new facilities for installation at the Otumara flowstation in order to handle the associated gas currently being flared and convert it to economic use are: High Pressure Associated Gas compressor, Low temperature separation vessel, TEG dehydration system and electric power generator. The estimated land coverage for the new facility is about 100 square meters within the existing Otumara flow station area on a swamp-piled foundation. As part of the Otumara flowstation upgrade, a 12''x12 km gas pipeline with pigging facilities would also be constructed using existing SPDC pipeline Right of Way (RoW).

Project also involves the design, supply, construction and commissioning of a 44-room Field Logistics Base (for staff accommodation) at Otumara. The estimated land coverage for the new FLB is about 150 m x 250 m. The land shall be sand-filled, and a community electrification project will be embarked upon.

Project Premises

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

1.4: Legal and Administrative Framework

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

1.4.1: Legislations guiding Environmental management in Nigeria

The Mineral Oil (Safety) Regulations, 1963

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

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

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

Petroleum (Drilling and Production) Regulations (1969)

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

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

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

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

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

format as required by FMEnv. The guidelines are intended to assist in the proper and detailed execution of EIA studies of projects in consonance with the EIA Act.

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

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

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

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

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

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

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

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

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

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

Nigeria's National Agenda 21 was developed to:

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

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

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

Forestry Law CAP 51, 1994

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

Land Use Act of 1978

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

National Inland Waterways Authority Act No 13 of 1997

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

Nigerian Ports Authority Act No 38 of 1999

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

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

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

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

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

The National Environmental Standards and Regulations Enforcement Agency (NESREA) was established as a parastatal of the Federal Ministry of Environment. NESREA is charged with

the responsibility of enforcing all environmental laws, guidelines, policies, standards and regulations in Nigeria.

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

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

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

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

1.4.2: Legislations guiding Environmental management in Delta State

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

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

Delta State Environmental Protection Agency Edict No 5 of 1997

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

Delta State Ecology Law, 2006

The law empowers the Delta State Ministry of Environment with the responsibility of protecting the environment in order to achieve sustainable environmental development in the State .It empowers the Ministry with the statutory responsibility of handling environmental pollution cases. It liaises with oil companies on pollution matters. It enables, the Ministry to participate in the management of oil spills in the State .It empowers the Ministry to be an integral part of the Joint Investigation team (JIV) that investigates the causes of oil spills;

carrying out assessment of damage to the environment, property, health and assessment of the ecological damage to the marine and terrestrial habitat as well as vegetation and ecosystem. The law also empowers the Ministry to handle flood and erosion cases.

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

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

Delta State Revenue Edict, 1997

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

Delta State Waste Management Law, 2004

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

Delta State Internal Revenue Consolidation Law, 2009

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

1.4.3: International Laws and Regulation

s

Nigeria is signatory to several laws, treaties and regulations that govern the environment.

Among these are:

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

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

The World Bank requires the execution of an EIA on a proposed industrial activity by a borrower as a pre-requisite for granting any financial assistance in form of loans. Details of

World Bank's EIA procedures and guidelines are published in the Bank's EA Source Book vols. I - III of 1991. Potential issues considered for EA in the upstream oil and gas industry include the following:

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

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

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

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

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

Convention on Biological Diversity

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

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

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

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

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

United Nations Framework Convention on Climate Change (1992)

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

and socially beneficial, determined to protect the climate system for present and future generations.

1.4.4: SPDC Policies and Principles

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

(a) Business Principles

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

(b) Governing Policies

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

(c) HSE Policy

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

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

The implications of implementing this policy are that,

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

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

(d) Environmental Assessment Policy (1998)

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

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

The implications of implementing the policy are:

- The environmental impact of all new activities or developments shall be thoroughly evaluated and the necessary preventive measures implemented,
- An Environmental Impact Assessment (EIA) shall be carried out for each new project or activity,
- Seismic Acquisition Field Development and Operations Reference Plans, shall include the recommendations of the EIA,
- The environmental impact of each operation shall be routinely monitored and corrective actions taken as necessary.
- All practical and reasonable measures shall be taken to minimize the generation of waste and to manage and dispose of unavoidable wastes in an environmentally acceptable manner,
- Waste Management plans shall catalogue waste identifications, quantification and appropriate disposal methods,
- Waste streams shall be monitored and recorded and efforts taken to progressively reduce emission or discharge of waste known to have negative impact on the environment with the eventual aim of eliminating them,
- Waste records shall cover the full life-cycle of each stream and shall provide an auditable trail as to its management and disposal,
- Past polluted sites shall be investigated and practical and efficient measures put in place to rehabilitate them,
- Chemicals shall only be used where operationally necessary only after justification with a balanced management decision. In selecting chemicals for use, the HSE

aspects shall be considered together with commercial and process performance attributes with the aim of choosing the least harmful,

- All chemicals shall be transported, stored, used and disposed of in accordance with statutory requirements and in a safe and environmentally acceptable manner.
- No new chemical shall be accepted from a supplier without the appropriate Material Safety Data Sheet (MSDS),
- All chemicals shall be covered with Safe Handling of Chemicals (SHOC) cards, and shall be acquired, transported, used and disposed of in compliance with the Department of Petroleum Resources (DPR), Federal Ministry of Environment (FMEnv) and SPDC regulations,
- All chemical handlers shall be specifically trained in the safe handling of chemicals.
- All hydrocarbon and chemical spills in the vicinity of the Company's operations shall be cleaned up in a timely and efficient manner,
- Resources shall be provided and contingency plans drawn up to respond to spills in a timely manner,
- Where the cause of the spill is unknown then the Company shall still effect the clean up and recoup costs at a later date.

(e) SCiN Biodiversity Policy

‘In Shell, we recognise the importance of biodiversity.

Therefore, we are committed to:

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

(f) Waste Management Policy

It is the policy of SPDC to:

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

Other considerations, including:

- Societal Expectations;
- Government Relations;
- Joint Venture Partner Relations;

- Sustainable Community Development;
- Land Acquisition and Compensation;
- Media Relations; etc. are based on SPDC Corporate Policies – 2000.

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

1.5: Declaration

SPDC in its capacity as the operator of the NNPC/Shell/Total/NAOC Joint Venture, and on behalf of her partners, hereby declares her intention to abide by the existing international and national laws and regulations regarding environmental protection during the facility upgrade of the Otumara flowstation and construction of 12" x 17 km gas pipeline from Otumara to the ELPS at Escravos for the Otumara Field Associated Gas (AG) Solutions project. SPDC management is committed to the implementation of the Environmental Management Plan (EMP) proposed in this EIA report. SPDC hereby declares that it has prepared this EIA report using the best available expertise in personnel, equipment, and internationally acceptable methods.

1.6: Structure of this EIA Report

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

1.7: Terms of Reference

SPDC commissioned this EIA of the proposed Otumara Field Associated GAS (AG) Solution project in order to comply with statutory requirements. The EIA will establish the

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

EIA Scope

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

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

- Natural/Biophysical Environment
- Social Environment
- Health Environment

The detailed scope of the baseline data acquisition was:

Biophysical

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

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

Social

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

Health

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

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

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

| Environmental Component | Environmental Aspect | Data Acquisition | Potential Environmental Impact Indicator |
|-----------------------------------------|-----------------------------------------|--------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Climate/ Meteorology | Microclimate/Regional Climatic features | <i>In situ</i> measurement, secondary data | Temperature, Rainfall, Relative humidity, Wind direction and speed, visibility, cloud cover and their local effects. |
| Air Quality | Local and Regional | <i>In situ</i> / laboratory analysis | Particulate, NO _x , SO _x , CO ₂ , CO, VOCs, H ₂ S Heavy metals (Fe, Cd, Cr, Pb, Ni, V, Zn) |
| Noise | Local | <i>In situ</i> measurement | Ambient noise level dB(A), communication interference. |
| Surface Water /Sediment Characteristics | Hydrology/ Hydrodynamics | <i>In situ</i> /secondary data | River depth, width, flow direction, flow rate, current/tidal information, drainage characteristic, sediment transport, river bank erosion |
| | Physicochemical Features | <i>In situ</i> measurements, Composite samples for laboratory analysis | Colour, alkalinity, TDS, TSS, Turbidity, EC, THC, pH, DO, Redox potential, BOD ₅ , COD, Oil & Grease, Anions/Cations, NH ₄ ⁺ , NO ₃ ⁻ , NO ₂ ⁻ , PO ₄ ³⁻ , SO ₄ ²⁻ , SiO ₂ , Na ⁺ , K ⁺ , Ca ²⁺ , Mn ²⁺ , Mg ²⁺ . Heavy metals (Fe, Cd, Cr, Ni, V, Pb, Zn, Hg). |
| | Hydrobiology | Composite samples for laboratory analysis | Species composition, distribution, diversity and abundance and seasonality of Phytoplankton, Zooplankton, Benthos, Aquatic macrophytes, Macrophyte-associated macrofauna |
| Surface Water /Sediment Characteristics | Fisheries | Direct observations/interviews, <i>In situ</i> measurements, composite samples for laboratory analysis | Species composition, catch-composition, Fisheries activities (including aquaculture) catch-per-unit of effort and price, fishing gears/methods, population in fisheries, spawning grounds, migration routes and |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| Environmental Component | Environmental Aspect | Data Acquisition | Potential Environmental Impact Indicator |
|------------------------------|------------------------------|----------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | | | patterns, productivity and pathology, Population of Fisher- Folks Proportion of male/female, Adult/Children etc |
| | Microbiology (surface water) | Composite samples for laboratory analysis | Total heterotrophic bacteria, fungi, Total hydrocarbon utilizing bacteria and fungi, total and faecal coliforms. |
| | Sediments | Composite grab samples for laboratory analysis | Colour, Texture, Temperature, pH, Redox potential, THC, Oil & Grease , Sediment geochemistry (Fe, Ni, V, Cd, Cr, Hg etc.), Sediment microbiology |
| | Water Use | Direct observation/ interviews | Traditional use of rivers and water bodies (navigation, sand mining, food processing, aquaculture, domestic etc) |
| Ground Water Characteristics | Physicochemical Features | <i>In situ</i> / laboratory analysis | Colour, odour, alkalinity, TDS, TSS, Turbidity, EC, THC, DO, pH, Redox potential, BOD ₅ , COD, Oil & Grease, Anions/Cations, NH ₄ ⁺ , NO ₃ , NO ₂ , PO ₄ , SO ₄ , SiO ₂ , Na, K, Ca, Mn, Mg, Heavy metals (Fe, Cd, Cr, Ni, V, Pb, Zn, Hg). |
| | Microbiology | Composite samples for laboratory analysis | Total heterotrophic bacteria, fungi, Total hydrocarbon utilising bacteria and fungi, total and faecal coliforms. |
| | Groundwater dynamics | <i>In situ</i> | Static Water Level (SWL), Flow direction/ Flow Rate. |
| Soil | Physical characteristics | In situ/ composite auger samples for lab analysis, Soil profile pits | Permeability, porosity, bulk density, texture (grain size), colour, |
| | Chemical characteristics | Composite samples for laboratory analysis | pH, anion, cation and cation exchange capacity (CEC), THC, heavy metals, Soil |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| Environmental Component | Environmental Aspect | Data Acquisition | Potential Environmental Impact Indicator |
|-------------------------------------------------------|----------------------|------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | | | capability |
| | Soil microbiology | Composite samples for laboratory analysis | Total heterotrophic bacteria, fungi, Total hydrocarbon bacteria and fungi, total and faecal coliforms |
| Biodiversity Status & issues relevant to biodiversity | Wildlife | Transect, direct observation, interviews, secondary data sources | Species composition/distribution, Information of level of hunting, seasonality, exploitation methods/level (kill rates/month/year, estimates of wildlife population etc). IUCN categorisation |
| | Vegetation | Transect, herbarium studies, tissue analysis | Vegetation map of locality, Land use, Quantification of different vegetation types, area cover, Habitat status, floral composition, density and distribution, vegetation structure, plant pathology |
| | Conservation | <i>In situ</i> observation, interviews, secondary data | Conservation status (rare, threatened and endangered species), conservation areas (forest reserves etc), environmentally sensitive areas – wetlands and swamps), local conservation practices. |

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

| Environmental Component | Environmental Aspect | Data Acquisition | Potential Environmental Impact Indicator |
|-------------------------------|-----------------------------------------|------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Climate/ Meteorology | Microclimate/Regional Climatic features | <i>In situ</i> measurement, secondary data | Temperature, Rainfall, Relative humidity, Wind direction and speed, visibility, cloud cover, sun shine duration and their local effects. |
| Air Quality | Local and Regional | <i>In situ</i> / laboratory analysis | Particulate, NO _x , SO _x , CO ₂ , CO, VOC, H ₂ S, BTEX Heavy metals (As, Fe, Cd, Cr, Pb, Ni, V, Zn) |
| Noise | Local | <i>In situ</i> measurement | Ambient noise level dB(A), communication interference. |
| Surface Water Characteristics | Hydrology/ Hydrodynamics | <i>In situ</i> /secondary data | River depth, width, flow direction, flow rate, current/tidal information, Drainage characteristic, sediment transport, river bank erosion |
| | Physicochemical Features | <i>In situ</i> measurements, Composite samples for laboratory analysis | Colour, Total alkalinity, carbonate alkalinity, Total hardness, TDS, TSS, Turbidity, EC, pH, salinity, DO, , BOD ₅ , COD, Oil & Grease, TOC, THC, TPH, Phenol, H ₂ S, NH ₃ , SiO ₂ , Anions/Cations, (NO ₃ ⁻ , NO ₂ ⁻ , PO ₄ ³⁻ , SO ₄ ²⁻ , CN ⁻ Ca ²⁺ , Mg ²⁺ , Mn ²⁺), Heavy metals (Fe, Ba, Cd, Cr, Cu, Ni, V, Pb, Zn, Hg). |
| | Hydrobiology | Composite samples for laboratory analysis | Species composition, distribution, diversity and abundance of Phytoplankton, Zooplankton, Aquatic macrophytes, Macrophyte-associated macrofauna |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| Environmental Component | Environmental Aspect | Data Acquisition | Potential Environmental Impact Indicator |
|-------------------------------|-------------------------------|--------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Surface Water Characteristics | Fisheries | Direct observations/interviews, <i>In situ</i> measurements, composite samples for laboratory analysis | Species composition, catch-composition, Fisheries activities (including aquaculture) catch-per-unit of effort and price, fishing gears/methods, population in fisheries, spawning grounds, migration routes and patterns, productivity and pathology. |
| | Microbiology (surface water) | Composite samples for laboratory analysis | Total heterotrophic bacteria & fungi, Total hydrocarbon utilizing bacteria & fungi, total bacterial count, total and faecal coliforms. |
| | Sediments | Composite grab samples for laboratory analysis | Colour, Texture, pH, Redox potential, TOC, Available PO ₄ -P, Total-N, Oil & grease, THC, TPH, heavy metals (Fe, Ni, V, Ba, Cd, Cr, Mn, Cu, Pb, Zn, Hg, etc.), |
| | Sediment Biology/Microbiology | Composite grab samples for laboratory analysis | Species composition, distribution, diversity and abundance of Benthos, Total heterotrophic bacteria & fungi, Total hydrocarbon utilizing bacteria & fungi. |
| | Water Use | Direct observation/ interviews | Traditional use of rivers and water bodies (navigation, sand mining, food processing, aquaculture, domestic, potable etc) |
| Groundwater Characteristics | Physicochemical Features | <i>In situ</i> / laboratory analysis | Temperature, colour, total alkalinity, carbonate, Hardness, TDS, TSS, Turbidity, EC, DO, pH, BOD ₅ , COD, H ₂ S, Oil & Grease, THC, TPH, PAHs, TOC, Phenol, NH ₃ , Anions/Cations, (Cl ⁻ , NO ₃ ⁻ , NO ₂ ⁻ , PO ₄ ³⁻ , SO ₄ ²⁻ , CN ⁻ , Ca ²⁺ , Mg ²⁺), Heavy metals (As, Fe, Ba, Cd, Cr, Cu, Ni, Mn, V, Pb, Zn, Hg). |
| | Microbiology | Composite samples for laboratory analysis | Total heterotrophic bacteria, fungi, Total hydrocarbon utilising bacteria and fungi, total bacterial count, total and faecal |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| Environmental Component | Environmental Aspect | Data Acquisition | Potential Environmental Impact Indicator |
|-------------------------------------------------------|--------------------------|----------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | | | coliforms. |
| | Groundwater dynamics | <i>In situ</i> | Static Water Level (SWL), Flow direction/ Flow Rate. |
| | Hydrogeology | Laboratory analysis, secondary data sources | Stratigraphy, Aquifer characteristics |
| Geology | Local and Regional | Secondary data, laboratory analysis | Regional geology, Stratigraphic / Lithologic properties, etc. |
| Soil | Physical characteristics | In situ/ composite auger samples for lab analysis, Soil profile pits | Permeability, porosity, bulk density, texture (grain size), colour, temperature |
| | Chemical characteristics | Composite samples for laboratory analysis | pH, TOC, exchangeable Cations, exchangeable acidity and cation exchange capacity (CEC), available PO ₄ -P, Total-N,, Oil and grease, heavy metals (As, Fe, Ba, Cd, Cr, CU, Ni, Mn, V, Co, Pb, Zn, Hg), THC, TPH |
| | Soil microbiology | Composite samples for laboratory analysis | Total heterotrophic bacteria and fungi, Total hydrocarbon utilizing bacteria and fungi |
| Land Use/Cover | Land cover | Secondary data sources | Land Use types: Recreational, agricultural, forestry, industrial, residential, institutional, commercial. Trends and time lapse mapping. |
| Biodiversity Status & issues relevant to biodiversity | Wildlife | Transect, direct observation, interviews, secondary data sources | Species composition/distribution (vegetational map of locality), seasonality, exploitation methods/level (kill rates/month/year, estimates of wildlife population etc). IUCN categorisation |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| Environmental Component | Environmental Aspect | Data Acquisition | Potential Environmental Impact Indicator |
|-------------------------|----------------------|--------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | Vegetation | Transect, herbarium studies, tissue analysis | Type, diversity, Habitat status, floral composition, density and distribution, vegetation structure, plant pathology, plant tissue chemical analysis. |
| | Conservation | <i>In situ</i> observation, interviews, secondary data | Conservation status (rare, threatened or endangered species), conservation areas (forest reserves etc), environmentally sensitive areas – wetlands and swamps), local conservation practices. |

Table 1.3: List of Study Communities and Local Governments

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

Necessary data and information on the communities as detailed in Table 1.4 will be collected.

Table 1.4: Socio-economic Data Needs

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

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

Table 1.5: Health Data Needs

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

1.8: Statistical Analysis

The biophysical, health and socio-economic information collected during the fieldwork and laboratory analysis will be analysed statistically where necessary to bring out the inherent trends and patterns. Specifically the health and socio-economic studies will focus on the different parameters listed in table-1.4 and 1.5.

1.9: Quality Assurance and Quality Control

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

Field Procedures

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

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

Reporting Exercise

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

1.10: Quantification and Evaluation of Impacts

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

1.11: Determination of Appropriate Remedial Measures

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

1.12: Monitoring Plan

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

1.13: Report Writing

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

CHAPTER TWO PROJECT JUSTIFICATION

2.1: Project Background

There are 74 producing flowstations currently in SPDC covering several fields. Twenty three (23) of these flowstations have Associated Gas Gathering (AGG) facilities, whilst 25 have ongoing projects, which are aimed at providing AGS facilities before the flares down date set by the Federal Government. A flares review that was initiated in 2004 identified Twenty six (26) flowstations which had no AGG plans in place, and were considered “stranded”. In considering commercial opportunities that could exist for achieving flares out in the fields, a number of feasible engineering solutions were proposed. These included use of multiphase pumping technology, HP gas injection into existing plants, gas shut-offs and sharing of SPDC/JV facilities in fields with close proximity. A ranking of the commercial opportunities was carried out on the basis of 2008 “No Further Activity” (NFA) oil production. Otumara Node consisting of Otumara and Saghara flowstations were considered as one of the high ranking opportunities, with possible economic solutions for Associated Gas Gathering.

Consequently, the Shell Petroleum Development Company of Nigeria Limited (SPDC), on behalf of the Joint Venture partners (Nigerian National Petroleum Corporation, Nigerian Agip Oil Company, and Total), plans to embark on the Otumara Field (Otumara & Saghara flow stations) Associated Gas Solution Project to meet the business objectives of Domestic Gas supply and bringing gas flares down to the barest minimum. At present, some of the associated gas produced at the Otumara flow station is being flared, the remainder is used as fuel gas for the crude oil export pumps and gas engine-driven power generators and for lift gas for oil wells that need secondary recovery to boost their production. The Otumara AG Solution Project was kicked off in order to achieve SPDC’s commitment and corporate goal of oil production without routine flaring of associated gas for the Otumara/Saghara Flowstations.

SPDC Business Plan forecast for Otumara Field shows that substantial Further Oil Development (FOD) activities would be executed in the field, and will require disposal of the produced Associated Gas (AG). In view of this, it is considered that a pre-investment in AG pipeline from Otumara flowstation to the Escravos Pipeline manifold will be required, by installing a 12’’ x 12km pipeline to the Nigera Gas Company Manifold at Escravos.

The overall project scope also involves the design and construction of a 44-room Field Logistics Base FLB (for staff accommodation) at Otumara and an electricity supply project for the transmission of electricity the three host communities (Ugborodo, Ugboegungun and Deghele) in the area. The electricity project is being embarked upon as part of SPDC’s sustainable community development efforts. The estimated land coverage for the new FLB is about 150m x 250m and the selected location shall be sand-filled. The Otumara Field has existing oil producing facilities and the proposed Otumara field AGS project is mainly a facility upgrade involving the installation of new facilities.

2.2: Need for the Project

The Federal Government of Nigeria through its joint venture participation is determined to harness its gas resources and grow the gas availability to both the domestic market and for export purposes. Towards this end, there is a planned expansion of gas gathering facilities within the SPDC operational areas of which the Otumara AGS project is one. These initiatives together with other similar initiatives will make the country to become also a major player in the global LNG market.

Locally it would create skilled and unskilled job opportunities and provide some socio-economic infrastructure (such as electricity) to improve the living standards of the rural communities. Thus the Otumara field Associated Gas Solution project is being undertaken to:

- Create additional opportunities for crude oil and gas production in Nigeria for domestic consumption and export.
- Enhance the efficiency of critical National Industries through the supply of more gas for power generation.
- Increase the revenue base of Nigeria through increased sales of crude oil and gas.
- Contribute to Nigeria's ability to sustain its growing energy needs.

This is a major effort in SPDC's drive to end gas flaring which is economically and environmentally desirable for the country.

2.3: Value of the Project

The value of the project may be judged by its positive impact on economy, social infrastructure, improved quality of life and quality of atmospheric environment, as follows:

- (a) Economy: Purposeful utilisation of associated gas and foreign exchange earnings from its sale are positive signs of real development. Income from employment of local hands will enhance the economic condition of the host communities' stemming from the fact that the CPF modules are to be fabricated in Delta State, Nigeria.
- (b) Social Infrastructure: Extension of electric power supply to the host communities, coupled with the community development activities associated with the project will boost the overall infrastructural status of the host communities.
- (c) Quality of life: The development projects in (b) above will have multiplier effect on the quality of life in the host communities.
- (d) The key objective of the project is to eliminate routine gas flaring and by implication reduce emissions into the atmosphere, thereby improving local atmospheric quality as well as reducing global warming potential.

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 industrialisation efforts. Furthermore, the AGS 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.

2.4: Project Schematics

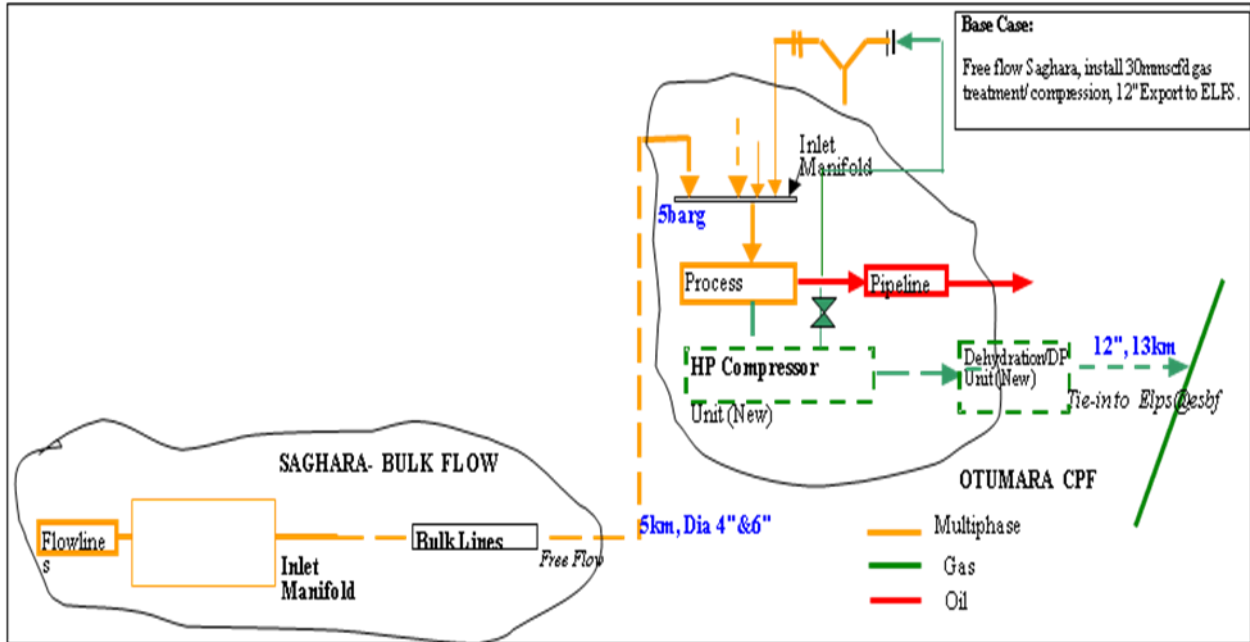


Fig. 2.1: Schematic for Otumara AGS Project Facilities

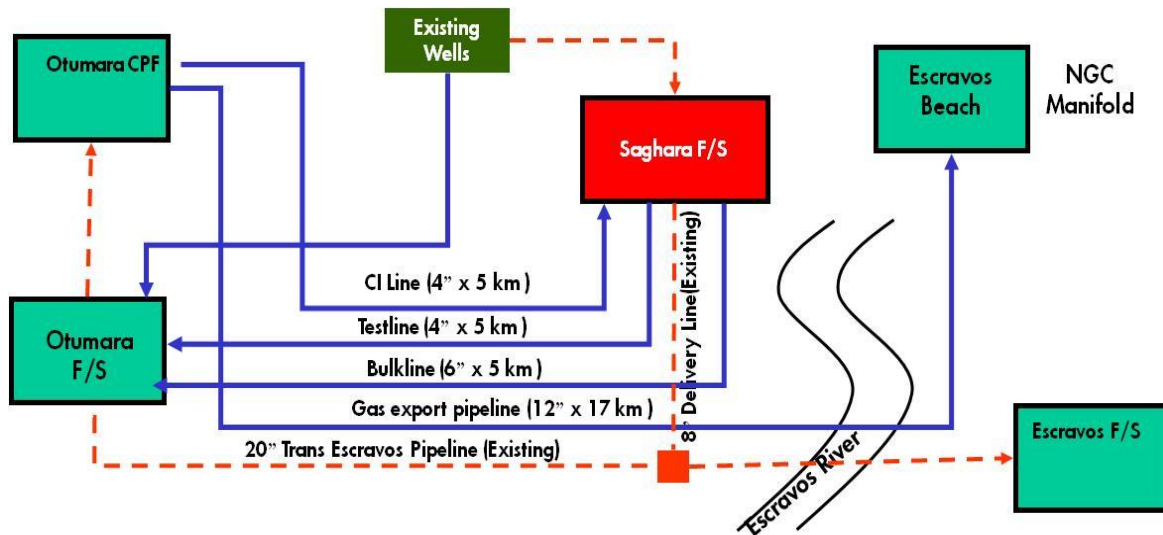


Fig. 2.2: Schematic for Otumara AGS Project Pipelines

2.5: Project Screening

A Concept selection Workshop for the Otumara AGS Project was held in 2008 to ensure an optimized and robust concept. Other workshops to address constructability and installation issues were also done which resulted in choosing the current concept and location for new CPF

facility next to the existing Otumara flow station. In the workshop, the position of the existing gas lift barge was selected and the float over option was selected for the installation method.

Table 2.1: Constructability Workshop Result

| SUMMARY OF RESULTS | | | | | | |
|--------------------------------|--|--|--------------|-----------------------|-------------------------|-----------------------|
| | | | Helipad Area | Opposite Flow station | Gas lift barge location | Other side of well 14 |
| Scores | | | | | | |
| Constructability & Operability | | | 129 | 225 | 177 | 237 |
| Community & Government | | | 206 | 204 | 148 | 204 |
| TOTAL | | | 335 | 430 | 324 | 442 |
| | | | Helipad Area | Opposite Flow station | Gas lift barge location | Other side of well 14 |
| Positions | | | | | | |
| Constructability & Operability | | | 1 | 3 | 2 | 4 |
| Community & Government | | | 3 | 2 | 1 | 2 |
| TOTAL | | | 4 | 5 | 3 | 6 |

Table 2.2 Installation Selection Workshop Result

| Results Table | | | | | | | |
|----------------------|-----------------------|-----------------------|---------------------|------------------------|------------------|-----------------------------|-------------|
| Installation Method | Criteria | | | | | | Total Score |
| | Minimum Site Exposure | Ease of Installations | Access on Waterways | Equipment Availability | Project Schedule | Anticipated Additional Cost | |
| Float Over | 3 | 3 | 2 | 3 | 3 | 2 | 16 |
| Roll Over | 2 | 2 | 2 | 2 | 3 | 2 | 13 |
| Lifting | 3 | 1 | 1 | 1 | 1 | 1 | 8 |
| On-Site Construction | 1 | 1 | 3 | 3 | 1 | 1 | 10 |

2.6: Relationship to Other Projects

SPDC's oil production is gathered in Otumara and Saghara flowstation for oil and gas separation before pumping oil to the Forcados crude oil terminal for dehydration and export. Flaring of the AG produced with the oil takes place locally at the flowstations.



Fig 2.3 Otumara Saghara Location Map

2.7: Project Alternatives/Options

The Otumara Field Associated Gas (AG) Solution Project has addressed various project alternatives based on the availability of process facilities, utilisation of existing facilities, technology, cost effectiveness and environmental issues.

The project development alternatives considered were;

- No Project Option
- Build on New location
- Build on existing location

The advantages and disadvantages of each alternative/options are summarized in Table 2.3

Table 2.3.: Project Options Considered

| S/N | Options | Advantages | Disadvantages |
|-----|-------------------|----------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. | No Project option | <ul style="list-style-type: none"> • No Capital Expenditure • No negative impact of project on the environment | <ul style="list-style-type: none"> • No Gas to sustain supply to the Gas Plants • Government aspirations to improve power supply by year 2014 will not be met. • Environmental degradation from gas flare will persist. • Gas supply to domestic market will not be met. • Loss of revenue. |

| S/N | Options | Advantages | Disadvantages |
|-----|----------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2. | Build on New location | <ul style="list-style-type: none"> • Requires land acquisition and therefore more money to the community. • Employment opportunities • Contract opportunities | <ul style="list-style-type: none"> • Increased pressure on existing social-economic infrastructures in view of influx of people. • Increased footprint and land take. • Negative environmental impact |
| 3. | Build on existing location | <ul style="list-style-type: none"> • Employment opportunities • Contract opportunities • No negative impact on project schedule • Minimal vegetation clearing • Improved environmental performance | <ul style="list-style-type: none"> • Increased pressure on existing facility in view of influx of people. |

The option for installation of the new facilities for the Otumara Field Associate Gas (AG) Solution Project on existing location (Option 3) was selected because it would generate the least environmental impacts. Other options for the installation of the CPF were considered, thereby allowing a degree of flexibility in the choice selected. The new facilities locations therefore offer advantage of no new land acquisition and hence it is envisaged that community and environmentally related problems would be minimal.

2.8: Sustainability

Oil and gas are non-renewable natural resources, so, in this context, we are talking about sustainability within the limits of availability. Sustainability is anchored on sound economic, social and environmental health. It is based not only on compliance with regulatory and corporate standards and guidelines, but also largely on performance improvement. In recent times, environmental managers have discovered that sustainable development means that they have to take into account labour conditions, employee's health and safety, community relations and other *soft* social and cultural factors, as well as uncertain environmental factors in relation to ecosystems (Krut and Gleckman, 1998). The thrust of the Otumara AGS sustainable development programme is derived from the SPDC's sustainable development management framework.

2.8.1: Economic Sustainability

The Otumara Node fields, namely Otumara and Saghara have proven reserves of natural gas. These reserves of gas can economically and commercially support the project following the high demand for natural gas in the domestic and international market. Part of this demand will be met from some of the fields in this node. The project will therefore contribute substantially to the revenue accruing to Nigeria.

SPDC policy on employment of indigenous contractors will be applied in the project. Skilled and unskilled indigenous labour will be hired in the construction phase and possibly in the future maintenance and running of the AG facility.

The main contractors employed in this development shall be required to award minor contracts to local indigenous contractors for jobs in which they have the required expertise. Such jobs will include but not limited to bush clearing, fencing, labour supply, catering, leasing, fabrication, surveillance, etc. Efforts will be made also to upgrade the technical and managerial capacities of such indigenous contractors.

2.8.2: Technical Sustainability

The Otumara Field AG Solution Project is technically sustainable because of SPDC's track record of strict adherence to Nigerian National (and International) engineering codes and standards. Only proven technologies that are economically viable with minimal environmental, social and health impacts shall be utilised in the execution of the Otumara AG Solution project.

2.8.3: Environmental Sustainability

The aim is to ensure that current use of the environment and its natural resources does not damage prospects for use by future generations. SPDC shall comply with all statutory regulations and its own corporate guidelines on Environmental Sustainability, continuously striving for performance improvement. Elimination of routine gas flaring is a positive step in the direction of sustainable development and will thus support transition to environmental sustainability. Adequate incentives are therefore needed to ensure that the cost of enhancing environmental performance does not inhibit business growth.

CHAPTER THREE

PROJECT DESCRIPTION

3.1: Introduction

In order to handle the associated gas currently being flared and convert it to economic use new facilities will be installed at Otumara flowstation. These are: High Pressure Associated Gas compressor, Low temperature separation vessel, TEG dehydration system and electric power generator. The estimated land coverage for the new facility is about 100 square meters within the existing Otumara flow station area on a swamp-piled foundation. Saghara flowstation shall be decommissioned, preserved and mothballed and converted to a free-flow manifold. As part of the Otumara flowstation upgrade, a 12''x12 km gas pipeline with pigging facilities would also be constructed using existing SPDC pipeline Right of Way (RoW).

The overall project scope also involves the design and construction of a 44-room Field Logistics Base FLB (for staff accommodation) at Otumara. The estimated land coverage for the new FLB is about 150m x 250m and the selected location shall be sand-filled. There is also an electricity supply project for the transmission of electricity to the three host communities in the area.. The three host communities that would receive the transmitted electricity are: Ugborodo, Ugboegungun and Deghele. The electricity project is being embarked upon as part of SPDC's sustainable community development efforts.

The field was discovered in 1969 and put on production in 1972. Up to end 2001, 51 wells have been drilled, 3 of which were abandoned. Mixtures of stabilised crude and produced water are pumped from the flowstations via a delivery line into the Trans-Escravos trunkline and thence to the Forcados Terminal some 45km away. Produced associated gas is currently used as fuel gas for the pumps and generators, for lift gas and the excess flared. The Otumara flowstation capacity is being increased from 60 Mbd to 104 Mbd. There is a 15mmscf/d leased gaslift compressor station installed on a barge opposite to the Flowstation. The Central Processing Facility (CPF) receives the AG from the gathering stations, compresses to export pressure and dehydrates the gas prior to transfer to the NGC.

3.2: Project Objectives

The strategic objectives of the Otumara Node AGS project are:

- Achieve Flares down and thus minimize impact on the environment and enhance the socio-economic development of the host communities in the area through sustainable development of the project over its life cycle.
- Align with government's aspirations by contributing to SPDC's plan to meet its assigned DOMGAS contributory quota and thus deliver 100 MMscf/d gas to the Western domestic gas market.
- Implement the drive for reliability and standardisation of major facilities using industry standards.
- Provide Lift Gas for Secondary Recovery

- Maintain Reputation
- Maintain License To Operate (LTO)
- Secure Developed Reserves
- Enable maturation/booking of undeveloped reserves
- Alignment with Stakeholders aspiration

3.3: Project Location

The Otumara Field is situated in OML-43, 65 km NW of Warri, a swamp field, geographically transversing the Warri South West Local Government Area of Delta State. The vegetation cover of the field falls within the sensitive tropical wetland vegetation ecosystem including four basic categories: the Salt Marsh, Mangrove Swamp, Phoenix swamp, and Fresh water swamp forest. The terrain, which lies between 10-50m above sea level, is monotonous, consisting only of consolidated sands, silt and clay.

Access to Otumara is possible via water and air transportation. Transportation from Warri to Otumara via helicopter takes about 20mins while by water transportation a boat journey would take about 2½ hours through the Warri-Escravos river that passes through to Otumara creeks.

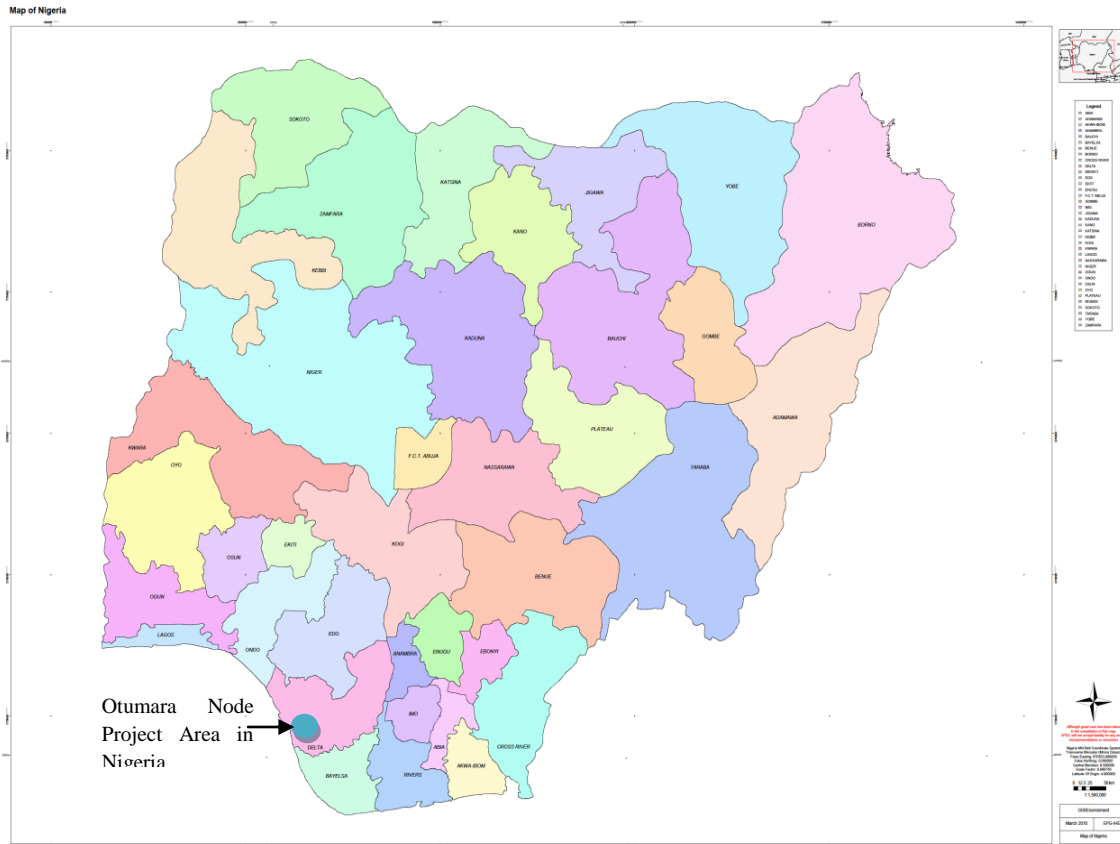


Fig 3.1: Map of Nigeria Showing Otumara Project Area

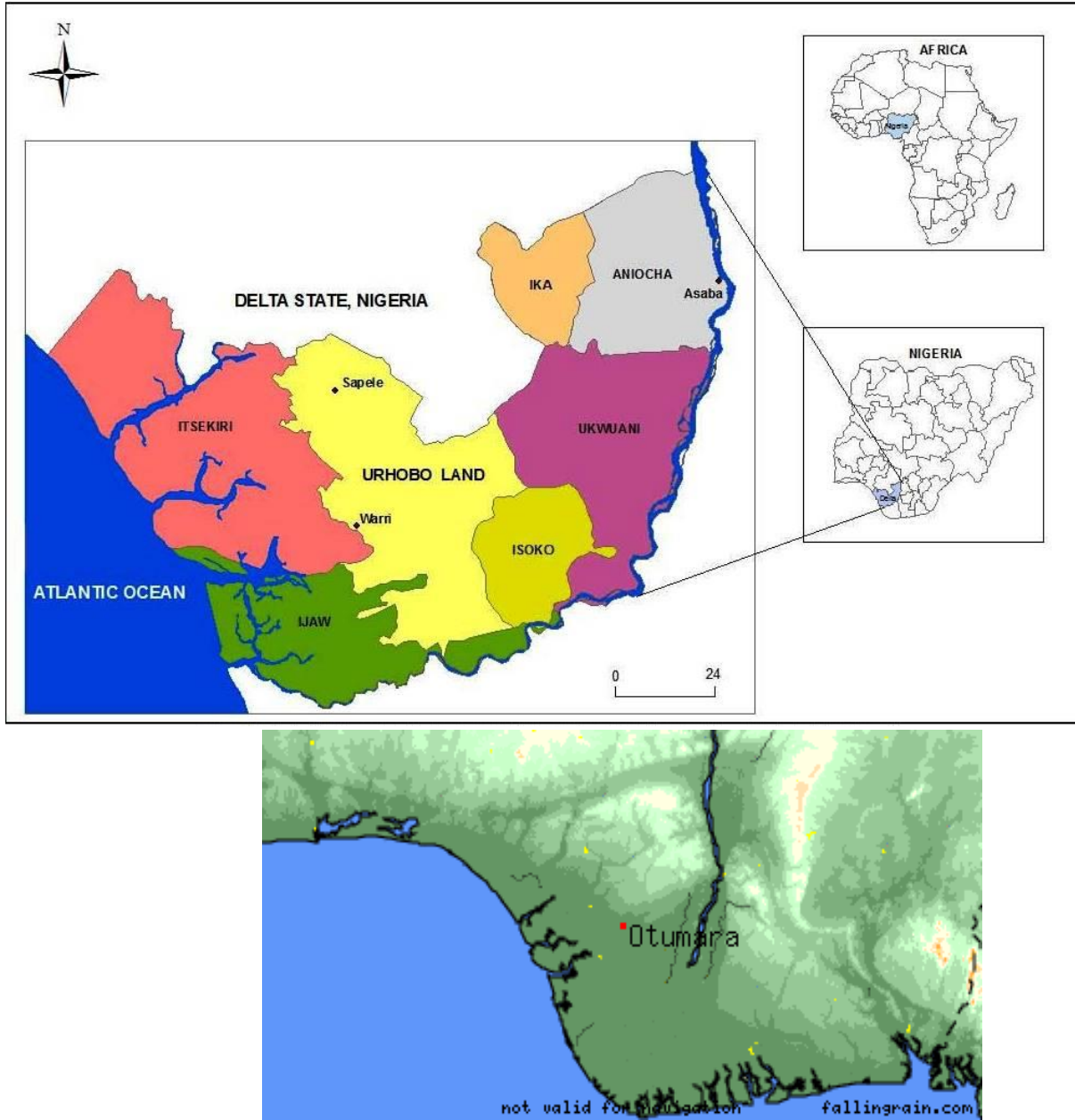


Fig 3.2: Map of Delta State showing project location

3.4: Proposed Project Scope

The Otumara field Associated Gas (AG) Solution Project is mainly a facility upgrade of the existing Otumara flowstation with addition of new facilities and laying of pipelines using the existing SPDC Right of Way (RoW). The scope of works has been divided into a facilities and pipeline scope. It will involve the following:

Facilities Scope

This has been further sub-divided into the following:

1. Otumara Central Processing Facility (CPF)
 - Gas Processing Module- Nominal 30 mmscf/day

- Gas Turbine Driven Compression Module - Nominal 20 mmscf/day
 - Power Generation/Utility modules- Circa 6.5 MW ISO
 - Flare Relief Systems
 - Blow Down Systems.
2. Otumara Flow station Brown Field works
- Piping Modifications and tie-ins to integrate the new CPF.
 - Site preparation and civil works including dredging, piling, concreting and shoring works.
3. Design and Construction of a 44-room Field Logistic Base (FLB)
- Design of the FLB
 - Additional Land Acquisition (11 ha)
 - Site preparatory works (Dredging, Sand filling, Shoring, Piling)
 - Construction of various infrastructures (Staff/Security Accommodations, Offices, Workshops, Utilities, Jetty, Bridges, Fences, Roads, Walkways, Landscaping)
4. Laying of ~30km, 11KV overhead electrical power line to communities (Ugboegungun, Deghelle, Ugborodo) and Saghara field
- Clearing of RoW
 - Installation of foundations piles and electric poles
 - Laying, Pulling, Stringing of overhead cables
 - Installation of terminal points, 500KVA transformers and Feeder Pillars

Pipeline Scope

- i. Corrosion Inhibition Lines - 2" x 5km (From Otumara CPF to Saghara Manifold)
- ii. Test Line - 4" x 5km (from Saghara Manifold to Otumara F/S)
- iii. Bulk line - 6" x 5km (from Saghara Manifold to Otumara F/S)
- iv. Gas Export line - 12" x 12km (from Otumara CPF to NGC)
- v. Flowlines – 15km (Re-routing of 7nos Otumara wells from Saghara F/S to Otumara F/S).
- vi. Manifolds and Pigging facilities (launcher and receiver)
- vii. Cathodic protection system
- viii. 21km Fibre Optic cable for data transmission

River Crossing

The Gas pipeline- 12" x 12 km from Otumara CPF to NGC will cross one major river (Escravos River).

3.5: Project Activities Description

Proposed Project Activities

The activities to be carried out for the Otumara field AG Solution Project will include the following aspects:

- Land and Marine transportation of heavy equipment
- Piling of civil foundation for new facilities at the Central Processing Facility (CPF), Flowstation and FLB sites.
- Lifting of equipment and materials during construction
- Excavation on the RoW for laying pipelines.
- Piping tie-ins, Welding, minor fabrication and testing at site.
- River crossing of pipelines by dredging
- Dredging of Otumara creek to allow passage of the barges/vessels that will convey fabricated modules from Warri to Otumara .
- Sand filling of the proposed FLB location
- Electrification of three host communities
- Bulkline and Flowline installations

3.6: Details of Main Project Activities:

A summary of the main project activities shall be covered under the following heading:

3.6.1: Design Considerations:

The facilities and pipeline, which shall have a design life of 25 years, shall be constructed in accordance with SPDC's DEPs, standard construction specifications and relevant government and other regulatory standards. Innovative technology that will reduce negative impact of facilities construction on the environment shall be utilized during the construction phase. All wastes generated during construction shall be disposed off in accordance with approved industry regulations (DPR and FMEnv). Emission to the atmosphere and noise pollution shall be minimized to acceptable regulatory limits. All the facilities shall have in-built special containment facilities for hydrocarbon spills, if any.

Bulk/flowlines in marshy/swampy areas and at water crossings shall have a yard applied tape wrapping over the anti-corrosion priming. The wrapping shall be done in a pipe yard before transportation to the site. The handling, loading and stacking of wrapped pipes shall be carried out strictly in accordance with the SPDC standard specifications.

3.6.2: Conceptual and Detailed Design

The conceptual design for the new facilities involves pipeline sizing, process simulation, slug catcher, material selection and requisition. Others include preliminary sizing of the separators, compressors and dehydration facilities, which is part of in-house design responsibility.

The detailed design is part of the Engineering Procurement and Commission (EPC) contract, which covers plant layout, survey, soil investigation, foundation, and inter-skid piping system. Also included in the detailed design contract are slug catcher, separators, corrosion inhibition plant, instrumentation, electrical, detailed process and pipeline design including interface to the existing facilities, material requisition, start-up/commissioning procedures and production of operators and maintenance manuals. The design contractor is to ensure a fit-for-purpose design.

3.6.3: Central Processing Facility (CPF)

Quality Assurance of Design

In a design of a complex system such as this project, it is imperative that certain basic parameters must be defined in the overall project specification to ensure that the full objectives of the project are realised. SPDC has, therefore, specified the following quality objectives for the design:

- Compliance with statutory requirements;
- System must meet performance requirements;
- Production availability;
- Environment and safety;
- Operationability and maintainability;
- Life expectancy;
- Extendibility;
- Compatibility with existing facilities

Applicable Standards and Codes

The engineering design, procurement and installation will be in accordance with the latest revisions of the following Statutory Codes and Standards: Federal Republic of Nigeria National Standards, SHELL Design and Engineering Practices (DEPs), SPDC Standard Facility Design Manuals, and applicable International standards and Manuals.

3.6.4: Planned Facilities

Facilities to be provided include:-

- Main gas turbine drive compressors.
- TEG dehydration facilities.
- Slugcatcher(s) and pig receiving facilities
- Power generation units
- Gas export metering
- Export pipeline pig launcher
- Utilities (Process liquid disposal, power distribution, control system, telecommunications including telemetry, instrument/utility air, glycol regeneration, fuel gas system, flare, drains and service).
- Tie-ins to the existing HP, LP & vent gas headers
- Booster compressor packages.
- Installation of HP pig launcher

- Emergency Shut Down (ESD) systems
- Corrosion inhibition system for the pipeline system
- Extension of existing piled flow station
- Power distribution system

Availability and Residual Flaring Target

The initial availability targets for the optimised AG utilisation scheme are:

| | | |
|--------------------------|---|-----------------------------|
| Overall residual flaring | : | Less than 10% of production |
| LP booster compression | : | not less than 85% |
| Central compression | : | not less than 95% |

Flaring "quota" of maximum of 10% of associated gas production per annum should be achievable by 2015 with continuous improvements thereafter. "

Flaring at CPF

The following situations would give rise to flaring at the CPF:

- Gas will be flared when main compressors trip due to process upsets.
- Gas will also be flared when facility is in blowdown mode in response to an emergency shutdown.

Fire Protection

The principle means of fire protection on the AG compression plants will be by shutdown of the process and venting the inventory to flare. The distance between the flowstations and the AG plants shall be sufficient for the two to be classed as separate fire areas.

Equipment spacing will provide for adequate passive fire protection between trains and process modules. The relative higher fire risk gas turbine drivers are to be fully enclosed with integral CO₂ fire fighting equipment.

Process Design

Process configuration

The CPF is to receive Associated Gas from the booster stations and shall process them to produce export quality gas for delivery to the Offshore Gas Gathering System (OGGS) facilities.

- Associated gas from the surge vessel will be compressed and commingled with the LP gas from the LP vessel. This gas is then compressed to the same pressure as the gas off the HP vessel and flows to the CPF.
- No gas treatment of fluids is required upstream of the CPF other than compression. Requirement for chemicals injection for corrosion control to be determined during conceptual design.
- The fluids from the gathering stations are to be compressed at the gathering stations to ensure arrival pressure of around 7 bar at the CPF.

- Liquid slugs in the feed pipelines from the Gathering stations to the CPF shall be accommodated by a slug catcher at the CPF
- The compression configuration shall consist of at least two identical parallel trains.
- Each train shall be driven by a single gas turbine.
- The gas will be dehydrated before export. The dehydration system will be based on either TEG units or Twister. The TEG units will be installed between 2nd stage and 3rd stage within each train or downstream of the compressor trains (to be determined in the conceptual design)
- Water and condensate recovered in interstage separators will be spiked into the Otumara crude pipeline. Before being spiked, the water condensate mix will be partly stabilised by flashing the liquid in a vessel at atmospheric pressure. Consideration shall be given to use the surge vessel at Otumara Flowstation, hazardous open drain system or atmospheric vent knock-out pot for this purpose. In any case, provisions shall be made to allow liquid spiking in case Otumara Flowstation is unavailable.
- For the CPF, recycle loops shall be applied around each stage of compression for control purposes and around each train or complete station (to be determined) for maximum throughput flexibility.

Mechanical Design

General

The following design basis highlights the overall criteria to be applied for the development of the project specifications for the Otumara AG facilities. The criteria takes into consideration SPDC requirements to promote a modular approach for the project in line with industry standards, as well as the need to install safe, low life-cycle cost facilities. All Otumara AG Solution project facilities are to be specified for a design life of 25 years.

Aircoolers

Constant speed Air coolers will be specified to API 661, using DEP 31.21.70.31-GEN as guidance and designed for maximum duty, plus an additional 10% excess area for fouling, coincident with operation at the maximum ambient air temperature of 35 °C. Air cooler design approach temperature will be taken as 10°C.

Heat Exchangers

Heat exchangers should be of Shell-Tube type (to be confirmed during conceptual design) and be to DEP 31.21.01.30 –Gen and DEP 31.21.01.31–Gen specifications. Heat exchangers shall be specified for the maximum duty plus 10 % excess area for fouling.

Vessels and Gas Processing Equipment

All vessels shall be of butt welded construction. All welding shall be in accordance with the latest edition of the relevant design codes. Welding procedures shall fulfil the requirements of ASME IX or equivalent.

Suction scrubbers shall be designed to efficiently remove solids and carry-over liquids from the flowstation to an acceptable level compatible with the requirements of the type of compressor. The design shall pay close attention to ensuring sustained performance under turndown conditions associated with minimum flow conditions, and ensure the scrubbers do not impose a significant additional system pressure drop. The design, construction, inspection and testing of the vessels will be in accordance with DEP's 31.22.10.32-Gen, 31.22.10.35-Gen and 31.22.20.31-Gen. Additional design requirements shall be met when designing pressure vessels using austenitic steel clad plates to DEP.30.10.02.11-Gen.

The design shall incorporate external loading such as wind loads, loads from testing, lifting and transport, etc. Stress analysis shall also be included in the design. Vessels including their supports shall be capable of supporting a full load of water, at atmospheric pressure, in the erected position. To ensure structural safety, vessels shall be checked for vibration due to wind. All piping and equipment shall be adequately supported to prevent excessive vibration and stress. All package-mounted instruments shall be supported in such a manner to ensure the proper operation of instrumentation, without subjecting it to the possibility of vibration damage.

Compressors

The design shall be based on proven, simple and robust technology with minimum equipment count. The system shall be designed to minimise shutdowns by maintaining continuous operation on full recycle when required.

Pumps

Process pumps will be designed in accordance with API 610 specification and DEP 31.29.03.30-GEN. Reciprocating pumps will be used for the glycol circulation at the CPF Pumps will be designed for the maximum liquid flow plus 10% control margin as per API 610 specification

3.6.5: Field Logistics Base

Design will be in accordance with the requirements for design and engineering of buildings DEP 34.17.00.32-Gen and other relevant DEPs including international and industry standards. The design for the FLB will be founded mainly on piles because of the swampy nature of the location. The design approach will also follow a modular approach by utilising already pre-fabricated modular buildings for the infrastructure. This will limit extent of construction work to be carried out in the field. The FLB safe guarding facilities will be linked to that of the new facilities (CPF). The design will entail utilising minimal land intake and allow for proper landscaping and horticulture.

The FLB shall be constructed on a piled foundation based on results of the geotechnical surveys that will be carried out.. It shall be constructed in accordance with the functional requirements to

provide operations personnel the capability to achieve 24hrs manning for the Otumara Central Processing Facility (CPF) and the existing facilities.

3.6.6: Pipelines

Design will be in accordance with the requirements of SPDC's Pipeline and Flowlines Design Manual and Shell DEP 31.40.00.10-Gen., Pipeline Engineering and other relevant DEP's. Pipelines routing shall be as per the completed route survey. Pipelines shall be designed according to the Design case.

Design parameters

Pipe design is determined based on the maximum fluid flowrate without an additional design margin. Pipe size selection is to be in accordance with DEP 31.38.01.11-Gen. "Piping General Requirements". All designs shall be based on site survey findings of the terrain, soil resistivity, stray currents and other possible interactions with neighbouring pipelines' cathodic protection systems.

All inter-field gas gathering pipelines shall be buried. Due to the swampy environment, heat loss calculations shall be based on as if pipes are lying under water and heat transfer data of water (at 20 °C) shall be used.

- Pipelines shall be trenched and back filled such that there is 1.5 meter of fill above the pipe.
- Three-layer polyethylene coating will be used as external anti-corrosion coating for the pipelines.
- There shall be no intermediate block valves on the Gas gathering or export pipelines
- Concrete coating shall be applied to swamp sections and river/estuary crossings.
- Intelligent pigging facilities shall be provided for all pipelines
- Pipeline between flowstations and adjacent or nearby (less than 200 meter) booster stations are considered plant piping and designed accordingly.
- Slugcatcher surge volumes shall be sized to accommodate sphere generated slugs during controlled pigging under reduced flow operations.
- Selection of pipe grade will be made on the basis of the following criteria:
 - Pressure containment and stresses
 - Construction lay stresses
 - Pipe standardization
 - Corrosion allowance and mitigation
 - Design life of pipeline

Pigging and Inspection

Pigging facilities will be installed on each pipeline for removal of liquids. Pipelines shall be designed for intelligent pigging. The design of the Pig Trap systems shall be guided by DEP 31.40.10.14-Gen., Design of Pig Trap Systems for Transmission Pipelines.

Corrosion Protection

Pipelines shall be provided with suitable corrosion protection and monitoring systems, using impressed current system (Cathodic Protection). In addition, corrosion inhibition chemicals may be injected at the Booster Stations. Corrosion inhibition chemicals approved by DPR shall be used.

Design Pressure, Temperature and Material Selection

The determination of design pressures temperatures and the material selection of equipment the rules from the Shell DEP standards will be followed. The materials selection will be based on the process conditions as indicated in the heat and mass balance and on the process flow diagrams.

3.7: Pre-construction Activities and Land take

Pre-Construction Activities

Pre-construction activities include (not necessarily in sequential order), but are not limited to:

- Permission to survey (PTS) and OPL applications;
- Conceptual and detailed design of the Otumara field AG Solution Project designs/plans and options;
- Topographical survey of pipeline route/right-of-way (ROW) and facilities installation areas;
- EIA;
- Land acquisition

Land Take

The option of using existing RoW and already acquired land for the pipelines and new facilities was given a high priority to reflect the ‘lean and green’ approach, involving minimum or no new land take, which is currently favoured by SPDC. The majority of the surface locations in the Otumara field can accommodate the proposed new facilities for installation (High Pressure associated gas compressor, Low temperature separation vessel, TEG dehydration system, 12’’x12 km gas pipeline and Pigging facilities for pipelines).

To minimise the attendant environmental impact of new acquisitions and costs, the project activities are being planned within existing facilities. However due to the nature of the project with the requirement for a Field logistic base that will cater for the manning of the new and existing facility (currently accommodation is with houseboats), additional land acquisition (circa 11 hectares) will be required to accommodate the 44 room FLB.

3.8: Construction Phase

Pre-Mobilization/Mobilization

Estimated population of workers for the project during mobilization and construction will be about 150, with a maximum of 250 at peak periods. Logistics and accommodation shall be provided for personnel using houseboats. The houseboats shall also serve as a field logistic base

for storage of essential supplies as appropriate and shall be movable (barge mounted) to provide effective support as the pipeline works transiting along the RoW.

As much as it is reasonably practicable, mobilization for pipeline installation activities shall be sequenced to maintain minimum site presence as well as exposure to personnel, equipment and resources. The houseboats can be moved as the crew transit the Right of Way to minimize intra field movement, security exposure and construction foot print.

The selected SPDC Contractor shall mobilise all equipment and materials to the site, ready to start work after necessary medical certification for fitness. The site can be accessed through water. Mobilisation to site shall include the following:

- Houseboats of 100 bed capacity (either in single or multiple units)
- Personnel boats
- Standby boat for use in case of emergencies.
- Shuttle boat
- Tugboats, Work barges, Cranes
- Swamp buggies and dry plant as applicable
- Small equipment and tools

Site Preparation Activities

Otumara is on swampy terrain. Prior to the commencement of site construction and installation activities for the CPF, FLB and pipeline works, sites preparation activities will include but not limited to the following activities:

- Site clearings
- Topographical surveys of pipeline route/right-of-way (RoW) and facilities installation areas
- Sub-soil Investigations
- Levelling and sand filling works
- Piling works and construction of concrete platform in Otumara

Site Surveys and Clearing

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

Site clearing, bush clearing and de-stumping shall be limited to the area, which is absolutely necessary. Bush clearing will involve the felling of all trees within the identified areas for the

new facilities and the removal of all stumps. Debris shall be piled next to, but within, the boundaries of the area of each site cleared. Appropriate construction equipment, namely - bulldozer, crawler/swamp buggy-excavator, pay-loader, excavator, and or any other SPDC approved equipment shall be used for bush cutting and de-stumping. Areas within SPDC's RoW will be cleared prior to excavation and laying of pipeline. Top soil stripping and segregation shall be performed prior to trenching on the Right of Way center line to facilitate effective reinstatement. Bush clearing shall be maintained within the project boundaries. The felled timbers shall be stacked and given to the communities.

Dredging/Location Preparation

Dredging of the access river to Otumara shall be carried out for the waterways within the Otumara/Saghara Creeks (circa 12km) to allow the passage of a hopper dredger that will bring sand offshore for location preparation (sand filling) of the FLB as well as the vessel that will transport the CPF modules from Warri fabrication yard to Otumara. The dredging technique to be used and handling of dredge spoil shall be designed to minimize impact to the environment.

Piling

A significant part of the work requires that steel piles of various diameters be driven down to about 45m depths to carry the new facilities for the CPF and the FLB superstructure. These piles will be filled with concrete and pile caps welded on.

Pipeline Construction

Pipeline Laying and Tie-in Process

Prior to ditching on any site, Contractor will use metal detectors to probe for the existence of facilities such as flowlines, pipelines etc along the flowline RoW. Positions of such facilities shall be plotted on paper and submitted to SPDC as part of the pre-ditching investigations. The Contractor shall peg out the actual positions of the identified, using reflective yellow buoys (on water) or pegs (on land).

During excavation and pipe laying activities in the field, the following would be observed:

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

- After the pipe is in position, the floats shall be carefully removed to prevent damaging to the coating, and
- The pipe shall be filled with filtered, clean water for flushing and pressure testing.

After successful lowering of the pipe, the trench shall be backfilled in layers not exceeding 15 cm at each layer, and uniformly compacted. The backfill material (free of stones, sticks, roots, debris and any other material which might possibly damage the pipe wrapping and/or initiate corrosion) shall be crowned (heaped up) along the trench line to a height of between 20 and 30 cm above the adjacent ground surface. During the course of backfilling and re-vegetation, the following precautions shall also be taken:

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

River and Creek crossings shall be designed in accordance to ASME B31.4/8, SPDC DEP and DPR guidelines for design and construction. The pipelines/flowlines and bulklines where ever they cross any river, creek, canal or other waterway shall comply with any and all regulations imposed by the Nigeria Inland Waterways Authority.

The pipelines and flowlines/bulklines shall be buried in the natural bed of the waterway and constructed in accordance with typical AFC drawings in such a way that it takes into consideration the requirement of public safety. Prior to construction, detailed work procedure and programme shall be supplied by the Contractor and approved. Care shall be taken to ensure that minimum clearances between new and existing trunklines, delivery lines and other pipelines/flowlines are achieved. Minimum depth cover shall not be less than 1m below natural bottom level of river or creek bed.

Welding and Radiography

This activity shall involve welding of the bulklines using the floatation method where the pipeline is laid from a single laybarge moving through a channel (burial trench) cut along the right of way. The line pipes shall be procured with capped bevel ends, A Pipe storage barge shall be moored next to the laybarge. The Pipelines shall be coated with three-layer polyethylene

coating to provide external corrosion protection. Field joints shall be coated with shrinkable sleeves.

Visual inspection and 100% radiography (non-destructive testing) of the welds shall be done as the welding progresses. Weld repairs shall be carried out where necessary, prior to Pipeline pressure testing. Waste generated from welding and NDT activities shall be contained and safely disposed. Successful welds shall be laid on already prepared trenches and the as-laid survey documented.

3.9: Operation and Maintenance

Operation Philosophy

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

The central processing facility at Otumara will be fully manned and the control room shall be designed for fully attended operation. The field logistics base will provide the requirements for manning the new and existing facilities. However, the design philosophy shall be based on an automated operation and minimal intervention requirements for maintenance and operations. Shutdown will be initiated either automatically or manually in a fail-safe mode and will be restarted only manually.

Facility Availability and Criticality

Associated gas is produced from the flowstation separators. The majority of the gas is available from the HP and LP separators at 12 and 4 bars respectively. LP gas is to be boosted from 4 bars to 12 bars in one stage compression and free-flowed together with HP gas, via a low pressure gathering pipeline, to the CPF where the gas is compressed to 135 bars in three stages. The booster compressors will be driven by electric motors while those at the CPF will be gas turbine driven.

Gas treatment at the CPF is required to process the raw AG in order to meet hydrocarbon dehydration acceptable for gas entering the OGGS pipeline. In the overall process optimisation and integration, handling of liquid and off-gas streams are critical issues. The compressor suction and interstage knock-out drums produce liquid streams containing liquid hydrocarbons which will be spiked into the oil export line to Forcados Terminal.

The system shall be designed such that a failure of one of the gas export compression train will not affect the other trains. The same applies for other parallel units such as the power generation units. The number of common mode failures should be kept to a minimum.

Facilities Safeguarding Philosophy

(a) Central Processing Facilities and Field Logistics Base

The CPF and FLB shall have its own Fire, Water and Safety systems, Potable and freshwater system, communications and control systems, including commencement of Emergency/ Operation Shutdowns (ESD/OSD). The CPF and FLB shall be also be fenced to comply with the relevant DEP and International Standards.

(b) Pipeline System

The pipeline/blockvalves/manifolds and their associated fittings shall be rated at a maximum working pressure of 150 barg to enable its utilisation for future extended gas gathering, gas lifting and sales. The design of pig trap facilities shall be in accordance with the latest version of SPDC Pipeline Design Manual and DEP 31.40.13-Gen: Design of Pipeline Pig Trap Systems. All Blockvalve/Manifold stations as well as Cathodic Protection facilities shall be duly fenced in accordance with DEP specifications

Maintenance Philosophy

(a) Upkeep of Structures

Maintenance and inspection activities, based on periodic inspection to determine the condition of structures and performance of their protection system include: refurbishment activity to restore the integrity of structures, replacement of and coating system applied to structures based on time maintenance schedule.

(b) Containment of Hydrocarbons

Periodic (monthly) inspections will be carried out to determine the condition of all elements of the process fluid containment envelope as well as any protective coatings applied thereon. Inspection programmes for certifiable pressure vessels, pressure/vacuum relieving devices will be inspected to meet the requirements of the Minerals Oils (Safety) regulations of Nigeria. Refurbishment activity to restore the integrity to the envelope will be based on their condition. Where appropriate, economic systems to mitigate the effects of corrosion shall be put in place and their effectiveness routinely monitored.

(c) Control and Protection

Control and protection system, will be based on periodic inspections/calibration/testing both their input and output functions as detailed in the Maintenance Job Routines (MJR). Non-availability of hydrocarbon production caused by such inspection/calibrations/test will be accounted for in the Production Plan. Change of set points will be controlled by the plant change procedure.

(d) Hazard Detection System

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

(e) Shutdown system

Maintenance of shut down system, both initiation and activation devices, will be based on periodic full function testing of both their input and output functions to ensure operation in accordance with SPDC guidelines. Non-availability of hydrocarbon production caused by such inspection/calibrations/test will be accounted for in the Otumara field AG solution plan. Where possible, for maintenance or construction activity that requires the facility to be shutdown, such function tests will be used to shut down and check the isolation of the facility. The testing schedule will be adjusted to reflect the unscheduled test.

Pre-commissioning

An SPDC pre-commissioning team, consisting of the project co-ordinator, production, maintenance and HSE personnel will be set up close to the completion of construction and installation works, and will be involved in the following pre-commissioning activities:

- Checking vendor data
- Preparing commissioning procedures
- Preparing test equipment/procedures
- Checking project documentation
- Assembling relevant project reference data
- Checking individual system

During the pre-commissioning, hydrostatic testing will be performed with water to ensure jointing and welding integrity at design pressure. DEP procedures require that the pressure testing water taken from the local environment be treated with biocides, corrosion inhibitor and oxygen scavenger. It is thus necessary that upon completion of testing, the spent water would be treated to remove the added chemicals before being discharged into the environment. Discharge would be made in such a manner that it does not stir up sediments.

3.10: Decommissioning/Abandonment

The pipeline system and its ancillary installations have a life expectancy of 25 years. The operation and maintenance procedure provide for monitoring the performance and the integrity of the system components.

When the performance of the system scales to diminishing returns, SPDC standard procedures for decommissioning shall be invoked. A decommissioning team is set up to plan and implement the laid down guidelines on decommissioning. The following activities are involved in decommissioning/abandonment:

- Demolition and site clean-up;
- Disposal of Wastes;
- Rehabilitation of site

Demolition and Site Clean-up

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

Rehabilitation of Site

After all manners of wastes have been satisfactorily disposed of, the top soil may be stripped and replaced with top soil from unimpacted neighbourhood. Seedlings from the original vegetation are obtained from neighbouring vegetation and planted as advised by landscaping expert.

3.11: Project Schedule

The current activity schedule for the Otumara Node AG Solutions Project is shown in Figure 3.3 below. First gas is expected from the node by last quarter of 2014.

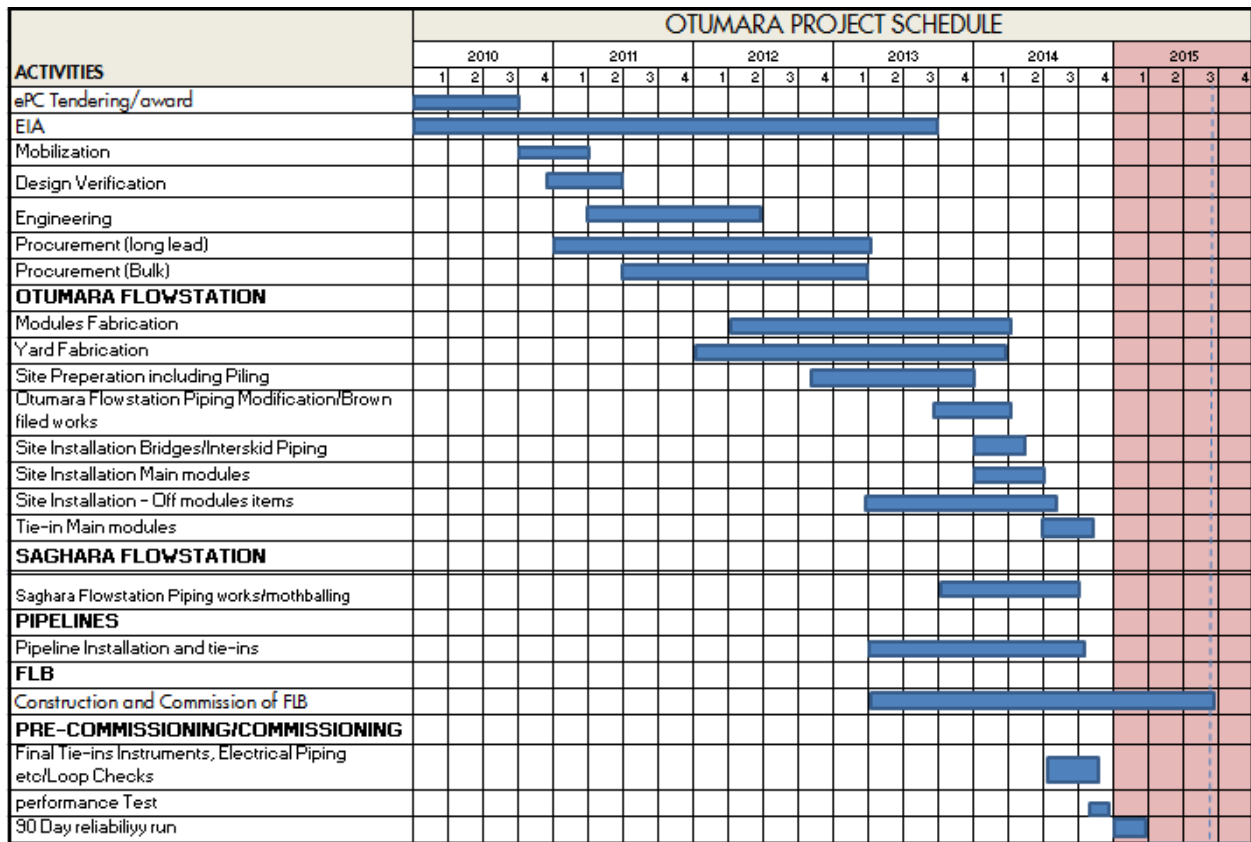


Fig 3.3: Project Activities and schedule

Environmental Impact Assessment (EIA) of Otumara AGS Project

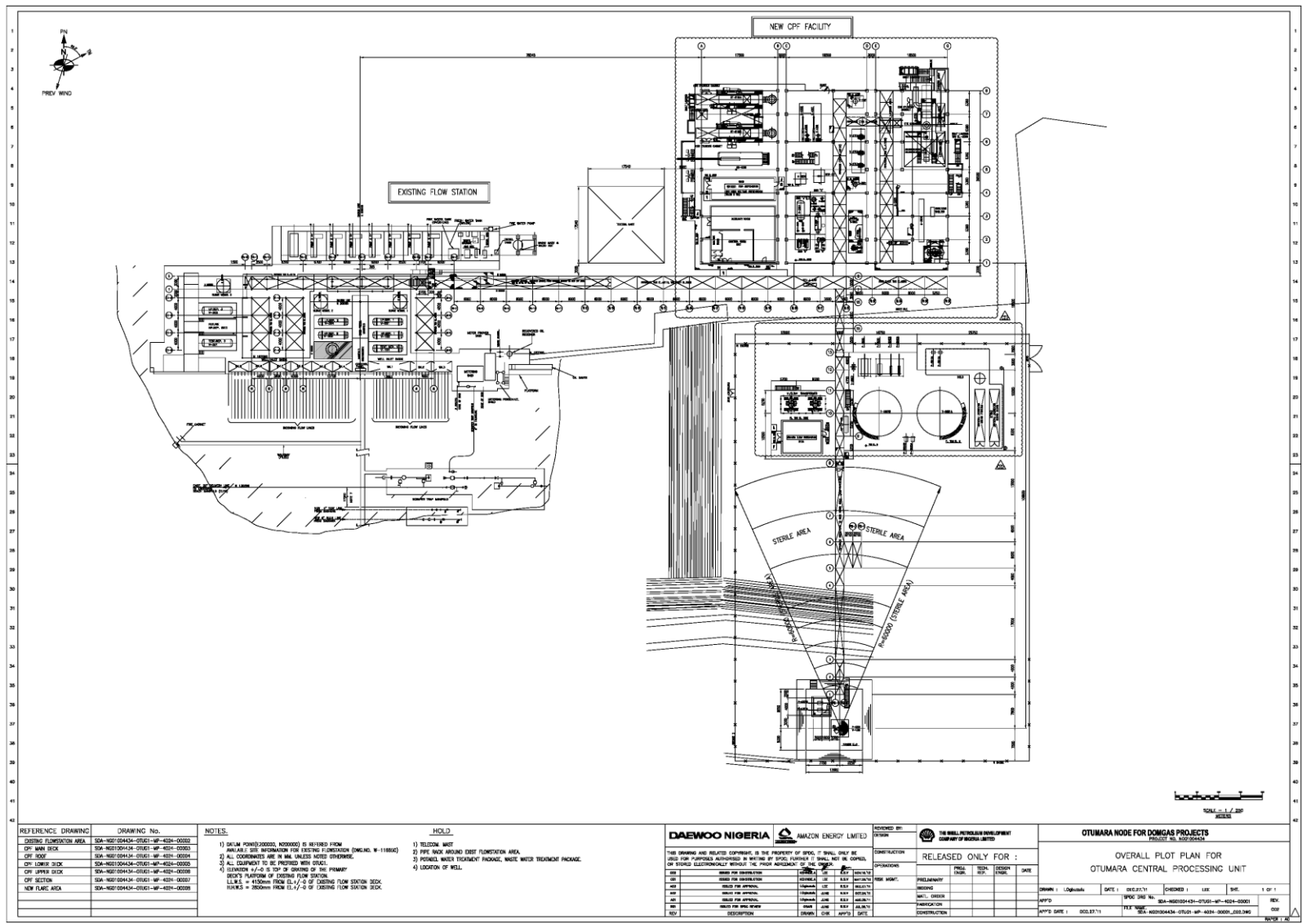


Fig. 3.4: CPF Facility Layout in Otumara Flowstation

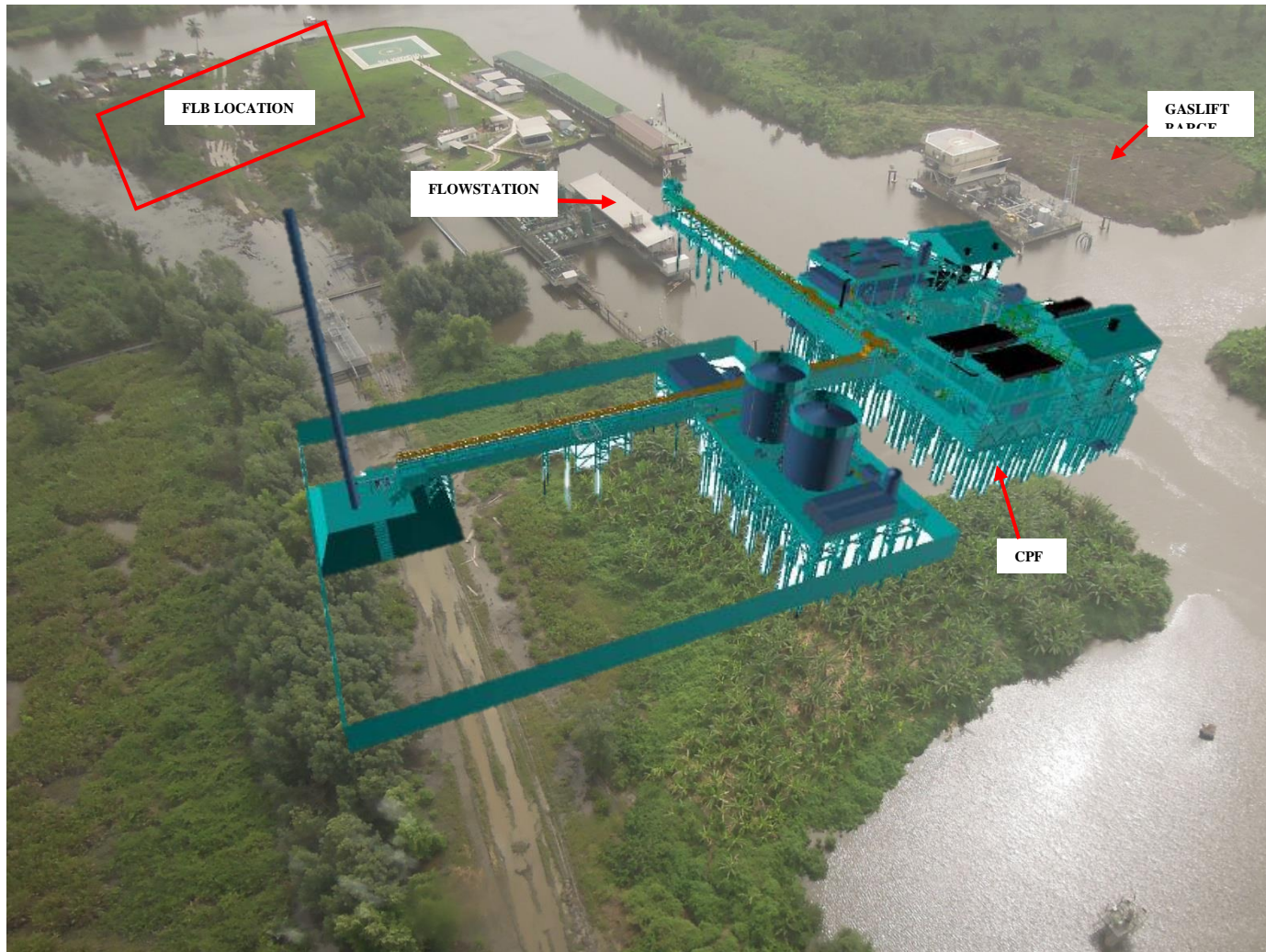


Fig 3.5 Proposed CPF Imposed on Otumara Flowstation

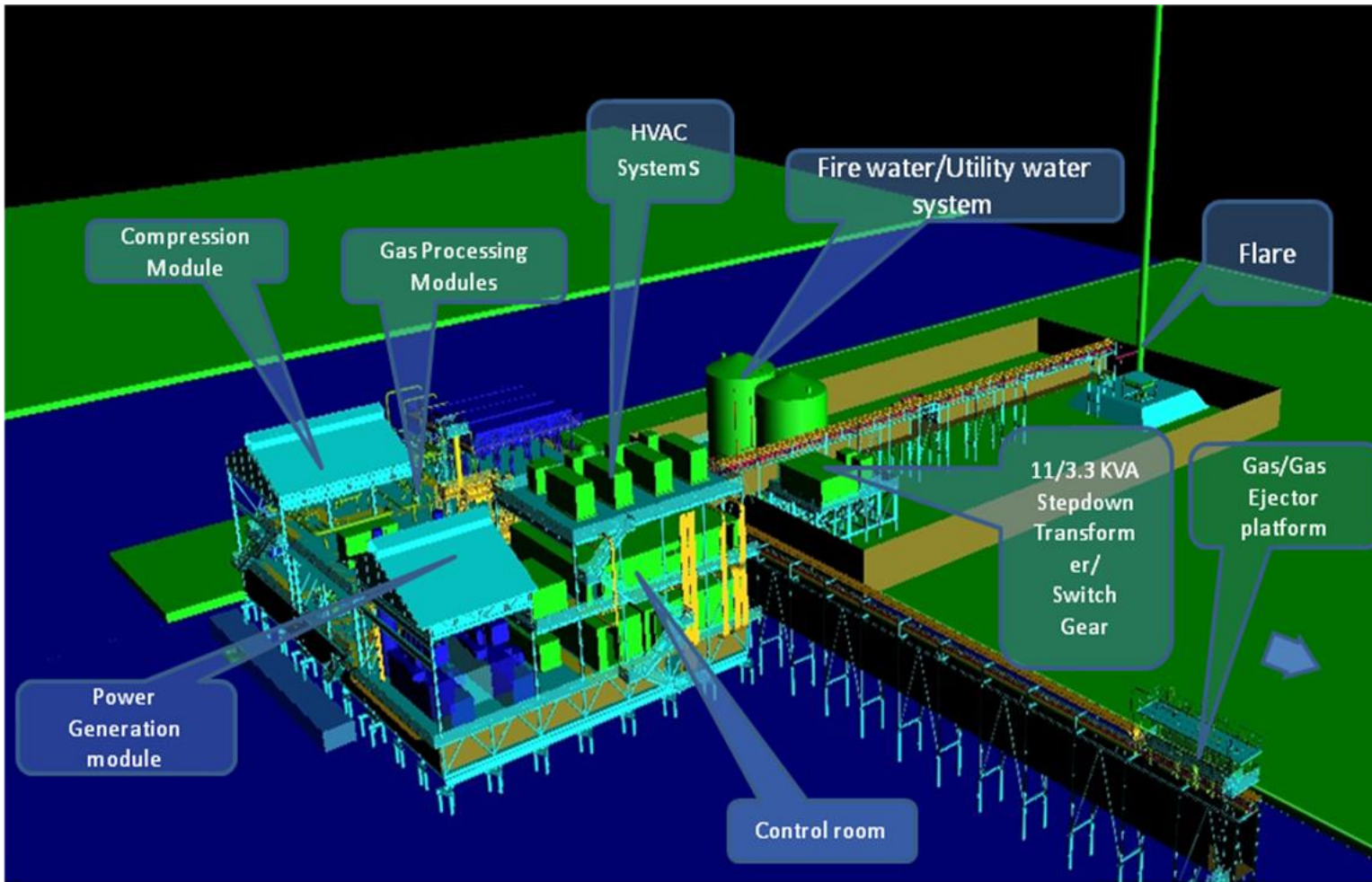


Fig 3.6: Central Processing Facility – 3D Model

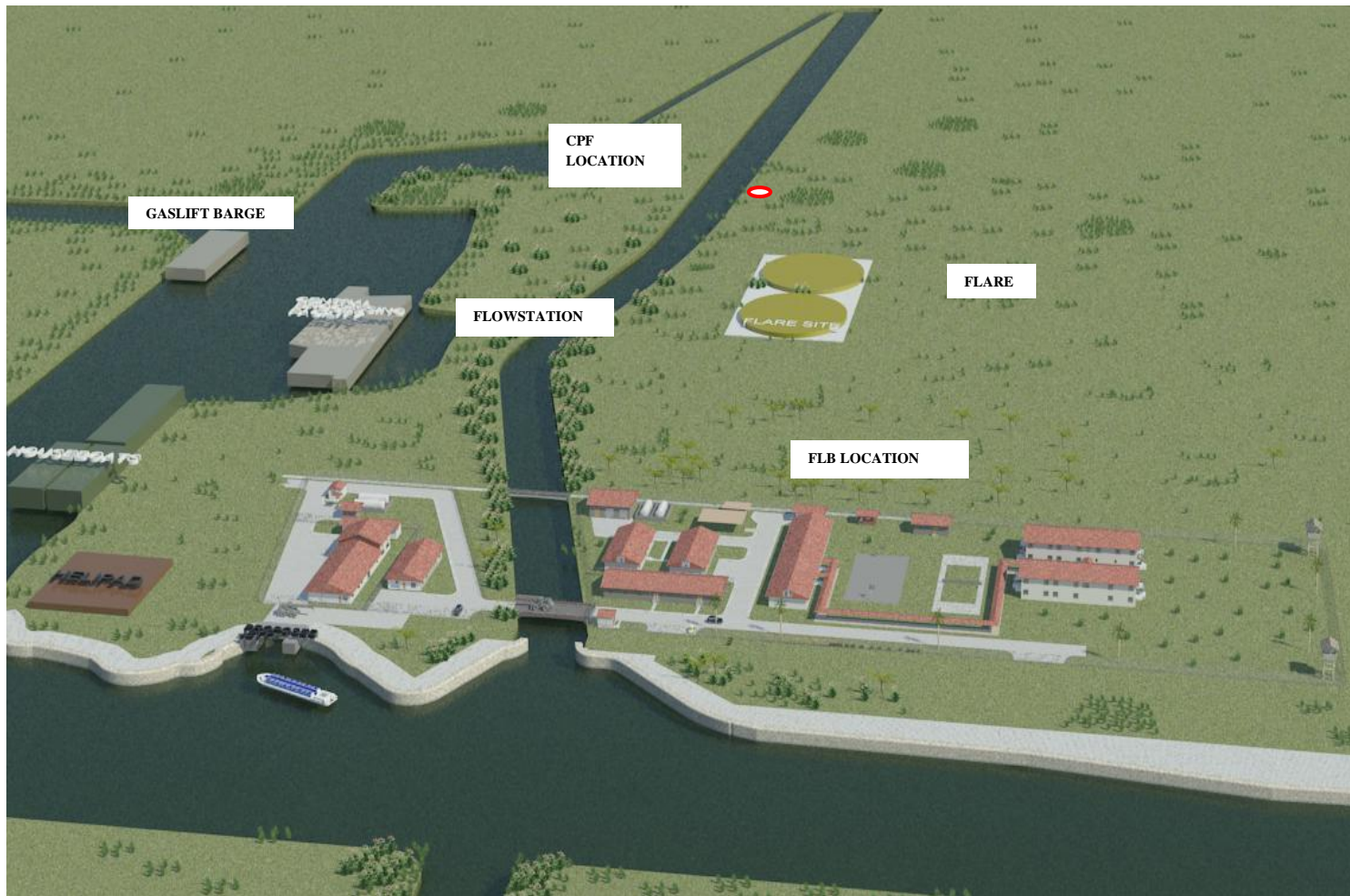


Fig 3.7 FLB superimposed on Otumara Field location

Environmental Impact Assessment (EIA) of Otumara AGS Project



Fig 3.8: Field Logistics Base – 3D Model

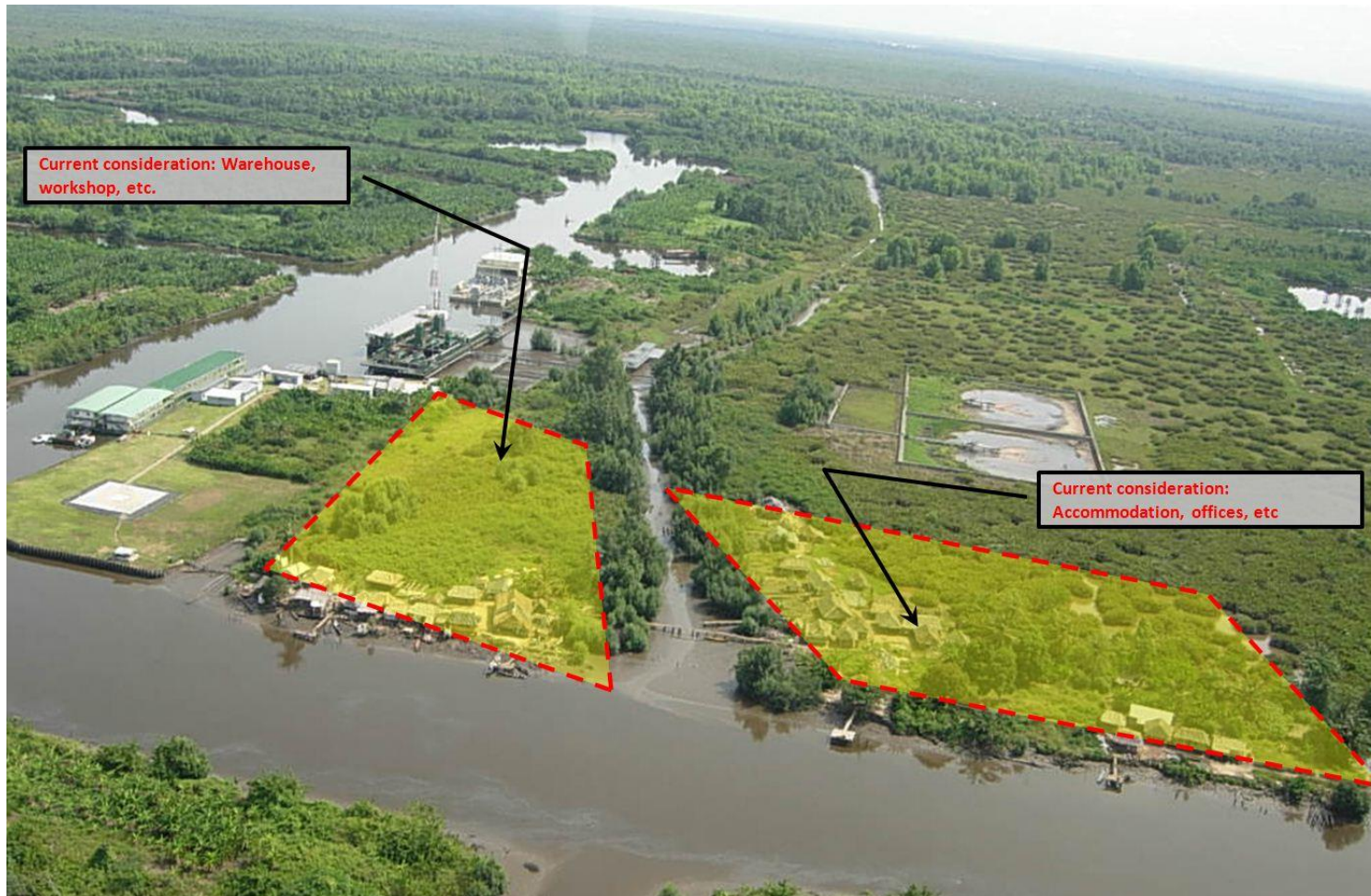


Fig 3.9: Pictorial View of Otumara Showing Proposed FLB Location



Fig 3.10: Superimposed FLB on Otumara location

Table 3.1: Potential Waste Expected From The Otumara AGS Project

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

Drainage Discharges

Drainage discharges will occur from a number of sources including:

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

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

CHAPTER FOUR

DESCRIPTION OF THE ENVIRONMENT

4.1 Introduction

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

4.1.1 Quality Assurance/Quality Control (QA/QC)

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

4.1.2 Sample Collection and Handling

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

4.1.3 Laboratory Analyses

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

4.1.4 Statistical Analysis

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

4.1.5 Data Coding and Manipulation

Environmental Impact Assessment (EIA) studies in most developing countries where reliable data banks are non-existent, invariably involve acquisition of large amounts of baseline data. To ensure preservation of the integrity of data collected, data coding forms for use in the field were designed in such a way that field data could be directly entered into computer data sheets. Since their analysis may be required in legal proceedings, it is essential to establish sample authenticity. Samples must be properly sealed and labelled. All data collected were labelled and the following information provided among others:

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

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

4.1.6 Scope of Work

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

Literature Review

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

Details of Environmental Description

The workscope of the proposed study is shown in Appendix 1.

Sampling Location

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

Table 4.1: Sampling Stations and Codes

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

The overriding considerations in the selection of sampling points included ecological features, geographical location of communities/settlements which are within a kilometer on either side of the pipeline network and a 5 km radius of a major facility such as the field flow

stations, Manifolds, CPF, and areas of interest from satellite imageries and situating control points in undisturbed areas outside the project area but within the same ecological zone.

The Study Area and its Topography

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

4.2 Meteorology, Air Quality and Noise Studies

4.2.1 Meteorology – Historical Background

The climatic information for the project area is based on the analysis of long term historical data collected for the study area by the Federal Meteorological Services Department, Oshodi for Warri between 1995 and 2006. Meteorological data were also collected during the fieldwork in the project area as shown in the sampling map (Fig. 4.1). The sampling locations are as listed in Table 4.2.

Wind speed and Direction

The project area is under the Tropical Wet climate zone. Analysis of climatic data obtained from synoptic stations in Warri shows the prevailing wind directions as presented in Fig. 4.2.1. The wind rose shows that Southerly and Southwesterly and Easterly winds are the most predominant. While the Southerlies record higher wind speeds ranging between 2 and 6 m/s frequently, the easterlies are generally below 2 m/s. The Southeasterlies, Northwesterlies and the others are rather less frequent. More detailed examination of the records show that the Southwesterly is predominant between March and October which roughly coincides with the rainy season. On the other hand, the Northeasterlies are rather frequent between November and February during the dry season. The Southeasterlies and Northwesterly are more evenly distributed throughout the year. The microclimate in this area is largely determined by these trade winds in a complex manner. The predominance of Easterlies and Westerlies may be due to the influence of the sea. Average wind speeds measured at the sampling points are presented in Table 4.2.1a, b, representing the Wet and the Dry Seasons respectively.

Wind velocities were observed to be very low at all the sites monitored. The measured wind speed range for all sampling points was 0.8 – 1.3 m/s in the Wet Season, and from 0.6 – 3.0

m/s in the Dry Season. The observed low wind velocity is worrisome, because wind speed determines the ability of the atmosphere to dilute and disperse the emitted pollutants. The wind directions were found to be Southwesterly at all the sampling points during the Wet Season and Northeasterly in the Dry Season.

Relative Humidity

The historical average Relative Humidity for the project area is presented in Figure 4.2.2. The figure shows that relative humidity values are high all year round with an average of 80.5% which is typical of equatorial climate. Humidity values naturally exceed 85% during the rainy season under the influence of moisture laden Southwesterly. The daily variation of relative humidity is intricate. Usually it is highest in the morning and drops to a low value just before dusk. The drop is very significant during the dry season, as can be seen by the minimum Relative Humidity values in the chart. Recorded values during field work ranged from 68.2% to 76.1% in the Dry Season and from 74% to 82.7% in the Wet Season. These values correlate well with the historical data average. This is a measure of the degree of wetness or dryness of the atmosphere.

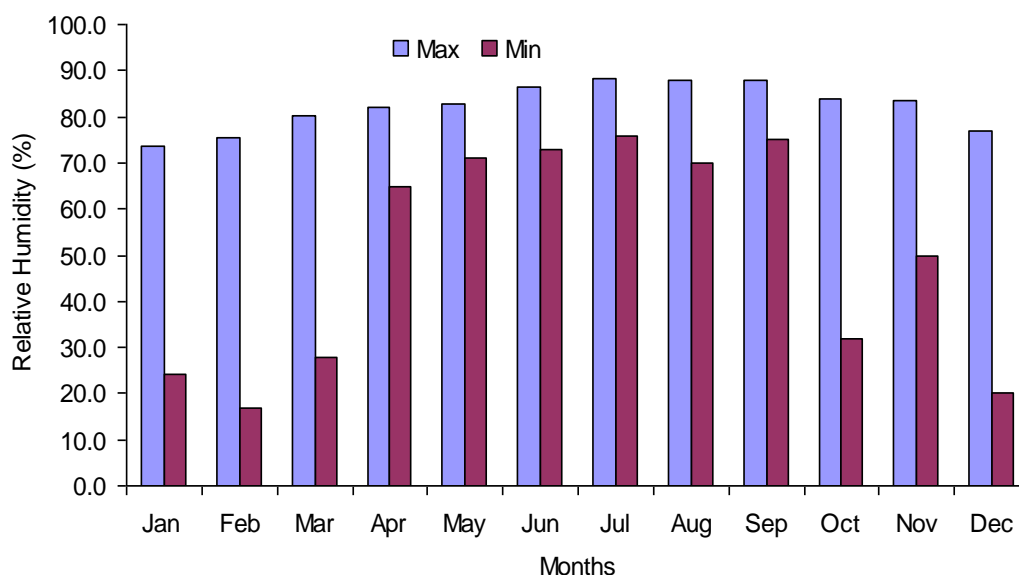


Fig. 4.2.1: Average Relative Humidity for Warri Synoptic Station
(Source: Nigerian Meteorological Agency, Oshodi, Lagos)

Rainfall

The project area is located within the equatorial belt that experiences rainfall for most of the year. Eleven year historical climatic data covering 1995 to 2006 confirms that rainfall is recorded year round. The average monthly rainfall is presented in Figure 4.2.3. The figure, however, shows that over 90% rainfall is recorded between the months of March and November. Rainfall in the area has a typical bimodal distribution which peaks in July, drops slightly in August rises again in September and drops off. The mean annual rainfall often exceeds 2450 mm.

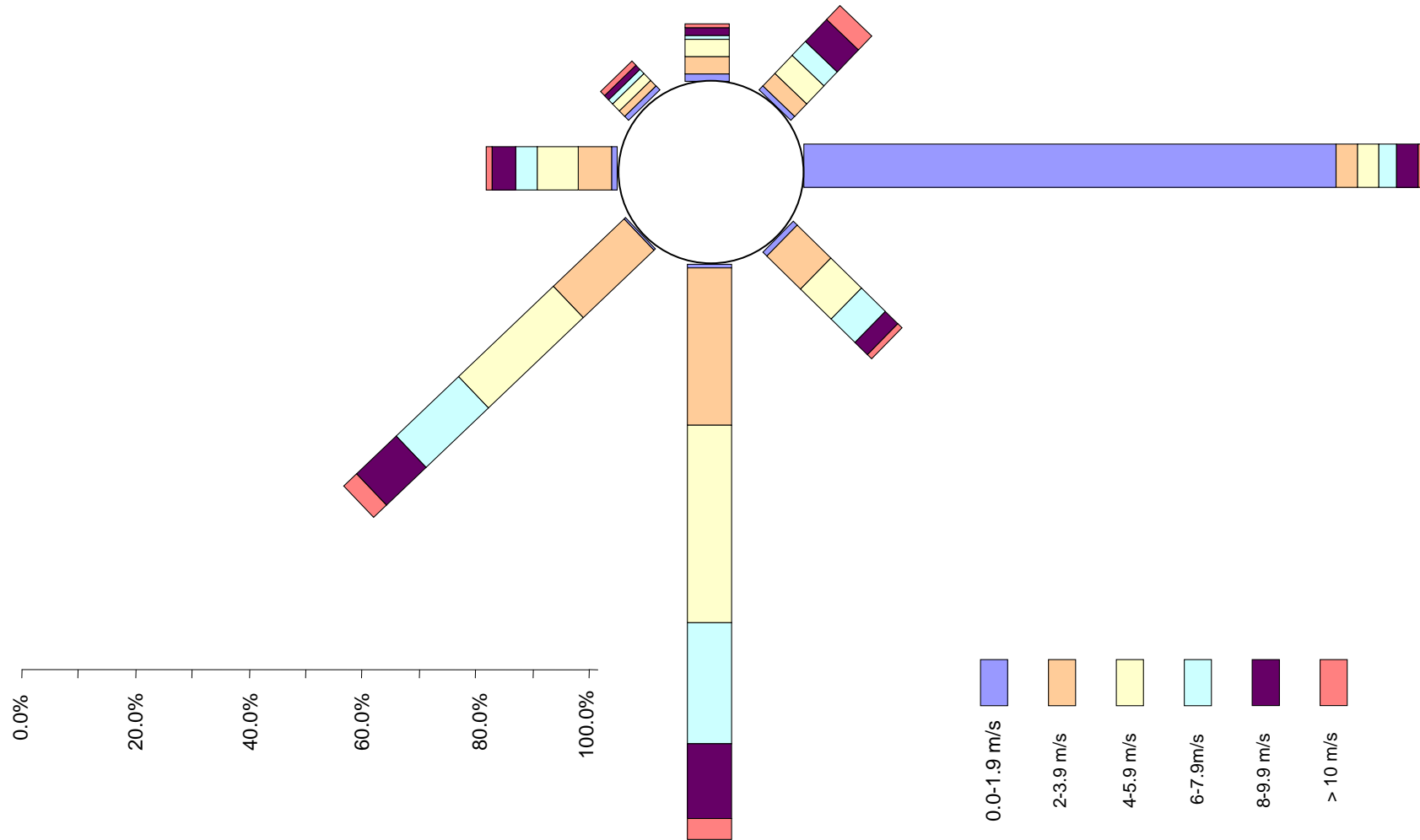


Fig. 4.2.2: Wind rose of 11 (1995-2006) year historical data of wind speed and direction for Warri synoptic station
 Source: Nigerian Meteorological Agency, Oshodi, Lagos

Table 4.2.1a: Ambient Temperature, Relative Humidity, Wind Speed and wind Direction within the Study Fields (August. 2012)

| Location ID | Geolocation | | Temp °C | Rel. Hum % | Wind speed m/s | Wind Direction |
|-------------------------|-------------|----------|-------------|------------------|-------------------|---------------------------|
| | Northings | Eastings | | | | |
| AQ9 Otumara | 182305 | 302770 | 30.0 | 70.5 | 0.8 | South Westerly |
| AQ10 Otumara | 182332 | 301447 | 28.9 | 68.2 | 1.0 | South Westerly |
| AQ11 Otumara | 183059 | 302082 | 31.2 | 68.4 | 1.1 | South Westerly |
| AQ12 Otumara | 183456 | 303392 | 31.2 | 76.1 | 1.1 | South Westerly |
| AQ13 Otumara | 184223 | 303789 | 29.5 | 60.5 | 1.3 | South Westerly |
| AQ14 Otumara | 183734 | 300838 | 30.0 | 71.5 | 0.8 | South Westerly |
| AQC2 Contrl | 166814 | 308511 | 30.5 | 70 | 1.1 | South Westerly |
| AQ7 Contrl | 180480 | 304582 | 31.5 | 68.3 | 1.2 | South Westerly |
| Mean | | | 30.4 | 69.2 | 1.05 | South Westerly |

Table 4.2.1b: Ambient Temperature, Relative Humidity, Wind Speed and wind Direction within the Study Fields (January. 2013)

| Location ID | Geolocation | | Temp °C | Rel. Hum % | Wind speed m/s | Wind Direction |
|-------------------------|-------------|----------|-------------|------------------|-------------------|-----------------------|
| | Northings | Eastings | | | | |
| AQ9 Otumara | 182305 | 302770 | 32.0 | 74.0 | 0.6 | North Easterly |
| AQ10 Otumara | 182332 | 301447 | 33.6 | 80.4 | 0.8 | North Easterly |
| AQ11 Otumara | 183059 | 302082 | 32.7 | 82.7 | 3.0 | North Easterly |
| AQ12 Otumara | 183456 | 303392 | 31.5 | 81.3 | 0.8 | North Easterly |
| AQ13 Otumara | 184223 | 303789 | 30.0 | 81.0 | 1.0 | North Easterly |
| AQ14 Otumara | 183734 | 300838 | 33.5 | 81.6 | 1.0 | North Easterly |
| AQC2 Contrl | 166814 | 308511 | 31.0 | 81.2 | 2.0 | North Easterly |
| AQ7 Contrl | 180480 | 304582 | 33.5 | 81.8 | 1.3 | North Easterly |
| Mean | | | 32.2 | 80.5 | 1.3 | North Easterly |

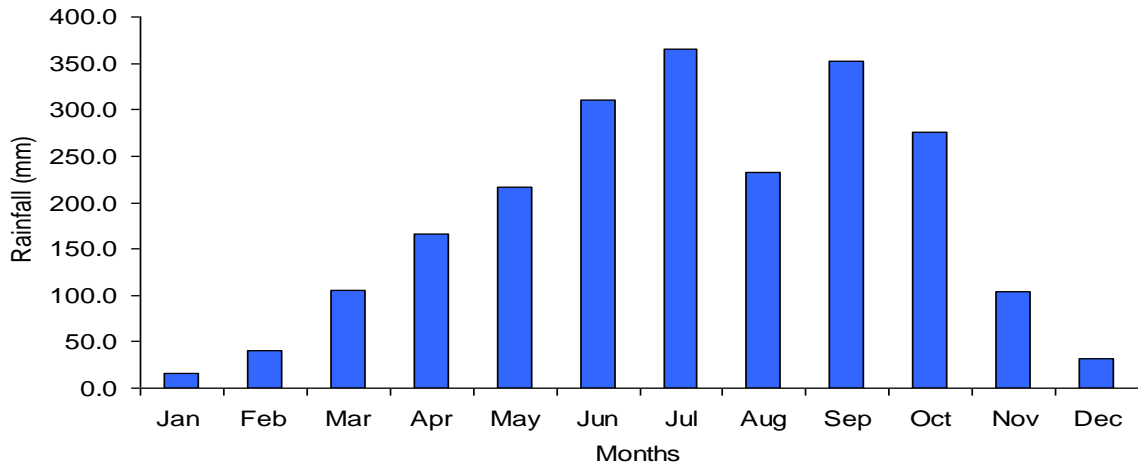


Fig. 4.2.3: Average Monthly Rainfall distribution for Warri Synoptic Stations
(Source; Nigerian Meteorological Agency, Oshodi, Lagos)

Temperature

Figure 4.2.4 shows the 10-year average maximum, minimum and the mean monthly temperatures for the project area. Temperatures are usually high and vary little year round which is typical of the equatorial belt. The mean temperature for the hottest months February/March is 34 °C while that of the coolest month (August) is 28 °C. The average temperature difference between the hottest and coolest months is about 3 °C while the mean daily temperatures range is over twice that (at about 6.5 °C). Air Temperatures recorded during the field work were between 27.8 °C and 31.5 °C and hardly exceeded 35 °C as presented in Table 4.2.1. Most of the readings were taken between 10.00 am and 5.00 pm when daily temperatures are at their maxima. These temperatures are typical of this region during this period of the year. As expected for a tropical climate, high atmospheric temperatures were measured at all the sampling locations.

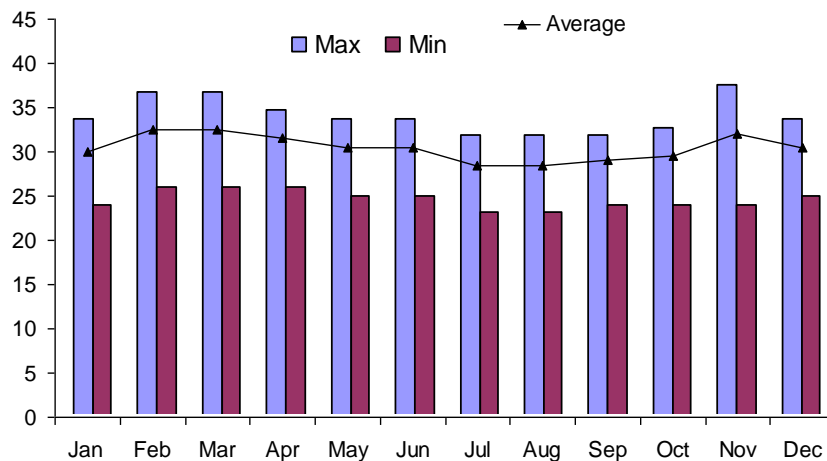


Fig. 4.2.4: Average Monthly Temperatures for Warri Synoptic Station
(Source; Nigerian Meteorological Agency, Oshodi, Lagos)

4.2.2 Air Quality and Noise

The following air pollution parameters were monitored during field work:

- (a) Noise level
- (b) Total suspended Particulates (TSP)
- (c) Suspended Particulate Matter (SPM)
- (d) Nitrogen Dioxide (NO₂)
- (e) Carbon Monoxide (CO)
- (f) Sulphur Dioxide (SO₂)
- (g) Ammonia (NH₃)
- (h) Volatile Organic Compounds (VOC/HCs)
- (i) Methane (CH₄)
- (j) Hydrogen Sulphide (H₂S)

Eight (8) Air Quality sampling points including two controls were designated within and around the field, while some of the sites were selected at remote locations along the windward direction from the facilities. The observed noise and air quality conditions at the study points are shown in Tables 4.3.2 a, b, for Wet and Dry Seasons respectively.

Table 4.2.2a: Measured Air Quality/Noise Parameters at the Monitoring Points (August, 2012 - Wet Season)

| Location ID | Geolocation | | Noise level dB(A) | SPM µg/m ³ | TSP | Air Quality ppm | | | | | | |
|-------------------------------|-------------|----------|----------------------|--------------------------|-------------|--------------------|-------------------|-------------|------------------|-----------------|-----------------|------------|
| | Northings | Eastings | | | | NO _x | SO _x | CO | H ₂ S | NH ₃ | CH ₄ | VOC |
| AQ9 Otumara | 302770 | 182305 | 54.2 | | | 0.10 | 0.21 | 5.41 | 0.01 | 0.01 | 0.01 | 2.0 |
| AQ10 Otumara | 301447 | 182332 | 58.9 | 1.18 | 2.16 | 0.06 | 0.01 | 3.17 | 0.01 | 0.01 | 0.01 | 3.5 |
| AQ11 Otumara | 302082 | 183059 | 56.8 | 2.66 | 40.9 | 0.08 | 0.27 | 4.01 | 0.01 | 0.01 | 0.01 | 6.4 |
| AQ12 Otumara | 303392 | 183456 | 56.2 | 2.33 | 2.81 | 0.29 | 0.07 | 2.36 | 0.01 | 0.01 | 0.01 | 7.4 |
| AQ13 Otumara | 303789 | 184223 | 46.3 | 1.14 | 2.01 | 0.08 | 0.01 | 1.73 | 0.01 | 0.01 | 0.01 | 0.80 |
| AQ14 Otumara | 300838 | 183734 | 46.5 | 1.06 | 1.32 | 0.10 | 0.01 | 3.51 | 0.01 | 0.01 | 0.01 | 2.4 |
| AQC2 Contr | 308511 | 166814 | 61.0 | 0.68 | 0.91 | 0.08 | 0.14 | 1.34 | 0.01 | 0.01 | 0.01 | 0.70 |
| AQ7 Contr | 304582 | 180480 | 60.0 | 1.12 | 1.46 | 0.06 | 0.01 | 1.84 | 0.01 | 0.01 | 0.01 | 2.10 |
| Mean | | | 54.99 | 1.45 | 7.37 | 0.11 | 0.09 | 2.92 | 0.01 | 0.01 | 0.01 | 3.2 |
| FMEEnv Guidelines & Standards | | | 90 | | 250 | 0.04- 0.06 | 0.01 0.10 | 10 - 20 | 0.00 6 | 0.29 | - | - |
| DPR Guidelines & Standards | | | | | 60-90 | 0.06 | 0.04 - 0.06 | 10 | - | - | - | - |
| WHO Guidelines & Standards | | | | 100- 150 | 150- 230 | 0.08 0.11* * | 0.17 5* | 10 | | | | |

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

Table 4.2.2b: Measured Air Quality/Noise Parameters at the Monitoring Points (January, 2013 - Dry Season)

| Location ID | Geolocation | | Noise level dB(A) | SPM ug/m ³ | TSP | Air Quality ppm | | | | | | | |
|------------------------------|-------------|----------|----------------------|--------------------------|-------------|--------------------|-----------------|-------------|------------------|-----------------|-----------------|-------------|--------------|
| | Northings | Eastings | | | | NO _x | SO _x | CO | H ₂ S | NH ₃ | CH ₄ | VOC | |
| AQ9 Otumara | 302770 | 182305 | 64.2 | 16.5 | 34.0 | 0.09 | 0.01 | 0.06 | 0.01 | 0.01 | 0.01 | 0.01 | 21.73 |
| AQ10 Otumara | 301447 | 182332 | 63.7 | 32.1 | 40.0 | 0.07 | 0.10 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 11.29 |
| AQ11 Otumara | 302082 | 183059 | 61.8 | 24.1 | 36.1 | 0.04 | 0.03 | 2.01 | 0.01 | 0.01 | 0.01 | 0.01 | 13.04 |
| AQ12 Otumara | 303392 | 183456 | 65.5 | 21.1 | 28.5 | 0.08 | 0.01 | 1.17 | 0.01 | 0.01 | 0.01 | 0.01 | 14.12 |
| AQ13 Otumara | 303789 | 184223 | 65.0 | 13.8 | 19.2 | 0.06 | 0.01 | 1.12 | 0.01 | 0.01 | 0.01 | 0.01 | 18.96 |
| AQ14 Otumara | 300838 | 183734 | 64.2 | 16.5 | 34.0 | 0.09 | 0.01 | 0.06 | 0.01 | 0.01 | 0.01 | 0.01 | 21.73 |
| AQC2 Contr | 308511 | 166814 | 63.7 | 32.1 | 40.0 | 0.07 | 0.10 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 11.29 |
| AQ7 Contr | 304582 | 180480 | 68.0 | 14.0 | 18.1 | 0.08 | 0.06 | 0.01 | 0.01 | 0.01 | 4.0 | 0.01 | 12.01 |
| Mean | | | 60.01 | 22.3 | 33.1 | 0.07 | 0.04 | 0.63 | 0.01 | 0.01 | 0.01 | 0.01 | 15.82 |
| FMEnv Guidelines & Standards | | | 90 | | 250 | 0.04 0.06 | 0.01 0.10 | 10 - 20 | 0.00 6 | 0.29 | - | - | - |
| DPR Guidelines & Standards | | | | | 60- 90 | 0.06 - | 0.04 0.06 | 10 | - | - | - | - | - |
| WHO Guidelines & Standards | | | | | 100- 150 | 0.08 0.11 ** | 0.17 5* | 10 | | | | | |

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

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

These two terminologies are often used interchangeably, but there is some subtle difference as reflected in Tables 4.2.2 a,b. It appears to be a matter of size.

Tiny airborne particles or aerosols that are less than 100 micrometers are collectively referred to as total suspended particulates (TSP). These particles constantly enter the atmosphere from many sources (see Figure 4.2.5).

Suspended Particulate Matter (SPM) on the other hand, constitute the sum of all solid and liquid particles suspended in air, ranging in size from 0.1 micrometer to about 30 micrometer in diameter, many of which are hazardous. This complex mixture contains for instance dust, pollen, soot, smoke, and liquid droplets.

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

The results in Tables 4.2.2 a, b, show negligible level of particulates at all sampled points (compared to National and WHO limits in Tables 4.2.3 and 4.2.4). As would be expected, particulates were higher in the dry season than in the wet season.

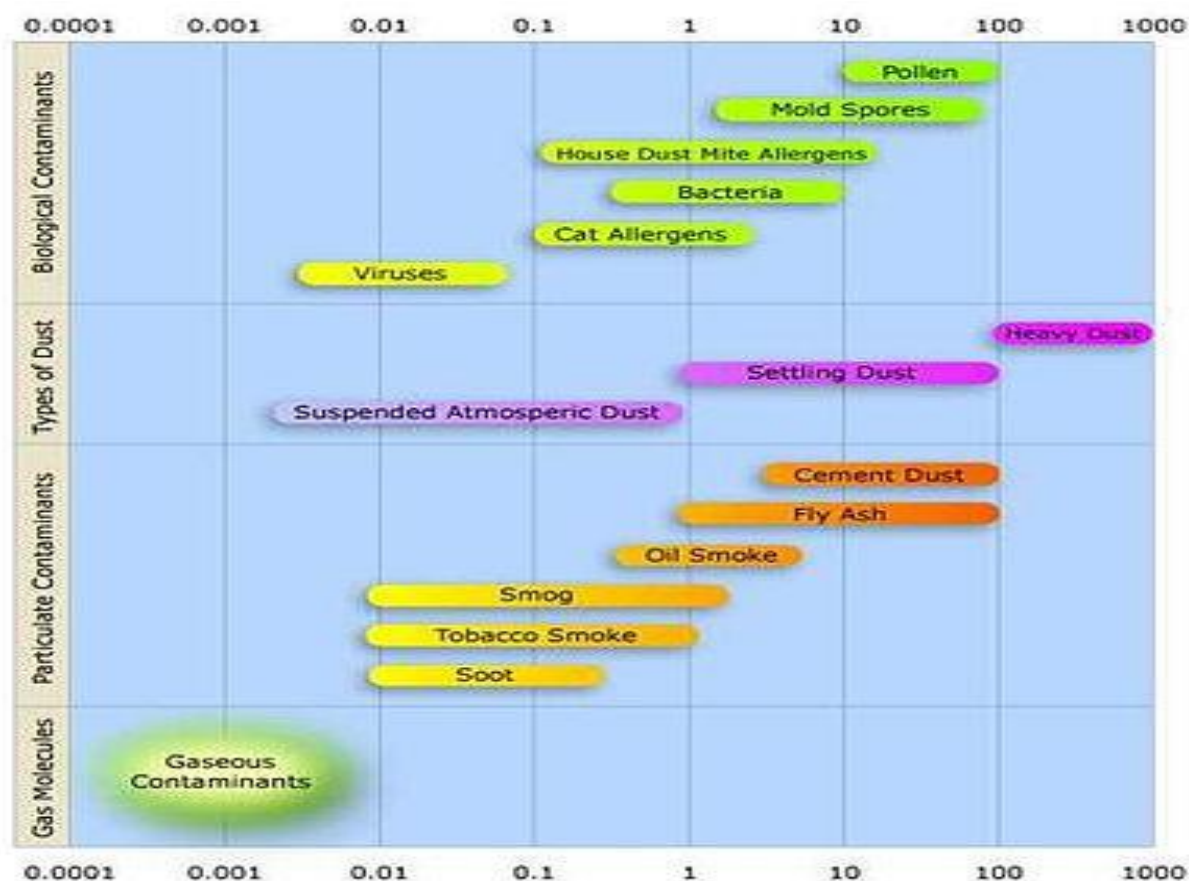


Fig. 4.2.5: Diagram showing the size distribution in micrometres of various types of atmospheric particulate matter.

It also shows the different types of particulates in the atmosphere

(Source: Wikipedia)

Other Parameters

Sulphur Dioxide (SO₂)

In discussing air quality results, one must be mindful of the *averaging sampling time*. Much higher concentrations are tolerable over shorter averaging time, like 10 minutes used in this study, than longer averaging times stipulated in the Regulatory Standards. For this reason, the WHO (2005) stated that “*controlled studies with exercising asthmatics indicate that some asthmatics experience changes in pulmonary function and respiratory symptoms after periods of exposure as short as 10 minutes. Based on this evidence, it is recommended that a value of 500 µg/m³ (0.175 ppm) for SO₂ should not be exceeded over averaging period of 10 minutes.*” It can therefore be deduced that the SO₂ concentration of 0.27 ppm measured at AQ11 during the wet season, is non-compliant with National and International limits. This sampling point is about 450 metres West of Otumara Flowstation and may have been influenced by the Flare Site. Fortunately, there is no Community within 2 km of this sampling point.

Nitrogen Dioxide (NO₂)

Many chemical species of nitrogen oxides (NO_x) exist, but the air pollutant species of most interest from the point of view of human health is nitrogen dioxide (NO₂), Nitrous Oxide, N₂O being a major contributor to global atmospheric warming potential.

On a global scale, emissions of nitrogen oxides from natural sources far outweigh those generated by human activities. Natural sources include intrusion of stratospheric nitrogen oxides, bacterial and volcanic action, and lightning. Because natural emissions are distributed over the entire surface of the earth, however, the resulting background atmospheric concentrations are very small. The major source of anthropogenic emissions of nitrogen oxides into the atmosphere is the combustion of fossil fuels in stationary sources, gas flares, (heating, power generation) and in motor vehicles (internal combustion engines).

Results in Table 4.2.2a, b, show that concentrations at all sampling points, except AQ11, were above the Regulatory Daily Hourly Range of 0.04-0.06 ppm. Given that the measured concentrations were averaged over a period less than 5 minutes, these values do not necessarily translate to non-compliance, because a 15-minute concentration of 2716 $\mu\text{g}/\text{m}^3$ (1.44 ppm) was recorded for a home with an unvented gas space heater, without noticeable deleterious effects (Koontz *et al.*, 1988). However, such exceedances should be of concern because even though averaging times were short, it is probable that such conditions could remain for much longer periods. This same observation is also applicable to comments made on SO_2 above. Although no host communities are within 2 km of Otumara Flowstation, if these concentrations persist for longer periods, they could pose occupational health hazards for SPDC staff.

Noise

The baseline outdoor noise levels within and around the proposed project areas are shown in Tables 4.2.2a, b. Noise level measurements were made at the same points as air quality. A mean noise range of 46.3 – 68 dB(A) was obtained outdoors. Noise levels were generally higher in the Dry Season, than in the Wet Season, as would be expected, due to higher ambient temperatures during the Dry Season (Speed of sound increases with temperature). All noise measurements were within the Regulatory Guideline of 90 dB(A). The noise level at AQ11, which is 450 m from Otumara Flowstation was 56.8 dBA while that at AQ13 which is about 2 km from the Flowstation was 46.3 dBA. Since no community is within 2 km of the Flowstation, it means that the existing operation of Otumara Flowstation has no impact on host communities. Tables 4.2.4 – 4.2.7 show the Nigerian Ambient Air Quality Standard, WHO Noise Exposure Guidelines, Natural Atmospheric Concentration of Some Greenhouse Gases and the Evolution of Atmospheric Concentrations of Key Greenhouse Gases influenced by Human Activities.

Table 4.2.3: Summary Comparison of the Mean Field Concentrations of Air Quality Indicators

| PARAMETER | OTUMARA NODE Dry Season Field Mean (Jan, 2013) | OTUMARA NODE Wet Season Field Mean (Aug, 2012) | FME _{env} | DPR |
|----------------------------------------------------------------------|------------------------------------------------------|------------------------------------------------------|--------------------|---------------|
| SPM [$\mu\text{g}/\text{m}^3$] | 25.3 | 1.45 | 250.0 | 150.0 – 230.0 |
| TSP | 36.5 | 7.37 | | |
| SO_x (as SO_2) [ppm] [$\mu\text{g}/\text{m}^3$] | 0.04 | 0.09 | 0.1 | 0.04 – 0.06 |
| NO_x (as NO_2) [ppm] | 0.07 | 0.11 | 0.04 – 0.06 | 0.08 |
| CO [ppm] | 0.85 | 2.92 | 10.0 | 26.0 |
| H_2S [ppm] | 0.01 | 0.01 | 0.006 | - |
| CH_4 ppm | 1.0 | 0.01 | - | - |
| VOC ppm | 15.82 | 3.2 | - | - |
| CO_2 [$\mu\text{g}/\text{m}^3$] | - | - | - | - |
| NH_3 [ppm] | 0.01 | 0.01 | 0.29 | - |
| Noise [dBA] | 63.04 | 54.99 | 90 | - |

Table 4.2.4: Nigerian Ambient Air Quality Standard.

| Pollutants | Time of Average | Limit |
|------------------------------------|---------------------------------------------------------------------------|------------------------------------------------------------------------------------|
| Particulates | Daily average of hourly values 1hr. | 250 $\mu\text{g}/\text{m}^3$ 600* $\mu\text{g}/\text{m}^3$ |
| SO _x as SO ₂ | Daily average of hourly values 1 hour Daily average of 3 hourly values | 0.01 ppm (26 $\mu\text{g}/\text{m}^3$) 0.1 ppm (260 $\mu\text{g}/\text{m}^3$) |
| NO _x as NO ₂ | Daily average of hourly values (range) | 0.04 - 0.06 ppm (75 - 113 $\mu\text{g}/\text{m}^3$) |
| Carbon Monoxide | Daily average hourly values (range) | 10 - 20 ppm (11.4 - 22.8 $\mu\text{g}/\text{m}^3$) |
| Petrochemical Oxidants | | 0.06 ppm |
| Non - Methane Hydrocarbon | Daily average of 8 - hourly values | 160 $\mu\text{g}/\text{m}^3$ |

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

Table 4.2.5: World Health Organisation (WHO) Guidelines For Maximum Exposure To The Major Pollutants And Some Possible Effects If These Recommendations Are Exceeded.

| Pollutant | Possible Effects | WHO Guidelines |
|-------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Sulphur dioxide (SO ₂) | Worsening respiratory illness from short term exposure, increased respiratory symptoms, including chronic bronchitis, from long-term exposures | 40-50 $\mu\text{g}/\text{m}^3$ (annual mean); 100-150 $\mu\text{g}/\text{m}^3$ (Daily average) |
| Suspended Particulate Matter (SPM) | Pulmonary effects are associated with the combined exposure to SPM and SO ₂ | Black: 40-60 $\mu\text{g}/\text{m}^3$ (Annual mean). 100-150 $\mu\text{g}/\text{m}^3$ (Daily average) Total SPM: 60-150 $\mu\text{g}/\text{m}^3$ (Annual mean); 150-230 $\mu\text{g}/\text{m}^3$ (Daily average) |
| Nitrogen dioxide (NO ₂) | Effects on lung function in persons suffering from asthma from short-term exposures | 150 $\mu\text{g}/\text{m}^3$ for 24 hr mean; 400 $\mu\text{g}/\text{m}^3$: Not to be exceeded |
| Carbon Monoxide (CO) | Reduced oxygen - carrying capacity of blood | 10 $\mu\text{g}/\text{m}^3$ (for 8 hr); not to be exceeded. |

Source: WHO Air Quality Guidelines for Europe 2010

Table 4.2.6: Natural Atmospheric Concentration of Some Greenhouse gases

| Gases | Concentrations |
|------------------|-----------------|
| CO ₂ | 340 ppmv |
| CH ₄ | 2 ppm v |
| N ₂ O | 0.3 ppm v |
| CO | 0.05 - 0.2 ppmv |
| O ₃ | 0.2 - 10 ppmv |
| NH ₃ | 4 ppbv |
| NO ₂ | 1 ppbv |
| SO ₂ | 1 ppbv |

| Gases | Concentrations |
|------------------|----------------|
| H ₂ S | 0.05 ppbv |

Source: Andersen-Sellers & Robinson (1986)

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

Table 4.2.7: Evolution of Atmospheric Concentrations of Key Greenhouse gases influenced by Human Activities

| Parameter | CO ₂ | CH ₄ | N ₂ O |
|--------------------------------------------------------|-----------------|-------------------|------------------|
| Pre-industrial atmospheric concentration (1750 - 1800) | 280 ppmv | 0.7 ppmv | 270 ppbv |
| Current atmospheric concentration 2010 | 388.5 ppmv | 1.87 ppmv | 323 ppbv |
| Current rate of annual atmospheric accumulation | 1.8 ppmv (0.5%) | 0.015 ppmv (0.9%) | 0.8 ppbv (0.25%) |
| Atmospheric life time (years) | (50 - 200) | 10 | 150 |

Source: IPCC 2011

4.3: Soil and Land Use

4.3.1: Soil quality

Soil Physical and Chemical Characteristics

Tables 4.3.1 present the analytical results of the physico-chemical, heavy metals and microbiological characteristics of the soil of Otumara Associated Gas Gathering (AGG) project area. The summary of the result is presented in Table 4.3.1, and discussed below:

Environmental Impact Assessment (EIA) of Otumara AGS Project

Table 4.3.1a: Physicochemical Analysis Of Soil At Otumara During The Wet Season

| S/N | Parameters | Units | OTU SSC1 | OTU SSC1 | OTU SS8 | OTU SS8 | OTU SS9 | OTU SS9 | OTU SS13 | OTU SS13 | OTU SS14 | OTU SS14 | OTU SS15 | OTU SS15 | OTU SS16 | OTU SS16 | OTU SS17 | OTU SS17 | OTU SS19 |
|---------------------|-------------------|----------|-------------|-------------|------------|------------|------------|------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| | Level | Cm | 0-15 | 15-30 | 0-15 | 15-30 | 0-15 | 15-30 | 0-15 | 15-30 | 0-15 | 15-30 | 0-15 | 15-30 | 0-15 | 15-30 | 0-15 | 15-30 | 0-15 |
| 1 | pH | | 4.3 | 4.9 | 4.4 | 3.7 | 3.9 | 3.7 | 3.3 | 3.7 | 4.3 | 5.2 | 4.3 | 4.1 | 4.6 | 4.4 | 4.4 | 4.8 | 5.3 |
| 2 | EC | µS/cm | 240 | 190 | 1800 | 1760 | 500 | 760 | 770 | 650 | 310 | 270 | 690 | 550 | 760 | 760 | 760 | 650 | 6650 |
| 3 | Org. C | % | 3.43 | 3.15 | 3.60 | 3.38 | 3.43 | 3.30 | 4.99 | 3.38 | 3.50 | 2.76 | 1.94 | 1.82 | 4.10 | 3.52 | 3.74 | 3.05 | 5.44 |
| 4 | Total N. | % | 0.72 | 0.64 | 0.70 | 0.66 | 0.67 | 0.64 | 0.96 | 0.65 | 0.67 | 0.52 | 0.37 | 0.35 | 0.79 | 0.68 | 0.72 | 0.59 | 1.05 |
| 5 | Na | meq/100g | 6.27 | 6.08 | 4.62 | 4.59 | 9.19 | 9.11 | 0.08 | 0.06 | 3.55 | 3.51 | 1.51 | 1.52 | 0.88 | 0.83 | 7.86 | 7.27 | 5.13 |
| 6 | K | “ | 6.32 | 6.36 | 2.61 | 2.59 | 2.39 | 2.37 | 1.16 | 1.13 | 3.70 | 3.67 | 2.99 | 2.98 | 4.04 | 4.02 | 5.15 | 5.09 | 0.11 |
| 7 | Ca | “ | 10.3 | 10.2 | 6.32 | 7.54 | 12.4 | 12.1 | 4.50 | 4.46 | 6.40 | 6.12 | 5.79 | 5.50 | 6.58 | 6.50 | 15.6 | 14.8 | 6.13 |
| 8 | Mg | “ | 7.30 | 7.11 | 5.12 | 5.60 | 9.80 | 9.89 | 1.46 | 1.34 | 3.14 | 1.98 | 2.18 | 2.10 | 2.54 | 2.46 | 8.60 | 8.13 | 2.14 |
| 9 | EA | “ | 4.5 | 2.3 | 5.4 | 2.8 | 6.8 | 4.7 | 8.0 | 6.0 | 6.8 | 2.9 | 2.2 | 1.5 | 1.9 | 1.6 | 5.4 | 1.6 | 2.2 |
| 10 | Cl ⁻ | mg/kg | 86 | 68 | 630 | 620 | 170 | 230 | 730 | 151 | 71 | 83 | 185 | 141 | 741 | 752 | 250 | 214 | 2192 |
| 11 | PO ₄ | “ | 33.2 | 32.4 | 85.2 | 78.4 | 44.4 | 40.4 | 45.2 | 42.8 | 70.0 | 64.8 | 39.6 | 29.6 | 32.0 | 27.6 | 30.8 | 22.8 | 26.0 |
| 12 | NH ₄ N | “ | 3.0 | 1.0 | 15.6 | 14.6 | 11.6 | 9.4 | 11.8 | 11.0 | 11.0 | 10.0 | 9.8 | 8.4 | 19.2 | 17.6 | 6.4 | 2.0 | 18.0 |
| 13 | NO ₂ N | “ | 8.2 | 2.6 | 5.0 | 1.8 | 8.6 | 3.8 | 5.6 | 1.8 | 8.2 | 5.3 | 9.4 | 7.8 | 10.2 | 6.4 | 9.4 | 8.0 | 9.0 |
| 14 | NO ₃ N | “ | 14.0 | 12.3 | 9.4 | 5.6 | 18.4 | 14.6 | 3.4 | 2.0 | 18.6 | 16.8 | 18.6 | 13.2 | 15.6 | 10.6 | 18.6 | 12.2 | 16.4 |
| 15 | SO ₄ | “ | 104 | 80 | 256 | 224 | 316 | 296 | 2004 | 1628 | 224 | 134 | 324 | 314 | 784 | 602 | 128 | 116 | 1016 |
| 16 | Silt | % | 3.4 | 4.9 | 1.6 | 2.0 | 1.9 | 2.2 | 2.5 | 2.7 | 1.8 | 3.0 | 2.8 | 3.4 | 3.3 | 1.6 | 1.5 | 0.7 | 1.9 |
| 17 | Clay | “ | 7.3 | 10.2 | 3.5 | 4.8 | 9.1 | 8.8 | 5.1 | 5.9 | 4.3 | 6.1 | 5.9 | 5.2 | 5.9 | 4.3 | 3.1 | 2.9 | 4.2 |
| 18 | Sand | “ | 89.3 | 84.9 | 94.9 | 93.2 | 89.0 | 89.0 | 92.4 | 91.4 | 93.9 | 90.9 | 91.3 | 91.4 | 90.8 | 94.1 | 95.4 | 96.4 | 93.9 |
| 19 | THC | mg/kg | 41.1 | 20.5 | 81.4 | 75.5 | 72.5 | 70.5 | 58.1 | 51.5 | 57.6 | 52.5 | 59.5 | 54.5 | 95.5 | 64.1 | 78.3 | 66.6 | 154.1 |
| 20 | TPH | “ | 0.007 | 0.004 | 0.041 | 0.045 | 0.036 | 0.038 | 0.036 | 0.039 | 0.052 | 0.049 | 0.043 | 0.041 | 0.061 | 0.059 | 0.061 | 0.054 | 0.069 |
| 21 | PAH | “ | 0.001 | 0.002 | 0.069 | 0.738 | 0.041 | 0.039 | 0.041 | 0.037 | 0.061 | 0.051 | 0.048 | 0.039 | 0.056 | 0.062 | 0.121 | 0.126 | 0.041 |
| 22 | Benzene | µg/kg | ND | 0.000 | 0.003 | 0.002 | 0.004 | 0.003 | 0.004 | 0.003 | 0.002 | 0.005 | 0.006 | 0.004 | 0.005 | 0.004 | 0.005 | 0.040 | 0.002 |
| 23 | Toluene | “ | 0.000 | 0.000 | ND | ND | ND | ND | ND | ND | 0.002 | 0.001 | ND | ND | ND | ND | ND | ND | 0.002 |
| 24 | Ethyl benzene | “ | ND | ND | ND | ND | ND | ND | ND | ND | ND | 0.002 | ND | ND | ND | ND | ND | ND | ND |
| 25 | Xylene | “ | ND | ND | 0.001 | 0.002 | 0.001 | 0.002 | 0.002 | 0.003 | 0.001 | 0.002 | 0.002 | 0.002 | 0.001 | 0.002 | 0.002 | 0.003 | 0.001 |
| 26 | Phenol | “ | 0.001 | 0.002 | 0.005 | 0.003 | 0.002 | 0.004 | 0.003 | 0.002 | 0.001 | 0.002 | 0.003 | 0.001 | 0.004 | 0.003 | 0.002 | 0.001 | 0.003 |
| Heavy metals | | | | | | | | | | | | | | | | | | | |
| 1 | Fe | mg/kg | 210.5 | 204.2 | 201.9 | 198.4 | 199.9 | 200.2 | 207.1 | 204.3 | 206.1 | 206.1 | 203.7 | 206.1 | 205.0 | 204.1 | 205.2 | 203.8 | 207.5 |
| 2 | Cu | “ | 5.39 | 4.95 | 3.93 | 3.92 | 4.75 | 4.97 | 4.76 | 4.94 | 4.37 | 4.72 | 6.88 | 7.10 | 5.32 | 5.02 | 4.54 | 4.69 | 5.32 |
| 3 | Mn | “ | 3.64 | 3.22 | 3.49 | 3.49 | 3.46 | 3.56 | 3.54 | 3.53 | 3.56 | 3.66 | 3.41 | 3.57 | 3.54 | 3.38 | 3.67 | 3.52 | 3.59 |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| S/N | Parameters | Units | OTU SSC1 | OTU SSC1 | OTU SS8 | OTU SS8 | OTU SS9 | OTU SS9 | OTU SS13 | OTU SS13 | OTU SS14 | OTU SS14 | OTU SS15 | OTU SS15 | OTU SS16 | OTU SS16 | OTU SS17 | OTU SS17 | OTU SS19 |
|-----|------------|-------|-------------|-------------|------------|------------|------------|------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| 4 | Zn | “ | 9.09 | 9.66 | 12.1 | 12.2 | 15.9 | 15.6 | 6.04 | 6.00 | 9.48 | 9.97 | 9.44 | 9.74 | 7.84 | 6.99 | 8.01 | 8.27 | 12.9 |
| 5 | Cd | “ | 0.14 | 0.18 | 0.25 | 0.30 | 0.22 | 0.29 | 0.20 | 0.18 | 0.22 | 0.22 | 0.24 | 0.29 | 0.29 | 0.31 | 2.28 | 2.18 | 2.90 |
| 6 | Cr | “ | 1.60 | 1.56 | 1.53 | 1.47 | 1.52 | 1.50 | 1.58 | 1.55 | 1.57 | 1.48 | 1.50 | 1.57 | 1.56 | 1.58 | 1.61 | 1.55 | 1.58 |
| 7 | Pb | “ | 2.90 | 2.16 | 2.54 | 2.65 | 1.09 | 1.07 | 3.47 | 3.26 | 1.45 | 1.38 | 4.01 | 3.62 | 0.72 | 0.98 | 2.59 | 2.54 | 5.43 |
| 8 | Ni | “ | 5.40 | 5.68 | 2.66 | 2.47 | 5.24 | 5.11 | 1.86 | 1.93 | 6.45 | 6.22 | 0.82 | 0.73 | 3.46 | 3.49 | 2.08 | 2.18 | 2.90 |
| 9 | V | “ | 4.85 | 4.90 | 2.12 | 1.94 | 4.79 | 4.68 | 1.41 | 1.40 | 4.02 | 4.11 | 0.72 | 0.57 | 2.69 | 2.89 | 1.75 | 1.83 | 2.26 |
| 10 | Hg | “ | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 11 | Ba | “ | 0.002 | 0.001 | 0.001 | 0.002 | 0.001 | 0.003 | 0.004 | 0.004 | 0.008 | 0.003 | 0.004 | 0.002 | 0.002 | 0.003 | 0.003 | 0.004 | 0.005 |

Table 4.3.1a: Otumara Physico-chemical analysis for Soil Sample (WET SEASON 2012) (con'd....)

| S/N | Parameters | Units | OTU SS19 | OTU SS20 | OTU SS20 | OTU SS21 | OTU SS21 |
|---------------------|-------------------|----------|-------------|-------------|-------------|-------------|-------------|
| | Level | cm | 15-30 | 0-15 | 15-30 | 0-15 | 15-30 |
| 1 | Ph | | 4.2 | 3.9 | 4.2 | 5.1 | 5.2 |
| 2 | EC | µS/cm | 6560 | 860 | 780 | 250 | 440 |
| 3 | Org. C | % | 4.13 | 4.63 | 4.03 | 3.38 | 2.90 |
| 4 | Total N. | % | 0.80 | 0.90 | 0.78 | 0.57 | 0.66 |
| 5 | Na | meq/100g | 4.48 | 3.55 | 3.45 | 6.60 | 6.36 |
| 6 | K | " | 0.08 | 2.18 | 2.11 | 1.35 | 1.33 |
| 7 | Ca | " | 5.64 | 5.32 | 5.25 | 8.90 | 8.76 |
| 8 | Mg | " | 2.03 | 1.89 | 1.47 | 3.78 | 3.50 |
| 9 | EA | " | 1.9 | 6.2 | 3.3 | 2.0 | 0.9 |
| 10 | CL ⁻ | mg/kg | 2096 | 302 | 293 | 85 | 135 |
| 11 | PO ₄ | " | 21.2 | 50.8 | 41.6 | 10.8 | 9.8 |
| 12 | NH ₄ N | " | 8.6 | 18.2 | 15.4 | 13.0 | 13.0 |
| 13 | NO ₂ N | " | 6.0 | 8.4 | 7.4 | 10.2 | 8.4 |
| 14 | NO ₃ N | " | 14.2 | 18.2 | 17.6 | 18.6 | 17.8 |
| 15 | SO ₄ | " | 980 | 716 | 714 | 618 | 512 |
| 16 | Silt | % | 1.5 | 2.1 | 2.4 | 1.9 | 1.6 |
| 17 | Clay | " | 2.9 | 5.8 | 4.0 | 3.0 | 5.7 |
| 18 | Sand | " | 95.6 | 92.1 | 93.6 | 95.1 | 92.7 |
| 19 | THC | mg/kg | 144.5 | 86.5 | 64.5 | 55.0 | 50.2 |
| 20 | TPH | " | 0.073 | 0.071 | 0.068 | 0.095 | 0.102 |
| 21 | PAH | " | 0.033 | 0.080 | 0.079 | 0.086 | 0.113 |
| 22 | Benzene | µg/kg | 0.001 | 0.004 | 0.003 | 0.005 | 0.004 |
| 23 | Toluene | " | 0.001 | ND | ND | ND | ND |
| 24 | Ethylbenzene | " | ND | ND | ND | ND | ND |
| 25 | Xylene | " | 0.002 | 0.000 | 0.002 | 0.001 | 0.003 |
| 26 | Phenol | " | 0.002 | 0.001 | 0.003 | 0.002 | 0.001 |
| Heavy metals | | | | | | | |
| 1 | Fe | mg/kg | 210.1 | 201.3 | 200.8 | 206.2 | 201.3 |
| 2 | Cu | " | 5.30 | 5.40 | 5.37 | 6.97 | 7.01 |
| 3 | Mn | " | 3.49 | 3.49 | 3.47 | 3.52 | 3.53 |
| 4 | Zn | " | 13.1 | 13.4 | 12.9 | 7.05 | 7.08 |
| 5 | Cd | " | 3.00 | 4.51 | 4.43 | 4.51 | 4.54 |
| 6 | Cr | " | 1.54 | 1.60 | 1.53 | 1.55 | 1.48 |
| 7 | Pb | " | 5.33 | 2.48 | 2.53 | 3.99 | 3.88 |
| 8 | Ni | " | 2.76 | 4.41 | 4.43 | 4.51 | 4.49 |
| 9 | V | " | 2.22 | 3.64 | 3.46 | 3.59 | 3.34 |
| 10 | Hg | " | ND | ND | ND | ND | ND |
| 11 | Ba | " | 0.001 | 0.003 | 0.002 | 0.003 | 0.002 |

Environmental Impact Assessment (EIA) of Otumara AGS Project

Table 4.3.1b: Physicochemical Analysis Of Soil At Otumara During The Dry Season

| S/N | Parameters | Units | SAMPLING POINTS | | | | | | | | | | | | | | | | |
|--------------|-------------------|----------|-----------------|----------|---------|---------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| | | | OTU SSC1 | OTU SSC1 | OTU SS8 | OTU SS8 | OTU SS13 | OTU SS13 | OTU SS14 | OTU SS14 | OTU SS15 | OTU SS15 | OTU SS16 | OTU SS16 | OTU SS17 | OTU SS17 | OTU SS18 | OTU SS18 | OTU SS19 |
| | Level | Cm | 0-15 | 15-30 | 0-15 | 15-30 | 0-15 | 15-30 | 0-15 | 15-30 | 0-15 | 15-30 | 0-15 | 15-30 | 0-15 | 15-30 | 0-15 | 15-30 | 0-15 |
| 1 | pH | | 4.77 | 5.29 | 4.99 | 5.12 | 3.83 | 3.70 | 5.80 | 6.24 | 4.59 | 4.58 | 4.00 | 4.09 | 4.16 | 4.12 | 5.10 | 4.82 | 4.68 |
| 2 | EC | µS/cm | 12510 | 2710 | 1260 | 1760 | 100 | 300 | 2560 | 5640 | 1660 | 1350 | 490 | 390 | 2370 | 670 | 150 | 450 | 5590 |
| 3 | Org. C | % | 3.89 | 3.47 | 1.44 | 1.10 | 1.87 | 1.15 | 1.80 | 1.25 | 0.82 | 0.17 | 3.24 | 2.54 | 1.22 | 0.62 | 2.45 | 2.16 | 2.16 |
| 4 | Total N. | % | 0.39 | 0.42 | 0.15 | 0.11 | 0.22 | 0.14 | 0.22 | 0.15 | 0.10 | 0.02 | 0.40 | 0.30 | 0.15 | 0.07 | 0.29 | 0.26 | 0.26 |
| 5 | Na | meq/100g | 9.90 | 5.80 | 7.50 | 5.13 | 3.36 | 3.04 | 9.51 | 8.80 | 10.57 | 9.38 | 10.94 | 10.82 | 9.32 | 6.70 | 12.29 | 8.78 | 5.51 |
| 6 | K | “ | 8.07 | 4.14 | 6.10 | 4.01 | 1.90 | 2.20 | 6.30 | 5.75 | 7.54 | 6.10 | 8.13 | 7.72 | 5.16 | 3.62 | 8.03 | 5.90 | 3.80 |
| 7 | Ca | “ | 13.30 | 8.55 | 10.80 | 9.48 | 6.32 | 5.10 | 10.26 | 11.66 | 12.01 | 10.73 | 12.56 | 12.35 | 10.54 | 8.08 | 15.10 | 10.01 | 7.77 |
| 8 | Mg | “ | 10.94 | 6.30 | 8.93 | 7.10 | 4.10 | 4.03 | 9.73 | 9.01 | 11.81 | 9.58 | 9.75 | 9.50 | 7.59 | 7.12 | 13.80 | 9.56 | 6.04 |
| 9 | EA | “ | 1.0 | 0.6 | 1.6 | 1.2 | 1.3 | 1.0 | 0.9 | 0.3 | 0.9 | 0.5 | 5.0 | 3.0 | 2.9 | 1.8 | 1.0 | 0.7 | 0.9 |
| 10 | Cl ⁻ | mg/kg | 3540 | 2700 | 179 | 140 | 209 | 123 | 2695 | 1990 | 1110 | 915 | 380 | 297 | 1150 | 720 | 189 | 151 | 119 |
| 11 | PO ₄ | “ | 24.9 | 23.4 | 21.5 | 18.8 | 14.5 | 13.1 | 35.4 | 34.4 | 34.5 | 32.4 | 24.2 | 13.2 | 24.8 | 24.5 | 34.8 | 33.7 | 24.8 |
| 12 | NH ₄ N | “ | 6.1 | 5.3 | 4.4 | 2.9 | 5.8 | 5.4 | 6.2 | 5.5 | 4.3 | 3.2 | 7.4 | 6.0 | 5.0 | 4.0 | 4.7 | 1.8 | 8.8 |
| 13 | NO ₂ N | “ | 9.1 | 4.6 | 8.3 | 5.6 | 12.4 | 9.8 | 8.6 | 3.8 | 10.7 | 4.4 | 9.0 | 6.5 | 9.8 | 9.1 | 7.8 | 4.6 | 8.3 |
| 14 | NO ₃ N | “ | 10.7 | 5.8 | 9.0 | 6.8 | 15.3 | 11.5 | 10.8 | 5.6 | 13.9 | 5.2 | 11.3 | 7.6 | 12.1 | 11.0 | 9.4 | 6.7 | 10.4 |
| 15 | SO ₄ | “ | 2402 | 2310 | 304 | 280 | 712 | 306 | 2118 | 2112 | 990 | 810 | 428 | 314 | 845 | 706 | 314 | 219 | 310 |
| 16 | Silt | % | 2.6 | 3.4 | 3.3 | 3.4 | 2.0 | 3.2 | 2.7 | 2.7 | 3.4 | 4.1 | 3.6 | 4.0 | 3.6 | 3.4 | 3.0 | 2.0 | 2.8 |
| 17 | Clay | “ | 7.2 | 6.5 | 6.4 | 6.9 | 5.8 | 5.9 | 5.5 | 5.9 | 7.4 | 6.6 | 7.7 | 7.1 | 6.9 | 7.4 | 6.1 | 6.3 | 6.0 |
| 18 | Sand | “ | 90.2 | 90.1 | 90.3 | 89.7 | 92.2 | 90.9 | 91.8 | 91.4 | 89.2 | 89.3 | 88.7 | 88.9 | 89.5 | 89.4 | 90.9 | 91.7 | 91.2 |
| 19 | THC | mg/kg | 16.3 | 14.7 | 35.6 | 33.2 | 28.1 | 25.4 | 38.1 | 29.0 | 21.6 | 14.8 | 33.2 | 31.6 | 42.1 | 37.9 | 54.7 | 41.6 | 66.9 |
| 20 | TPH | “ | 0.033 | 0.024 | 0.027 | 0.024 | 0.122 | 0.118 | 0.099 | 0.051 | 0.964 | 0.761 | 0.146 | 0.107 | 0.196 | 0.102 | 0.081 | 0.056 | 0.232 |
| 21 | PAH | “ | 0.018 | 0.012 | 0.011 | 0.009 | 0.019 | 0.013 | 0.025 | 0.022 | 0.104 | 0.096 | 0.031 | 0.029 | 0.037 | 0.031 | 0.051 | 0.022 | 0.136 |
| 22 | Benzene | µg/kg | 0.002 | ND | 0.004 | 0.003 | 0.003 | 0.001 | 0.004 | 0.002 | 0.005 | 0.004 | 0.002 | 0.001 | 0.003 | 0.002 | 0.003 | 0.001 | 0.009 |
| 23 | Toluene | “ | ND | ND | ND | 0.000 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 24 | Ethyl benzene | “ | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 25 | Xylene | “ | 0.003 | 0.001 | 0.002 | 0.001 | ND | ND | 0.002 | 0.001 | ND | 0.001 | 0.003 | 0.001 | 0.003 | 0.002 | 0.003 | 0.002 | 0.005 |
| 26 | Phenol | “ | 0.003 | 0.001 | 0.003 | 0.002 | 0.004 | 0.001 | 0.003 | 0.002 | 0.007 | 0.003 | 0.006 | 0.004 | 0.006 | 0.002 | 0.005 | 0.003 | 0.007 |
| Heavy metals | | | | | | | | | | | | | | | | | | | |
| 1 | Fe | mg/kg | 127.6 | 125.6 | 131.2 | 129.1 | 134.6 | 132.8 | 134.0 | 133.1 | 129.2 | 133.7 | 149.1 | 148.2 | 133.4 | 132.2 | 140.6 | 139.8 | 134.9 |
| 2 | Cu | “ | 10.3 | 10.5 | 15.7 | 15.6 | 19.0 | 19.8 | 17.5 | 18.9 | 10.4 | 10.7 | 11.2 | 10.6 | 18.2 | 18.8 | 18.9 | 18.7 | 21.3 |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| | | | SAMPLING POINTS | | | | | | | | | | | | | | | | |
|-----|------------|-------|-----------------|-------------|------------|------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| S/N | Parameters | Units | OTU SSC1 | OTU SSC1 | OTU SS8 | OTU SS8 | OTU SS13 | OTU SS13 | OTU SS14 | OTU SS14 | OTU SS15 | OTU SS15 | OTU SS16 | OTU SS16 | OTU SS17 | OTU SS17 | OTU SS18 | OTU SS18 | OTU SS19 |
| | Level | Cm | 0-15 | 15-30 | 0-15 | 15-30 | 0-15 | 15-30 | 0-15 | 15-30 | 0-15 | 15-30 | 0-15 | 15-30 | 0-15 | 15-30 | 0-15 | 15-30 | 0-15 |
| 3 | Mn | “ | 60.1 | 61.2 | 16.1 | 16.0 | 16.3 | 16.2 | 16.1 | 15.8 | 58.6 | 61.3 | 7.3 | 7.0 | 16.9 | 16.6 | 24.3 | 24.1 | 16.5 |
| 4 | Zn | “ | 11.0 | 10.8 | 17.0 | 16.8 | 8.5 | 8.4 | 13.3 | 14.0 | 11.1 | 11.5 | 15.6 | 13.9 | 11.2 | 11.6 | 15.2 | 15.1 | 18.1 |
| 5 | Cd | “ | 0.33 | 0.30 | 0.24 | 0.23 | 0.20 | 0.17 | 0.23 | 0.22 | 0.44 | 0.53 | 0.44 | 0.48 | 2.4 | 2.2 | 0.50 | 0.48 | 2.6 |
| 6 | Cr | “ | 0.10 | 0.12 | 1.36 | 1.31 | 1.41 | 1.38 | 1.40 | 1.32 | 0.05 | 0.05 | 1.42 | 1.45 | 1.43 | 1.38 | ND | ND | 1.4 |
| 7 | Pb | “ | 17.7 | 17.2 | 11.7 | 12.2 | 15.9 | 15.0 | 6.7 | 6.3 | 18.6 | 16.8 | 21.6 | 29.4 | 11.8 | 11.5 | 1.22 | 1.06 | 25.1 |
| 8 | Ni | “ | 8.6 | 7.9 | 7.2 | 6.7 | 5.0 | 5.2 | 16.4 | 15.8 | 10.2 | 9.1 | 11.1 | 11.2 | 5.6 | 5.9 | 11.7 | 11.2 | 7.8 |
| 9 | V | “ | 7.4 | 6.8 | 6.1 | 5.8 | 4.2 | 4.3 | 14.6 | 13.4 | 8.8 | 7.8 | 9.4 | 9.9 | 4.9 | 4.6 | 10.1 | 9.3 | 6.7 |
| 10 | Hg | “ | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 11 | Ba | “ | 0.005 | 0.004 | 0.005 | 0.003 | 0.003 | 0.002 | 0.004 | 0.001 | 0.005 | 0.002 | 0.007 | 0.004 | 0.008 | 0.004 | 0.006 | 0.002 | 0.003 |

Table 4.3.1b: Otumara Physico-chemical analysis for Soil Sample (Dry Season 2013) (con'd....)

| S/N | Parameters | Units | OTU SS19 | OTU SS20 | OTU SS20 | OTU SS21 | OTU SS21 |
|---------------------|-------------------|----------|-------------|-------------|-------------|-------------|-------------|
| | Level | cm | 15-30 | 0-15 | 15-30 | 0-15 | 15-30 |
| 1 | pH | | 5.08 | 4.03 | 4.05 | 4.86 | 4.79 |
| 2 | EC | µS/cm | 5780 | 900 | 160 | 3110 | 2400 |
| 3 | Org. C | % | 1.73 | 2.57 | 1.80 | 4.15 | 3.70 |
| 4 | Total N. | % | 0.21 | 0.31 | 0.22 | 0.50 | 0.44 |
| 5 | Na | meq/100g | 4.90 | 10.88 | 10.69 | 10.58 | 9.40 |
| 6 | K | “ | 1.83 | 7.77 | 7.64 | 7.54 | 6.79 |
| 7 | Ca | “ | 7.10 | 13.31 | 12.90 | 13.03 | 10.16 |
| 8 | Mg | “ | 5.80 | 11.78 | 11.01 | 11.56 | 9.50 |
| 9 | EA | “ | 0.5 | 5.8 | 3.8 | 1.5 | 0.9 |
| 10 | Cl ⁻ | mg/kg | 92 | 150 | 104 | 161 | 124 |
| 11 | PO ₄ | “ | 24.5 | 33.6 | 22.6 | 14.8 | 13.8 |
| 12 | NH ₄ N | “ | 7.6 | 5.4 | 4.4 | 9.7 | 8.6 |
| 13 | NO ₂ N | “ | 4.2 | 11.5 | 4.4 | 9.8 | 6.3 |
| 14 | NO ₃ N | “ | 5.0 | 14.0 | 5.7 | 12.9 | 7.2 |
| 15 | SO ₄ | “ | 174 | 137 | 223 | 210 | 238 |
| 16 | Silt | % | 2.3 | 2.0 | 2.1 | 3.8 | 4.3 |
| 17 | Clay | “ | 3.8 | 6.3 | 6.8 | 6.2 | 6.6 |
| 18 | Sand | “ | 93.9 | 91.7 | 91.1 | 90.0 | 89.1 |
| 19 | THC | mg/kg | 64.2 | 111.1 | 110.0 | 54.7 | 51.0 |
| 20 | TPH | “ | 0.104 | 0.538 | 0.069 | 0.041 | 0.039 |
| 21 | PAH | “ | 0.088 | 0.241 | 0.040 | 0.026 | 0.018 |
| 22 | Benzene | µg/kg | 0.005 | 0.005 | 0.001 | 0.005 | 0.003 |
| 23 | Toluene | “ | ND | 0.002 | 0.001 | ND | ND |
| 24 | Ethylbenzene | “ | ND | 0.001 | ND | ND | ND |
| 25 | Xylene | “ | 0.001 | 0.003 | 0.002 | 0.003 | 0.002 |
| 26 | Phenol | “ | 0.003 | 0.005 | 0.003 | 0.004 | 0.002 |
| Heavy metals | | | | | | | |
| 1 | Fe | mg/kg | 136.6 | 148.2 | 163.4 | 133.0 | 130.8 |
| 2 | Cu | “ | 21.2 | 20.3 | 21.8 | 14.4 | 14.5 |
| 3 | Mn | “ | 16.1 | 20.5 | 25.1 | 11.9 | 11.9 |
| 4 | Zn | “ | 18.4 | 8.0 | 16.3 | 30.5 | 30.6 |
| 5 | Cd | “ | 2.4 | 0.68 | 0.54 | 0.47 | 0.48 |
| 6 | Cr | “ | 1.3 | 1.56 | 0.61 | 0.16 | 0.15 |
| 7 | Pb | “ | 24.5 | 29.5 | 22.1 | 34.5 | 33.5 |
| 8 | Ni | “ | 7.5 | 15.7 | 12.5 | 11.0 | 10.9 |
| 9 | V | “ | 6.4 | 13.6 | 10.9 | 9.5 | 9.4 |
| 10 | Hg | “ | ND | ND | ND | ND | ND |
| 11 | Ba | “ | 0.005 | 0.005 | 0.002 | 0.004 | 0.001 |

Table 4.3.2: Summary of physicochemical properties of soil in Otumara field

| S/N | Parameters | Units | DRY SEASON | | | | | WET SEASON | | | | | DPR TARGET – INTERVENTION LIMITS | Soil Critical Level |
|-----|-------------------|----------|------------|-------|-------|----------------|-----------------|------------|-------|-------|----------------|-----------------|----------------------------------|---------------------|
| | | | MIN | MAX | MEAN | Control (0-15) | Control (15-30) | MIN | MAX | MEAN | Control (0-15) | Control (15-30) | | |
| | Level | Cm | | | | | | | | | | | | |
| 1 | pH | | 3.70 | 5.80 | 4.67 | 4.77 | 5.29 | 3.3 | 5.3 | 4.4 | 4.3 | 4.9 | 5.5-6.5 | |
| 2 | EC | µS/cm | 100 | 12510 | 2377 | 12510 | 2710 | 190 | 6650 | 1225 | 240 | 190 | | |
| 3 | Org. C | % | 0.17 | 4.15 | 2.06 | 3.89 | 3.47 | 1.82 | 5.44 | 3.53 | 3.43 | 3.15 | | 10 |
| 4 | Total N. | % | 0.02 | 0.50 | 0.24 | 0.39 | 0.42 | 0.35 | 1.05 | 0.69 | 0.72 | 0.64 | | |
| 5 | Na | meq/100g | 3.04 | 12.29 | 8.35 | 9.90 | 5.80 | 0.08 | 9.19 | 4.39 | 6.27 | 6.08 | | 50 |
| 6 | K | “ | 1.83 | 8.13 | 5.73 | 8.07 | 4.14 | 0.11 | 6.36 | 2.90 | 6.32 | 6.36 | | 98.84 |
| 7 | Ca | “ | 5.10 | 15.10 | 10.51 | 13.30 | 8.55 | 4.46 | 12.4 | 7.96 | 10.3 | 10.2 | | 761.52 |
| 8 | Mg | “ | 4.03 | 13.80 | 8.84 | 10.94 | 6.30 | 1.34 | 9.89 | 4.25 | 7.30 | 7.11 | | 238.40 |
| 9 | EA | “ | 0.3 | 5.0 | 1.7 | 1.0 | 0.6 | 0.9 | 6.8 | 3.7 | 4.5 | 2.3 | | |
| 10 | Cl ⁻ | mg/kg | 104 | 3540 | 784 | 3540 | 2700 | 68 | 2192 | 465 | 86 | 68 | | |
| 11 | PO ₄ | “ | 13.1 | 35.4 | 24.7 | 24.9 | 23.4 | 9.8 | 85.2 | 40.0 | 33.2 | 32.4 | | |
| 12 | NH ₄ N | “ | 1.8 | 9.7 | 5.6 | 6.1 | 5.3 | 1.0 | 19.2 | 11.3 | 3.0 | 1.0 | | |
| 13 | NO ₂ N | “ | 3.8 | 12.4 | 7.7 | 9.1 | 4.6 | 1.8 | 10.2 | 6.9 | 8.2 | 2.6 | | |
| 14 | NO ₃ N | “ | 5.0 | 15.3 | 9.5 | 10.7 | 5.8 | 2.0 | 18.6 | 13.9 | 14.0 | 12.3 | | |
| 15 | SO ₄ | “ | 137 | 2402 | 748 | 2402 | 2310 | 80 | 1016 | 550 | 104 | 80 | | |
| 16 | Silt | % | 2.0 | 4.3 | 3.1 | 2.6 | 3.4 | 0.7 | 4.9 | 2.3 | 3.4 | 4.9 | | |
| 17 | Clay | “ | 3.8 | 7.7 | 6.4 | 7.2 | 6.5 | 2.9 | 10.2 | 5.4 | 7.3 | 10.2 | | |
| 18 | Sand | “ | 88.7 | 93.9 | 90.5 | 90.2 | 90.1 | 84.9 | 96.4 | 92.3 | 89.3 | 84.9 | | |
| 19 | THC | mg/kg | 14.7 | 111.1 | 43.4 | 16.3 | 14.7 | 20.5 | 154.1 | 70.7 | 41.1 | 20.5 | | |
| 20 | TPH | “ | 0.024 | 0.964 | 0.179 | 0.033 | 0.024 | 0.004 | 0.102 | 0.052 | 0.007 | 0.004 | 5000 | 50 |
| 21 | PAH | “ | 0.009 | 0.241 | 0.049 | 0.018 | 0.012 | 0.001 | 0.738 | 0.089 | 0.001 | 0.002 | | |
| 22 | Benzene | µg/kg | 0.001 | 0.009 | 0.003 | 0.002 | ND | 0.001 | 0.006 | 0.005 | ND | 0.000 | | |
| 23 | Toluene | “ | 0.000 | 0.002 | 0.001 | ND | ND | 0.001 | 0.002 | 0.001 | 0.000 | 0.000 | | |
| 24 | Ethyl benzene | “ | 0.000 | 0.001 | 0.001 | ND | ND | ND | ND | 0.002 | ND | ND | | |
| 25 | Xylene | “ | 0.001 | 0.005 | 0.002 | 0.003 | 0.001 | 0.001 | 0.003 | 0.002 | ND | ND | | |
| 26 | Phenol | “ | 0.001 | 0.007 | 0.004 | 0.003 | 0.001 | 0.001 | 0.004 | 0.002 | 0.001 | 0.002 | | |
| 27 | Fe | mg/kg | 125.6 | 163.4 | 142.4 | 127.6 | 125.6 | 198.4 | 210.5 | 204.3 | 210.5 | 204.2 | | 200 |
| 28 | Cu | “ | 10.3 | 21.8 | 18.4 | 10.3 | 10.5 | 3.92 | 7.10 | 5.26 | 5.39 | 4.95 | | |
| 29 | Mn | “ | 7.0 | 61.3 | 17.1 | 60.1 | 61.2 | 3.22 | 3.67 | 3.52 | 3.64 | 3.22 | | |
| 30 | Zn | “ | 8.0 | 30.6 | 20.8 | 11.0 | 10.8 | 6.00 | 15.9 | 10.1 | 9.09 | 9.66 | 720 | 250 |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| S/N | Parameters | Units | DRY SEASON | | | | | WET SEASON | | | | | DPR TARGET – INTERVENTION LIMITS | Soil Critical Level |
|-----|------------|-------|------------|-------|-------|----------------|-----------------|------------|-------|-------|----------------|-----------------|----------------------------------|---------------------|
| | | | MIN | MAX | MEAN | Control (0-15) | Control (15-30) | MIN | MAX | MEAN | Control (0-15) | Control (15-30) | | |
| | Level | Cm | | | | | | | | | | | | |
| 31 | Cd | “ | 0.17 | 2.4 | 0.91 | 0.33 | 0.30 | 0.14 | 4.54 | 1.44 | 0.14 | 0.18 | | 50 |
| 32 | Cr | “ | 0.05 | 1.56 | 0.76 | 0.10 | 0.12 | 1.47 | 1.61 | 1.55 | 1.60 | 1.56 | 380 | 50 |
| 33 | Pb | “ | 1.06 | 34.5 | 28.8 | 17.7 | 17.2 | 1.07 | 5.43 | 2.73 | 2.90 | 2.16 | 530 | 100 |
| 34 | Ni | “ | 5.0 | 16.4 | 11.5 | 8.6 | 7.9 | 0.73 | 6.45 | 3.60 | 5.40 | 5.68 | | 50 |
| 35 | V | “ | 4.2 | 13.6 | 9.96 | 7.4 | 6.8 | 0.57 | 4.02 | 2.87 | 4.85 | 4.90 | | |
| 36 | Hg | “ | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | | |
| 37 | Ba | “ | 0.001 | 0.008 | 0.003 | 0.005 | 0.004 | 0.001 | 0.008 | 0.003 | 0.002 | 0.001 | | |

Soil Colour

The soil at Otumara varied in colour ranging from brown superficial (7.5YR 5/3) to light brown (7.5 6/3) at the subsurface level. The surface soil level has higher content of decomposed organic matter, and this is also a contributing factor to the darker colouration.

Soil pH (Reaction) and Exchangeable acidity

Soil reaction which is given in terms of pH value is a measure of the free hydrogen ion (H^+) concentration of soil solution. The value of the free H^+ concentration in a soil influences the availability of nutrients and biochemical reactions in the soil (Bohn *et al.*, 1984). In strongly acidic soils for instance basic cation uptake by plants roots is inhibited. Also beneficial soil microorganisms are affected by soil reaction (Isirimah *et al.*, 2003). Soil reaction is thus important for nutrients availability for plants uptake.

The pH values obtained in the project area during the wet season ranged from 3.3 to 5.3 at the surface soil level and from 3.7 to 5.2 at the sub-surface soil level. The soil reactions of Otumara project area ranged from ultra acid to slight acid at the surface and sub surface soil levels according to the United States Department of Agriculture (USDA 1979) soil pH ranges classification. Generally, during the dry season, pH ranged from 3.83 – 5.80 with a mean of 4.67, whereas at the control it was 4.77 in the surface and 5.29 in the sub-surface. The results during the dry season were similar to that of the wet season. Low pH is not unusual in mangrove environment even in the Niger Delta (Ohimain, 2004; Ohimain *et al.*, 2004).

Soil pH is often considered in terms of the soil capability and suitability to support plants growth. The majority of crops thrive well in slightly acidic soils. Also some soil nutrient elements are more available at lower pH levels. During the acidification process the decrease in pH results in a release of positively charged ions (cations) from the cation exchange surfaces (organic matter and clay minerals). The pH of 4.8 is set as the lower limit for optimum growth of plants, and conversely the pH of 9.5 is regarded as the extreme upper limit of alkalinity at which plants can still grow (Udo 1986).

The exchangeable acidity (EA) was lower in the dry season (0.3 – 5.0 meq/100g with a mean of 1.7 meq/100g) than the wet season (0.9 – 6.8 meq/100g with a mean of 3.7 meq/100g). The EA of the control during the dry season (1.0 meq/100g at the surface and 0.6 meq/100g at the sub-surface) was similarly lower than that of the wet season (4.5 meq/100g at the surface and 2.3 meq/100g at the sub-surface), which are within the values recorded in the main sampling points.

Electrical Conductivity

The electrical conductivity (EC) of a soil indicates the total ionic strength (anions and cations) of such a soil. Low total ionic strength in a soil indicates low dissolved salt content; conversely, high total ionic strength in a soil indicates high dissolved salt content. The values of electrical conductivity of soils of the Otumara project area during the wet season ranged from 250 to 2960 $\mu\text{S}/\text{cm}$ at the surface soil level and from 210 to 6560 $\mu\text{S}/\text{cm}$ at the subsurface soil level. The electrical conductivity values of the soil varied from low at the surface soil level, to high at the subsurface soil level. Overall, EC was several orders higher in the dry season (100 – 12510 $\mu\text{S}/\text{cm}$ with a mean of 2377 $\mu\text{S}/\text{cm}$) than the wet season (190 -6650 $\mu\text{S}/\text{cm}$ with a mean of 1225 $\mu\text{S}/\text{cm}$).

The control during the dry season similarly had high EC levels being 12510 $\mu\text{S}/\text{cm}$ at the surface and 2710 at the sub-surface, but were significantly lower during the wet season, being 240 $\mu\text{S}/\text{cm}$ at the surface and 190 $\mu\text{S}/\text{cm}$ at the sub-surface. Dilution effect may have been responsible for the large variability in the seasonal pattern of EC. Notwithstanding, electrical conductivity tolerance levels for plants growing on soils have been set at 4000 $\mu\text{S}/\text{cm}$ in the saturated soil extract (Tel, 1984).

Total Organic Carbon

The organic carbon (TOC) content of the soils of the Otumara area during the wet season ranged from 1.94 to 5.44 % at the surface and from 1.82 to 4.13 % at the subsurface soil level. During the dry season, TOC ranged from 1.15- 4.15 % for surface and 0.17 – 3.70% for subsurface soil with a mean of 2.06%. Higher values were recorded for the control, 3.89% at the surface and 3.47% at the subsurface. Similarly, higher TOC values were recorded during the wet season ranging from 1.94 – 5.44% for surface soil and 1.82-4.13% for subsurface soil with a mean of 3.53%. The values of the wet season control were about the same with the main sampling points. The reason for the higher TOC may be attributed to increased rates of biodegradation during the wet season due to increased availability of water from rainfall.

Soil organic carbon consists of dead, decayed, and decomposing animals and plants remains. Organic carbon content of soils is a source of nutrients such as oxidized forms of nitrogen, phosphorus, sulphur and also serves as source of nutrients for soil micro organisms. The organic carbon of soil is an important element in maintaining its physical conditions and significantly affects its productivity (Sposito, 1989). For instance the dark colour associated with rich fertile soil is largely a measure of its organic carbon content. Organic carbon binds and stabilizes the soil aggregates which results in greater resistance to erosion as mass movement is less likely when soils are able to retain structural strength under greater moisture levels. Soil organic carbon enhances soil water holding capacity, and greater soil water holding capacity reduces overland flow and recharge to groundwater. The water saved and held by the soil remains available for use by plants.

Phosphate

Phosphate is one the nutrients that is very essential for plant growth. Phosphates are the main source of phosphorus in soils. However not all the total phosphorus in the soil is available for plants uptake. This is because phosphorus occurs in soil matrix either in the fixed, active, or solution form. The solution form of phosphorus is readily available for plant uptake. Most of the phosphorus in tropical soils that are available for plant uptake is induced by microbial activities in the soil. Thus, phosphorus availability is also affected by soil environmental factors that affect microbial activities.

The phosphate content of the soils of Otumara project area during the wet season ranged from 10.8 – 85.2 mg/kg at the surface soil level and from 9.8 – 78.4 mg/kg at the subsurface soil level. For the controls, available phosphorus was 33.2 mg/kg in the surface and 32.4 mg/kg in the subsurface. Available Phosphorus was lower during the dry season. According to Enwezor *et al.* (1988), Available phosphorus content of <8ppm, 8 -20ppm, and >20ppm is classified as low,

moderate and high respectively. Hence, the available phosphorus recorded during this study in both seasons was generally high.

Total Nitrogen, Nitrite, Nitrate and Ammonium Nitrogen

Nitrogen is one of the macro nutrients in soils that have very significant effect on plants growth. Plant growth is limited by Nitrogen more than by any other plant nutrient element. The more available forms of Nitrogen in soil are Nitrate (NO_3^-), Ammonium (NH_4^+). Nitrites (NO_2^-) are reduced form of nitrates.

The Total Nitrogen content of Otumara area soil during the dry season ranged from 0.10– 0.50% for surface soil and 0.02 -0.44% for subsurface soils with a mean of 0.24%, whereas at the controls, total nitrogen was 0.39% at the surface and 0.42% at the subsurface. During the wet season, total nitrogen ranged from 0.37 – 1.05% for surface soil and 0.35-0.80% for subsurface soil with a mean of 0.69%, whereas at the control, it was 0.72% at the surface and 0.64% at the subsurface.

During the wet season, ammonium concentration ranged from 6.4 to 19.2 mg/kg at the surface soil, and 2.0 to 17.6 mg/kg at the subsurface soil, whereas the control station had ammonium concentration of 3.0 mg/kg at the surface and 1.0 mg/kg at the subsurface. However, lower values were generally recorded during the dry season. During the wet season, nitrate concentration ranged from 3.4 to 18.6 mg/kg at the surface soil level, and from 2.0 to 17.8 mg/kg at the subsurface soil level. The control station had a nitrate concentration of 14.0 mg/kg at the surface and 12.3 mg/kg at the subsurface. Generally, nitrate was lower in the dry season. The nitrite content of the soil of the project area during the wet season, ranged from 5.0 to 10.3 mg/kg at the surface soil level and from 1.8 to 9.5 mg/kg at the sub surface soil level, notwithstanding, the control stations had nitrite concentration with this range at both the surface and subsurface. Nitrites were slightly higher during the dry season.

Sulphate

Most soil sources of sulphur are in the organic matter (proteins, nucleic acids and lipids) and are concentrated in the surface soil. Elemental Sulphur is not available to crops as they must be converted to the sulphate (SO_4^{--}) form to become available. This conversion is performed by soil microbes(sulphur oxidizing bacteria) and therefore requires soil conditions that are warm, moist, and well drained to proceed rapidly. The Sulphur form of S is an anion (negative charge), and therefore is leachable. The concentration of Sulphate in the soil of the Otumara area during the wet season ranged from 80 to 2004 mg/kg at the surface soil level, and from 80 to 1628 mg/kg at the subsurface soil level. The variability of the data is as a result of the different salinity profiles associated with the different land use types in the area; the freshwater area having lower sulphate concentrations compared to the salt marsh and mangrove swamps. The control station had sulphate concentration of 104 mg/kg in the surface and 80 mg/kg in the subsurface. The variation in sulphate level between the control and the study area can be explained by the inherent variability in salinity and chloride content due to salt water intrusion. Results obtained during the dry season were not different from that of the wet season.

Chloride Content

The concentration of chloride in the soil of Otumara area during the wet season ranged from 71 to 2192 mg/kg at the surface soil level and from 83 to 2096 mg/kg at the sub surface soil level. The control had chloride concentration of 86 mg/kg at the surface and 68 mg/kg at the subsurface. The difference in chloride levels observed between the study and control points is as a result of salt water intrusion in the study area. The concentration of chloride was apparently higher in the dry season than the wet season. The dilution effect of rainfall on salinity is responsible for the seasonal differences.

Chloride (Cl⁻) is a micronutrient that is highly soluble and is found predominantly dissolved in the soil water. Chloride is found in the soil as the chloride ion. Being an anion, it is fully mobile except where held by soil anion exchange sites. In areas where rainfall is relatively high and internal soil drainage is good as the Otumara area, chloride may be leached from the soil profile.

Exchangeable Cations (Nutrient Elements)

Exchangeable cations refer to the positively charged ions which are loosely attached to the edge of clay particles or organic matter in the soil. The cations include sodium, potassium, calcium and magnesium. The total number of these positively charged ions is known as the cation exchange capacity. Several soil properties such as acidity, nutrient availability and nutrient leachability depend on the relative proportions of the cations present. A large proportion of hydrogen ions in the exchange complex for instance is one of the causes of soil acidity and concentration of trace elements (Isirimah *et al.*, 2003).

During the wet season, sodium concentration ranged from 0.08 to 9.19 meq/100g at the surface soil level and from 0.06 to 9.11 meq/100g at the subsurface soil level. Potassium concentration ranged from 0.11 to 5.15 meq/100g at the surface soil level and from 0.08 to 5.09 meq/100g at the subsurface soil level. Calcium concentration ranged from 1.50 to 15.6 meq/100g at the surface soil level and from 1.30 to 14.8 meq/100g at the subsurface soil level. Magnesium concentration ranged from 0.76 to 9.80 meq/100g at the surface level and from 0.67 to 9.89 meq/100g at the subsurface soil level. The order of hierarchy of occurrence of exchangeable cations of the Otumara project area was calcium > sodium > magnesium > potassium.

Hydrocarbons

Hydrocarbon related parameters studied include Total Hydrocarbon Content (THC), Total Petroleum Hydrocarbon (TPH), Polycyclic Aromatic Hydrocarbon (PAH), Benzene, Toluene, Ethylene, and Xylene (BTEX), and Phenol. Hydrocarbons are organic compounds that contain hydrogen and carbon only. They can be of petroleum origin or of recent biogenic origin. Natural plant and animal hydrocarbons are ubiquitous in the environment (Environment Canada, 1980).

The presence of hydrocarbon in any environment is an indication of petroleum hydrocarbon production or utilization especially from human activities such as pipeline rupture and oil spills resulting from illegal bunkering activities. During the wet season, the THC of the soil of the Otumara project area ranged from 54.5 to 154.1 mg/kg at the surface soil level and from 50.2 to 144.5 mg/kg at the subsurface soil level. The Total Petroleum Hydrocarbon Content of the soil of Otumara area ranged from 0.036 to 0.304 mg/kg at the surface soil level, and from 0.038 to 0.296

mg/kg at the subsurface soil level. Total Petroleum Hydrocarbon content of soil is the concentration of hydrocarbon that is solely of petroleum origin, and that might have resulted from petroleum exploration and production activities. Results of this study showed that the TPH levels recorded were far below the DPR intervention level of 5000 mg/kg.

The concentration of PAH in the soil of Otumara project area during the wet season ranged from 0.039 to 0.086 mg/kg at the surface soil level and from 0.033 to 0.113 mg/kg at the subsurface soil level. Polycyclic Aromatic Hydrocarbon, also known as Poly-Aromatic Hydrocarbons are potent atmospheric pollutants that consist of fused aromatic rings and do not contain heteroatoms. The PAHs occur in oil, coal, and tar and are produced as byproducts of fuel burning. As a pollutant, they are of concern because some compounds have been identified as carcinogenic, mutagenic, and teratogenic. PAH values were less than DPR intervention value of 40mg/kg.

During the wet season, the concentration of Benzene in Otumara area soil varied from below the detectable limit of the analytical equipment (<0.001 mg/kg) to 0.006 mg/kg at the surface soil level. The subsurface soil level concentration also varied from below the detectable limit of the analytical equipment to 0.005 mg/kg. Toluene concentration varied from below detectable limit of the analytical equipment, to 0.002 mg/kg at the surface soil level. The subsurface soil level concentration of Toluene varied from below detectable limit of the analytical equipment to 0.003 mg/kg. Ethyl Benzene concentration varied from below the detectable limit of the analytical equipment to 0.008 mg/kg at the surface soil level, while the subsurface soil level concentration varied from below detectable limit of the analytical equipment to 0.002 mg/kg. Xylene concentration varied from below detectable limit of the analytical equipment to 0.003 mg/kg at the surface soil level, and from 0.001 to 0.003 mg/kg at the subsurface soil level.

Benzene, Toluene, Ethylene, and Xylene are respectively organic chemical compounds and are natural constituents of crude oil. They are widely used in the chemical and petrochemical industry. Pollution concerns are as a result of their adverse health effects as it has been established that long term exposure to them can result in cancer and general tiredness and weakness. The values of these compounds in soil were less than the DPR intervention values of 1.0mg/kg, 130mg/kg, 50 mg/kg, and 250mg/kg for Benzene, Toluene, Ethylene, and Xylene respectively.

Phenol is a caustic crystalline compound that is found in petroleum hydrocarbons, coal, wood tar and benzene. The presence of Phenol in Otumara soil environment is attributable to oil and gas exploration and production activities. The concentration of phenol in the soils of Otumara area ranged from 0.001 mg/kg to 0.005 mg/kg at the surface soil level and from 0.001 mg/kg to 0.004 mg/kg at the subsurface soil level. Note however that there is no critical level prescribed for phenol in FMEnv and DPR guidelines. The value of phenol in soil was less than the DPR intervention value of 40mg/kg.

Heavy Metals (Trace Elements)

In both wet and dry seasons, iron concentration was higher than the concentrations of the other heavy metals in the soil of Otumara area. During the wet season, the concentration of iron ranged from 199.9 to 207.5 mg/kg at the surface soil, and from 198.4 to 206.1 mg/kg at the subsurface soil. Similar values were reported during the dry season. The soils of the Niger Delta area have

been reported to contain high concentrations of iron due to genesis of soil formation (Anderson 1967; Ohimain *et al.* 2004).

The concentrations of other heavy metals recorded during the wet season are discussed below. Copper concentration ranged from 1.41 to 6.97 mg/kg at the surface soil level, and from 1.39 to 7.10 mg/kg at the subsurface soil level. Manganese concentration ranged from 3.41 to 3.67 mg/kg at the surface soil level, and from 3.27 to 3.66 mg/kg at the subsurface soil level. Zinc concentration ranged from 6.04 to 15.9 mg/kg at the surface soil level, and from 6.00 to 15.6 mg/kg at the subsurface soil level. Cadmium concentration ranged from 0.20 to 6.55 mg/kg at the surface soil level, and from 0.04 to 6.50 mg/kg at the subsurface soil level. Chromium concentration ranged from 1.39 to 1.61 mg/kg at the surface soil level, and from 1.44 to 1.58 mg/kg at the subsurface soil level. Lead concentration ranged from 0.72 to 5.43 mg/kg at the surface soil level, and from 0.98 to 5.33 mg/kg at the subsurface soil level. Nickel concentration ranged from 0.82 to 6.45 mg/kg at the surface soil level, and from 0.73 to 6.47 mg/kg at the subsurface soil level. Vanadium concentration ranged from 0.72 to 4.79 mg/kg at the surface soil level, and from 0.57 to 4.68 mg/kg at the subsurface soil level. Barium concentration ranged from 0.001 to 0.008 mg/kg at the surface soil level, and from 0.001 to 0.004 mg/kg at the subsurface soil level. The concentration of Mercury was below the detectable limit of the analytical equipment (i.e <0.001 mg/kg).

Heavy Metals (Trace elements) are chemical substances that are required in trace or very small concentrations in soils for plants growth. However, these elements can become hazardous to humans and animals if absorbed in the food chain even in small concentrations as they usually can become biomagnified. Low concentrations of heavy metals occur naturally in most soils. The concentration of these metals can however be increased to become potential pollutants if heavy metals – containing waste products from industrial or domestic activities are introduced into the environment (Bohn *et al.*, 1984). Concern over the presence of heavy metals in an environment arises from the fact that they cannot easily be broken down into non toxic forms. Thus once ecosystems are contaminated by heavy metals; they remain a potential threat for many years (Isirimah *et al.*, 2003). Results of this study showed that the heavy metal levels recorded were far below the DPR intervention limits of 190 mg/kg, 12 mg/kg, 10 mg/kg, 530 mg/kg, 210 mg/kg and 720mg/kg for Cu, Cd, Hg, Pb, Ni and Zn respectively.

Soil Textural Classification

Soil textural classification is the percentage of sand, silt, and clay present in a soil. The textural analysis results of the soil of the Otumara project area revealed the soil varied from sand to Loamy Sand at the surface and subsurface levels. The texture of a soil determines the water absorption/infiltration rate, and water holding capacity. It also determines the amount of soil aeration, ease of tilling, and soil fertility (Udo 1986).

Soil Microbiology

Microbial population densities in both dry and wet seasons are presented in Tables 4.3.3a and 4.3.3b respectively. In the dry season, total heterotrophic bacteria (THB) ranged from 3.8 – 6.4 x 10⁵ cfu/g at the surface and 3.5 – 5.9 x 10⁵ cfu/g at the subsurface. Hydrocarbon utilizing bacteria (HUB) population ranged from 1.2 – 3.4 x 10³ cfu/g at the surface and 0.7 – 3.1 x 10³ cfu/g at the

subsurface. The population of THB and HUB were slightly higher in the soil surface than the subsurface due to higher concentration of oxygen and organic matter at the soil surface. The HUB accounted for about 1% of the heterotrophic species, indicating non-pollution from petroleum sources. Though, a similar trend was observed during the wet season, the population of bacteria was generally higher in the wet season than dry season, perhaps due to more availability of oxygenated water in the pores of the soil. The THB ranged from $5.3 - 8.4 \times 10^5$ cfu/g at the soil surface and $4.9 - 8.2 \times 10^5$ cfu/g at the subsurface. The HUB ranged from $0.9 - 4.2 \times 10^3$ cfu/g at the soil surface and $0.5 - 4.0 \times 10^3$ cfu/g at the subsurface. At the control station, THB population was 6.0×10^5 cfu/g at the surface and 5.8×10^5 cfu/g at the subsurface, whereas, HUB was 1.3×10^3 cfu/g at the surface and 1.1×10^3 cfu/g at the subsurface. Predominant bacteria species in the study area include *Bacillus* sp, *Micrococcus* sp, *Pseudomonas* sp, *E. coli*, *Enterobacter* sp, and *Staphylococcus* sp.

Fungal population density in the soil was also studied in two seasons (wet and dry) and across two soil strata (surface and subsurface). Heterotrophic and hydrocarbon utilizing fungi were enumerated. In the dry season, total fungi (TF) population ranged from $1.2 - 2.1 \times 10^5$ cfu/g at the soil surface and $1.0 - 1.8 \times 10^5$ cfu/g at the subsurface. Hydrocarbon utilizing fungi (HUF) ranged from $0 - 1.8 \times 10^3$ cfu/g at the surface and $0 - 1.3 \times 10^3$ cfu/g at the subsurface. Again, HUF accounted for <1% of the TF, which suggests non-pollution from crude oil sources. In the wet season, TF population ranged from $0.9 - 2.1 \times 10^5$ cfu/g at the soil surface and $0.5 - 2.0 \times 10^5$ cfu/g at the subsurface strata. The HUF density ranged from $0.5 - 1.6 \times 10^3$ cfu/g at the surface and $0.3 - 1.2 \times 10^3$ cfu/g at the subsurface. Thus, HUF was <1% of the TF at both soil strata. A similar trend was recorded at the control station where TF was 1.4×10^5 cfu/g at the surface and 1.1×10^5 cfu/g at the subsurface. The HUF was 1.2×10^3 cfu/g at the surface and 1.0×10^3 cfu/g at the subsurface. Predominant fungal species isolated from the study area include *Aspergillus* sp., *Mucor* sp. and *Penicillium* sp.

Table 4.3.3a: Soil Microbial Population during The Dry Season

| CODE | Level | THB | HUB | Most Predominant Bacterial Isolate | TF | HUF | Most Predominant Fungal Isolate |
|---------|--------|--------------|--------------|---------------------------------------------------------------------|--------------|--------------|-----------------------------------------------|
| | | 10^5 cfu/g | 10^3 cfu/g | | 10^5 cfu/g | 10^3 cfu/g | |
| OTUSS 8 | 0 - 15 | 4.4 | 1.7 | <i>Staphylococcus</i> sp, <i>Pseudomonas</i> sp, <i>Bacillus</i> sp | 2.0 | 0.7 | <i>Penicillium</i> sp |
| OTUSS 8 | 15-30 | 4.1 | 1.5 | <i>Pseudomonas</i> sp, <i>Staphylococcus</i> sp, | 1.6 | 0.6 | <i>Penicillium</i> sp, <i>Aspergillus</i> sp |
| OTUSS12 | 0 - 15 | 3.9 | 2.9 | <i>Bacillus</i> sp, <i>Pseudomonas</i> sp | 2.0 | 0.8 | <i>Aspergillus</i> sp, <i>Penicillium</i> sp, |
| OTUSS12 | 15-30 | 3.7 | 2.7 | <i>Staphylococcus</i> sp, <i>Bacillus</i> sp | 1.8 | 0.5 | <i>Penicillium</i> sp, <i>Mucor</i> sp |
| OTUSS13 | 0 - 15 | 5.9 | 3.1 | <i>Bacillus</i> sp, <i>Pseudomonas</i> sp | 1.9 | 1.1 | <i>Aspergillus</i> sp, <i>Penicillium</i> sp, |
| OTUSS13 | 15-30 | 5.7 | 2.6 | <i>Pseudomonas</i> sp, <i>Enterobacter</i> sp | 1.3 | 0.9 | <i>Mucor</i> sp, <i>Penicillium</i> sp |
| OTUSS14 | 0 - 15 | 5.1 | 3.3 | <i>Bacillus</i> sp, <i>Pseudomonas</i> sp | 2.0 | 0.6 | <i>Aspergillus</i> sp, <i>Mucor</i> sp |
| OTUSS14 | 15-30 | 4.9 | 2.6 | <i>Staphylococcus</i> sp, <i>Bacillus</i> sp, <i>Pseudomonas</i> sp | 1.7 | 0.3 | <i>Penicillium</i> sp, <i>Aspergillus</i> sp |
| OTUSS15 | 0 - 15 | 5.2 | 3.4 | <i>Bacillus</i> sp, <i>Pseudomonas</i> sp | 1.8 | 1.8 | <i>Aspergillus</i> sp, <i>Mucor</i> sp |
| OTUSS15 | 15-30 | 5.0 | 3.1 | <i>Pseudomonas</i> sp, <i>Staphylococcus</i> sp | 1.6 | 1.3 | <i>Penicillium</i> sp, |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| CODE | Level | THB | HUB | Most Predominant Bacterial Isolate | TF | HUF | Most Predominant Fungal Isolate |
|---------|--------|-----------------------|-----------------------|--------------------------------------------------------|-----------------------|-----------------------|----------------------------------------|
| | | 10 ⁵ cfu/g | 10 ³ cfu/g | | 10 ⁵ cfu/g | 10 ³ cfu/g | |
| OTUSS16 | 0 - 15 | 4.2 | 2.8 | <i>Bacillus sp, Pseudomonas sp, Enterobacter sp</i> | 1.4 | 1.5 | <i>Aspergillus sp, Penicillium sp</i> |
| OTUSS16 | 15-30 | 3.9 | 2.6 | <i>Pseudomonas sp, Staphylococcus sp</i> | 1.0 | 1.3 | <i>Penicillium sp, Mucor sp</i> |
| OTUSS17 | 0 - 15 | 5.6 | 2.0 | <i>Pseudomonas sp, Enterobacter sp, Bacillus sp</i> | 1.2 | 0.0 | <i>Aspergillus sp, Mucor sp</i> |
| OTUSS17 | 15-30 | 5.9 | 2.4 | <i>Pseudomonas sp, Micrococcus sp, Bacillus sp</i> | 1.5 | 0.0 | <i>Penicillium sp</i> |
| OTUSS18 | 0 - 15 | 3.8 | 1.8 | <i>Micrococcus sp, Pseudomonas sp, Bacillus sp</i> | 1.7 | 0.0 | <i>Aspergillus sp, Penicillium sp</i> |
| OTUSS18 | 15-30 | 3.5 | 1.6 | <i>Pseudomonas sp, Staphylococcus sp,</i> | 1.5 | 0.0 | <i>Penicillium sp, Mucor sp</i> |
| OTUSS19 | 0 - 15 | 4.4 | 1.2 | <i>Bacillus sp, Pseudomonas sp, Staphylococcus sp,</i> | 2.0 | 1.4 | <i>Aspergillus spp, Mucor sp</i> |
| OTUSS19 | 15-30 | 3.9 | 0.7 | <i>Bacillus sp, Pseudomonas sp, Enterobacter sp</i> | 1.6 | 0.8 | <i>Penicillium sp, Aspergillus spp</i> |
| OTUSS20 | 0 - 15 | 4.5 | 2.1 | <i>Bacillus sp, Pseudomonas sp, Enterobacter sp</i> | 2.0 | 1.1 | <i>Aspergillus spp, Mucor sp</i> |
| OTUSS20 | 15-30 | 4.1 | 1.6 | <i>Pseudomonas sp, Bacillus sp</i> | 1.7 | 0.9 | <i>Penicillium sp, Aspergillus spp</i> |
| OTUSS21 | 0 - 15 | 6.4 | 2.2 | <i>Pseudomonas sp, Staphylococcus sp, Bacillus sp</i> | 2.1 | 0.0 | <i>Mucor sp, Penicillium sp</i> |
| OTUSS21 | 15-30 | 6.1 | 1.9 | <i>Staphylococcus sp, Enterobacter sp, Bacillus sp</i> | 1.8 | 0.0 | <i>Mucor sp, Aspergillus spp,</i> |

Table 4.3.3b: Soil Microbial Population During The Wet Season

| CODE | Level | THB | HUB | Most Predominant Bacterial Isolate | TF | HUF | Most Predominant Fungal Isolate |
|---------|--------|-----------------------|-----------------------|-------------------------------------------------------|-----------------------|-----------------------|-------------------------------------------------|
| | | 10 ⁵ cfu/g | 10 ³ cfu/g | | 10 ⁵ cfu/g | 10 ³ cfu/g | |
| OTUSSC1 | 0 - 15 | 6.0 | 1.3 | <i>Micrococcus sp, Bacillus sp</i> | 1.4 | 1.2 | <i>Aspergillus sp, Penicillium sp</i> |
| OTUSSC1 | 15-30 | 5.8 | 1.1 | <i>Bacillus sp, Pseudomonas sp., Enterobacter sp</i> | 1.1 | 1.0 | <i>Aspergillus sp, Penicillium sp.</i> |
| OTUSS8 | 0 - 15 | 6.8 | 2.1 | <i>Bacillus sp, Staphylococcus sp, Micrococcus sp</i> | 1.5 | 0.9 | <i>Aspergillus sp, Mucor sp, Penicillium sp</i> |
| OTUSS8 | 15-30 | 6.5 | 1.9 | <i>Bacillus sp, Micrococcus sp</i> | 1.2 | 0.6 | <i>Penicillium sp, Aspergillus sp</i> |
| OTUSS9 | 0 - 15 | 5.3 | 1.5 | <i>Staphylococcus sp, Pseudomonas sp,</i> | 0.9 | 0.9 | <i>Aspergillus sp, Penicillium sp</i> |
| OTUSS9 | 15-30 | 5.0 | 1.1 | <i>Enterobacter sp, Staphylococcus sp</i> | 0.5 | 0.6 | <i>Aspergillus sp</i> |
| OTUSS13 | 0 - 15 | 8.4 | 3.9 | <i>Micrococcus sp, Pseudomonas sp</i> | 1.7 | 1.0 | <i>Aspergillus sp</i> |
| OTUSS13 | 15-30 | 8.2 | 3.3 | <i>Bacillus sp, Staphylococcus sp</i> | 1.0 | 0.8 | <i>Penicillium sp, Aspergillus sp</i> |
| OTUSS14 | 0 - 15 | 7.3 | 2.0 | <i>Micrococcus sp, Bacillus sp</i> | 1.8 | 0.5 | <i>Aspergillus sp</i> |
| OTUSS14 | 15-30 | 7.0 | 1.8 | <i>Bacillus sp, Staphylococcus sp</i> | 1.6 | 0.3 | <i>Aspergillus sp, Mucor sp</i> |
| OTUSS15 | 0 - 15 | 7.3 | 4.2 | <i>Bacillus sp, Micrococcus sp</i> | 2.1 | 1.6 | <i>Aspergillus sp</i> |
| OTUSS15 | 15-30 | 7.1 | 4.0 | <i>Micrococcus sp, Pseudomonas sp</i> | 2.0 | 1.2 | <i>Aspergillus sp, Penicillium sp</i> |
| OTUSS16 | 0 - 15 | 7.1 | 3.3 | <i>Staphylococcus sp, Enterobacter sp</i> | 1.6 | 1.4 | <i>Aspergillus sp, Penicillium sp</i> |

| CODE | Level | THB | HUB | Most Predominant Bacterial Isolate | TF | HUF | Most Predominant Fungal Isolate |
|---------|--------|-----------------------|-----------------------|--------------------------------------------------------------------------------|-----------------------|-----------------------|-----------------------------------------------------------------------|
| | | 10 ⁵ cfu/g | 10 ³ cfu/g | | 10 ⁵ cfu/g | 10 ³ cfu/g | |
| OTUSS16 | 15-30 | 6.9 | 3.0 | <i>Staphylococcus sp</i> , <i>Enterobacter sp</i> | 1.3 | 1.2 | <i>Penicillium sp</i> , <i>Mucor sp</i> |
| OTUSS17 | 0 - 15 | 8.3 | 3.2 | <i>Pseudomonas sp</i> , <i>Staphylococcus sp</i> | 2.1 | 0.9 | <i>Aspergillus sp</i> , <i>Penicillium sp</i> |
| OTUSS17 | 15-30 | 7.5 | 2.8 | <i>Staphylococcus sp.</i> , <i>Micrococcus sp</i> , <i>Bacillus sp</i> | 1.5 | 0.3 | <i>Aspergillus spp</i> , <i>Mucor sp</i> |
| OTUSS19 | 0 - 15 | 6.3 | 1.5 | <i>Bacillus sp</i> , <i>Micrococcus sp</i> , <i>Pseudomonas sp</i> | 2.1 | 1.3 | <i>Aspergillus sp</i> |
| OTUSS19 | 15-30 | 5.5 | 0.8 | <i>Bacillus sp</i> , <i>Staphylococcus sp</i> | 1.6 | 0.7 | <i>Penicillium sp</i> , <i>Aspergillus sp</i> |
| OTUSS20 | 0 - 15 | 6.3 | 2.6 | <i>Bacillus sp</i> , <i>Staphylococcus sp</i> | 1.9 | 0.9 | <i>Penicillium sp</i> , <i>Aspergillus sp</i> |
| OTUSS20 | 15-30 | 5.8 | 2.0 | <i>Micrococcus sp</i> , <i>Staphylococcus sp</i> , <i>Pseudomonas sp</i> | 1.3 | 0.5 | <i>Mucor sp</i> , <i>Aspergillus sp</i> , <i>Penicillium sp</i> |
| OTUSS21 | 0 - 15 | 5.5 | 0.9 | <i>Staphylococcus sp</i> , <i>Bacillus sp</i> | 1.6 | 0.7 | <i>Aspergillus spp</i> , <i>Mucor sp</i> |
| OTUSS21 | 15-30 | 4.9 | 0.5 | <i>Bacillus sp</i> , <i>Staphylococcus sp</i> | 1.1 | 0.3 | <i>Penicillium sp</i> , <i>Aspergillus sp</i> |

Soil Carrying Capacity (Limit of Acceptable Change)

Soil carrying capacity is the maximal alteration of the biological, physical and chemical components that a soil area can support without lessening its ability to further provide nutrients and support vegetative growth. When a soil exceeds its carrying capacity, such a soil’s suitability and capability status will have to be altered or enhanced for it to be able to serve other purposes.

The Otumara area is a brown field and has been supporting oil exploration and production activities for over four decades. The analytical results indicated that the soil still has the capacity to support vegetative and faunal growth, and has not been altered beyond tolerable or regulatory limit (Fig. 4.3.1 and Table 4.3.2).

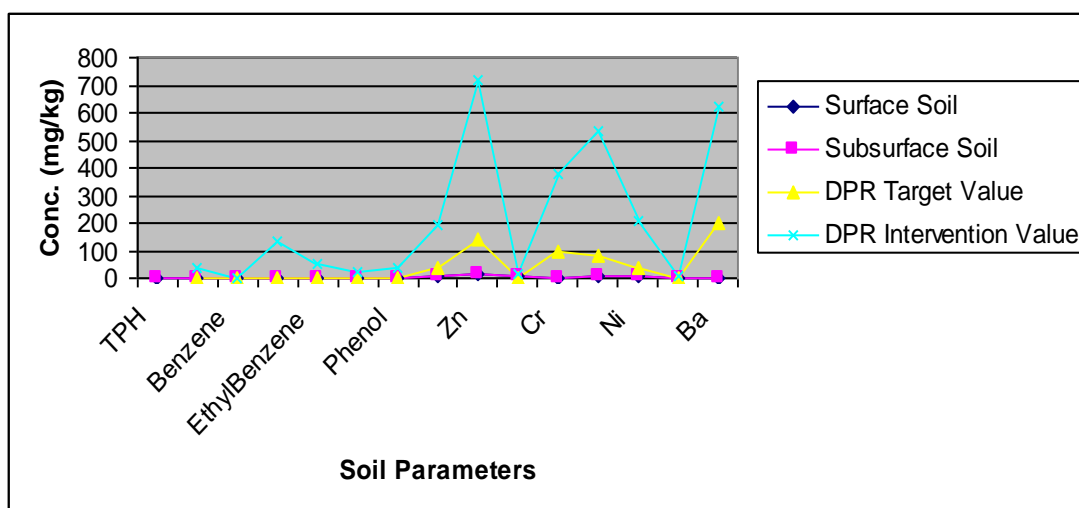


Fig. 4.3.1: Soil Parameters Concentration as Compared to DPR Limits

4.3.2 Land Use and Agriculture

Land Use refers to the various uses to which the land in Otumara project area is put into. This was ascertained by observing directly in the field the various land use patterns. The major land use types in Otumara area include mangrove forest, dwelling places, cultivated agricultural lands, fallow lands, oil/gas exploration and production facilities, and communication facilities. A panoramic view of the various land uses in Otumara area is presented in **Plate 4.3.1**, while a checklist of the various land uses in the area is presented in **Table 4.3.4**.



Plate 4.3.1: A Panoramic View of the Various Land Uses in Otumara Area

Table 4.3.4: Various Land Uses in Otumara Project Area

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

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

4.4 Surface Water Quality

Natural waters are extremely dilute chemical solutions with very small quantities of dissolved organic and inorganic compounds, and existing in equilibrium with the natural atmospheric gases. The concentration of the dissolved compounds, especially the alkaline earth metals determine whether the water is fresh, brackish or marine.

A total of nine (9) water samples including a control point were collected from water bodies (creeks and dredge slots) within the Otumara Project area. The detailed physico-chemical results of surface waters are provided in Tables 4.4.1 while the summary indicating the minimum, maximum, mean and regulatory limits are reported in Table 4.4.2. All the water samples in this study were moderately acidic to moderately alkaline in nature. The pH values of the surface water samples ranged from 6.75 in the dry season to a maximum of 7.4 in the wet season. The pH of the control station (SWC3) was more alkaline (varying from 7.06 in the dry season to 7.4 in the wet season) due to its more brackish nature.

Water temperature variations follow closely the changes in atmospheric temperatures. The water temperatures in this study ranged between 25.7 °C in the wet season and 32.9 °C in the dry season, with a mean of 26.5 °C and 32.2 °C for the wet and dry seasons respectively. These values are within the acceptable limit of 35 °C set by Federal Ministry of Environment (1999).

Electrical Conductivity (EC), also called specific conductance, is a measure of the ability of a water sample to convey an electrical current and it is related to the concentration of ionized substances in water. The conductivity values recorded in this study ranged from 3039 in the wet season to 20860 µS/cm in the Control station. The mean conductivity value was higher in the dry than in the wet season. These values are characteristic of brackish water environment.

Table 4.4.1a: Details of the Wet Season Physico-Chemical Results of Surface waters within Otumara

| S/N | Parameters | Units | OTU SWC3 | OTU SW8 | OTU SW9 | OTU SW10 | OTU SW11 | OTU SW12 | OTU SW13 | OTU SW14 | OTU SW15 |
|-----|-------------------|-------|-------------|------------|------------|-------------|-------------|-------------|-------------|-------------|-------------|
| 1 | pH | | 7.4 | 6.8 | 6.9 | 6.9 | 6.8 | 6.9 | 7.0 | 7.0 | 6.9 |
| 2 | Temp | °C | 28.2 | 26.3 | 26.3 | 26.6 | 26.6 | 26.3 | 26.6 | 26.0 | 25.7 |
| 3 | EC | µS/cm | 20860 | 4206 | 4367 | 3039 | 3816 | 3236 | 3285 | 3411 | 3506 |
| 4 | Salinity | g/l | 9.43 | 1.90 | 1.96 | 1.37 | 1.73 | 1.46 | 1.49 | 1.54 | 1.63 |
| 5 | Colour | Pt.Co | 9.9 | 9.1 | 15.3 | 10.4 | 13.9 | 18.5 | 16.0 | 9.5 | 10.2 |
| 6 | Turbidity | NTU | 6.3 | 7.8 | 11.4 | 7.6 | 10.1 | 13.6 | 14.5 | 7.1 | 7.3 |
| 7 | TSS | mg/l | 9.5 | 9.9 | 9.3 | 9.8 | 11.3 | 17.4 | 17.9 | 10.2 | 15.5 |
| 8 | TDS | “ | 10430 | 2054 | 2131 | 1523 | 1851 | 1580 | 1595 | 1705 | 1755 |
| 9 | DO | “ | 7.36 | 6.82 | 6.88 | 6.87 | 6.78 | 6.87 | 7.00 | 6.97 | 6.92 |
| 10 | BOD ₅ | “ | 5.50 | 2.20 | 2.70 | 2.90 | 1.40 | 1.90 | 1.90 | 2.40 | 1.30 |
| 11 | COD | “ | 13.6 | 1.6 | 1.6 | 8.8 | 4.8 | 16.0 | 7.2 | 5.6 | 14.6 |
| 12 | HCO ₃ | “ | 97.6 | 79.3 | 91.5 | 73.2 | 91.5 | 152.5 | 122.0 | 79.3 | 79.3 |
| 13 | Na | “ | 165 | 122 | 163 | 164 | 154 | 163 | 160 | 170 | 102 |
| 14 | K | “ | 139.3 | 117.0 | 95.2 | 143.9 | 130.3 | 26.4 | 139.6 | 140.2 | 26.4 |
| 15 | Ca | “ | 44.0 | 33.9 | 35.7 | 35.8 | 31.6 | 41.3 | 55.3 | 57.2 | 55.3 |
| 16 | Mg | “ | 55.3 | 55.0 | 54.3 | 54.1 | 53.6 | 53.9 | 31.2 | 42.5 | 31.2 |
| 17 | Cl | “ | 17900 | 5620 | 5580 | 3880 | 4300 | 3750 | 3700 | 3930 | 4130 |
| 18 | PO ₄ | “ | 6.15 | 1.60 | 2.01 | 1.83 | 1.85 | 2.10 | 1.65 | 1.61 | 1.65 |
| 19 | NH ₄ N | “ | 1.92 | 1.83 | 1.77 | 1.80 | 1.89 | 2.13 | 1.82 | 1.90 | 1.90 |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| S/N | Parameters | Units | OTU SWC3 | OTU SW8 | OTU SW9 | OTU SW10 | OTU SW11 | OTU SW12 | OTU SW13 | OTU SW14 | OTU SW15 |
|-----|-------------------|-------|-------------|------------|------------|-------------|-------------|-------------|-------------|-------------|-------------|
| 20 | NO ₂ N | “ | 1.03 | 1.05 | 1.19 | 1.20 | 1.03 | 1.26 | 1.98 | 1.21 | 1.10 |
| 21 | NO ₃ N | “ | 2.63 | 2.50 | 2.67 | 2.81 | 2.61 | 2.76 | 3.05 | 3.17 | 2.87 |
| 22 | SO ₄ | “ | 56.5 | 68.4 | 69.0 | 69.5 | 71.4 | 55.8 | 57.5 | 56.8 | 57.1 |
| 23 | THC | “ | 0.31 | 0.19 | 0.22 | 1.05 | 0.82 | 0.34 | 0.32 | 0.36 | 0.09 |
| 24 | TPH | mg/l | 0.001 | 0.018 | 0.011 | 0.012 | 0.011 | 0.009 | 0.010 | 0.022 | 0.022 |
| 25 | PAH | µg/l | 0.001 | 0.005 | 0.004 | 0.008 | 0.007 | 0.009 | 0.006 | 0.012 | 0.013 |
| 26 | Benzene | “ | ND | 0.001 | ND | ND | 0.004 | 0.002 | 0.003 | 0.001 | ND |
| 27 | Toluene | “ | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 28 | Ethylbenzene | “ | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 29 | Xylene | “ | ND | ND | ND | ND | ND | ND | ND | 0.001 | 0.003 |
| 30 | Phenol | “ | 0.001 | 0.002 | 0.001 | 0.004 | 0.005 | 0.007 | 0.006 | 0.008 | 0.004 |
| 1 | Fe | mg/l | 1.59 | 1.26 | 1.18 | 1.62 | 1.33 | 1.55 | 1.09 | 1.27 | 1.31 |
| 2 | Cu | “ | 0.013 | 0.037 | 0.041 | 0.038 | 0.006 | 0.031 | 0.051 | 0.013 | 0.012 |
| 3 | Mn | “ | 0.069 | 0.024 | 0.027 | 0.043 | 0.058 | 0.040 | 0.047 | 0.055 | 0.060 |
| 4 | Zn | “ | 0.053 | 0.029 | 0.033 | 0.025 | 0.073 | 0.018 | 0.032 | 0.045 | 0.039 |
| 5 | Cd | “ | 0.014 | 0.014 | 0.024 | 0.011 | 0.011 | 0.030 | 0.007 | 0.011 | 0.010 |
| 6 | Cr | “ | 0.030 | 0.016 | 0.022 | 0.019 | 0.025 | 0.014 | 0.021 | 0.024 | 0.027 |
| 7 | Pb | “ | 0.072 | 0.076 | 0.080 | 0.072 | 0.072 | 0.078 | 0.072 | 0.109 | 0.110 |
| 8 | Ni | “ | 0.040 | 0.045 | 0.041 | 0.032 | 0.016 | 0.042 | 0.040 | 0.004 | 0.010 |
| 9 | V | “ | 0.034 | 0.033 | 0.034 | 0.025 | 0.014 | 0.033 | 0.037 | 0.003 | 0.008 |
| 10 | Hg | “ | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 11 | Ba | “ | 0.005 | 0.001 | 0.005 | 0.003 | 0.004 | 0.003 | 0.002 | 0.003 | 0.006 |

4.4.1b: Details of the Dry Season Physico-Chemical Results of Surface waters within Otumara

| S/N | Parameters | Units | OTU SWC3 | OTU SW9 | OTU SW10 | OTU SW11 | OTU SW12 | OTU SW13 | OTU SW14 | OTU W15 | OTU SW16 |
|-----|-------------------|-------|-------------|------------|-------------|-------------|-------------|-------------|-------------|------------|-------------|
| 1 | pH | | 7.06 | 7.01 | 6.88 | 6.75 | 7.16 | 7.10 | 7.22 | 7.28 | 7.31 |
| 2 | Temp | °C | 31.6 | 31.7 | 32.3 | 32.8 | 32.5 | 32.9 | 31.9 | 32.0 | 32.1 |
| 3 | EC | µS/cm | 19180 | 18960 | 18720 | 18570 | 18430 | 18300 | 18730 | 18610 | 18820 |
| 4 | Salinity | g/l | 8.67 | 8.57 | 8.47 | 8.40 | 8.34 | 8.28 | 8.47 | 8.41 | 8.51 |
| 5 | Colour | Pt.Co | 11.2 | 10.2 | 8.9 | 15.3 | 11.3 | 18.3 | 11.4 | 9.8 | 10.3 |
| 6 | Turbidity | NTU | 9.2 | 7.9 | 7.1 | 9.8 | 9.0 | 11.0 | 8.3 | 6.8 | 8.7 |
| 7 | TSS | mg/l | 9.3 | 10.9 | 9.5 | 14.8 | 18.3 | 10.7 | 12.6 | 10.2 | 15.8 |
| 8 | TDS | “ | 10165 | 10149 | 9922 | 9842 | 9768 | 9699 | 9927 | 9863 | 9975 |
| 9 | DO | “ | 5.2 | 5.0 | 4.7 | 4.8 | 4.6 | 4.3 | 5.0 | 4.9 | 4.7 |
| 10 | BOD ₅ | “ | 3.0 | 3.8 | 2.4 | 2.6 | 2.7 | 3.1 | 2.9 | 3.0 | 2.8 |
| 11 | COD | “ | 62.4 | 59.2 | 43.2 | 35.2 | 32.8 | 59.2 | 60.8 | 52.0 | 56.8 |
| 12 | HCO ₃ | “ | 146 | 122 | 238 | 141 | 153 | 165 | 214 | 159 | 153 |
| 13 | Na | “ | 124.2 | 139.6 | 142.5 | 152.4 | 141.0 | 139.1 | 154.1 | 158.7 | 154.1 |
| 14 | K | “ | 111.0 | 134.5 | 102.3 | 92.2 | 112.5 | 124.5 | 105.3 | 107.8 | 107.9 |
| 15 | Ca | “ | 59.2 | 57.7 | 51.2 | 53.5 | 49.1 | 53.7 | 50.9 | 52.5 | 58.3 |
| 16 | Mg | “ | 61.2 | 57.1 | 58.9 | 53.4 | 53.3 | 57.8 | 53.9 | 53.6 | 53.3 |
| 17 | Cl ⁻ | “ | 6250 | 6350 | 6210 | 6290 | 6380 | 6560 | 6470 | 6650 | 6610 |
| 18 | PO ₄ | “ | 1.26 | 1.30 | 0.98 | 2.34 | 1.49 | 1.20 | 1.69 | 2.10 | 2.22 |
| 19 | NH ₄ N | “ | 0.33 | 0.12 | 0.22 | 0.10 | 0.36 | 0.21 | 0.14 | 0.08 | 0.12 |
| 20 | NO ₂ N | “ | 1.20 | 1.89 | 1.10 | 2.56 | 1.08 | 1.30 | 2.10 | 1.19 | 0.98 |
| 21 | NO ₃ N | “ | 1.36 | 2.81 | 1.27 | 3.42 | 1.37 | 1.68 | 2.50 | 1.29 | 1.52 |
| 22 | SO ₄ | “ | 79.5 | 65.8 | 66.4 | 61.2 | 69.3 | 60.7 | 59.6 | 63.8 | 58.4 |
| 23 | THC | “ | 0.15 | 0.20 | 0.24 | 1.30 | 0.94 | 0.30 | 0.64 | 0.79 | 0.25 |
| 24 | TPH | mg/l | 0.003 | 0.003 | 0.006 | 0.002 | 0.007 | 0.009 | 0.018 | 0.012 | 0.015 |
| 25 | PAH | µg/l | 0.005 | 0.002 | 0.004 | 0.003 | 0.001 | 0.002 | 0.001 | 0.003 | 0.008 |
| 26 | Benzene | “ | 0.001 | 0.001 | ND | ND | ND | 0.001 | ND | ND | ND |
| 27 | Toluene | “ | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 28 | Ethylbenzene | “ | ND | ND | ND | ND | ND | ND | ND | ND | ND |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| S/N | Parameters | Units | OTU SWC3 | OTU SW9 | OTU SW10 | OTU SW11 | OTU SW12 | OTU SW13 | OTU SW14 | OTU W15 | OTU SW16 |
|---------------------|------------|-------|-------------|------------|-------------|-------------|-------------|-------------|-------------|------------|-------------|
| 29 | Xylene | “ | ND | 0.001 | ND | 0.002 | 0.002 | 0.001 | 0.001 | 0.002 | ND |
| 30 | Phenol | “ | 0.001 | 0.002 | 0.001 | 0.002 | 0.002 | 0.001 | 0.002 | 0.003 | 0.004 |
| Heavy metals | | | | | | | | | | | |
| 1 | Fe | mg/L | 0.063 | 0.058 | 0.062 | 0.043 | 0.064 | 0.062 | 0.057 | 0.058 | 0.049 |
| 2 | Cu | “ | 0.043 | 0.010 | 0.052 | 0.014 | 0.051 | 0.052 | 0.046 | 0.050 | 0.050 |
| 3 | Mn | “ | 0.015 | 0.021 | 0.168 | 0.019 | 0.004 | 0.001 | 0.003 | 0.006 | 0.011 |
| 4 | Zn | “ | 0.012 | 0.026 | 0.040 | 0.016 | 0.095 | 0.012 | 0.018 | 0.020 | 0.026 |
| 5 | Cd | “ | 0.004 | 0.001 | 0.003 | 0.002 | 0.003 | ND | 0.001 | 0.004 | 0.002 |
| 6 | Cr | “ | 0.002 | 0.002 | 0.002 | 0.001 | 0.002 | 0.002 | 0.003 | 0.001 | 0.002 |
| 7 | Pb | “ | 0.201 | 0.108 | 0.168 | 0.112 | 0.182 | 0.150 | 0.148 | 0.162 | 0.172 |
| 8 | Ni | “ | 0.056 | 0.030 | 0.043 | 0.026 | 0.043 | ND | 0.038 | 0.041 | 0.051 |
| 9 | V | “ | 0.048 | 0.024 | 0.036 | 0.019 | 0.036 | ND | 0.032 | 0.034 | 0.042 |
| 10 | Hg | “ | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 11 | Ba | “ | 0.002 | 0.003 | 0.005 | 0.001 | 0.004 | 0.002 | 0.003 | 0.001 | 0.004 |

Table 4.4.2: Summary of the Physico-Chemical Results of Surface waters within Otumara

| Parameters | Units | WET SEASON | | | | DRY SEASON | | | | DPR/ *FMEnv |
|---------------------|-------|------------|-------|-------|---------|------------|-------|-------|---------|----------------------|
| | | Min | Max | Mean | Control | Min | Max | Mean | Control | |
| pH | | 6.8 | 7.4 | 6.96 | 7.4 | 6.75 | 7.31 | 7.09 | 7.06 | 6.5-9.2/ 6.5-8.5* |
| Temp | °C | 25.7 | 28.2 | 26.5 | 28.2 | 31.6 | 32.9 | 32.2 | 31.6 | 30 |
| EC | µS/cm | 3039 | 20860 | 5525 | 20860 | 1830 | 19180 | 18702 | 19180 | |
| Salinity | ‰ | 1.37 | 9.66 | 2.50 | 9.43 | 8.28 | 8.67 | 8.46 | 8.67 | |
| Colour | Pt.Co | 9.1 | 18.5 | 12.5 | 9.9 | 8.9 | 18.3 | 11.86 | 11.2 | |
| Turbidity | NTU | 7.1 | 14.5 | 9.5 | 6.3 | 6.8 | 11.0 | 8.64 | 9.2 | 1.0* |
| TSS | mg/l | 9.3 | 17.9 | 12.3 | 9.5 | 9.3 | 18.3 | 12.5 | 9.3 | <10* |
| TDS | “ | 1523 | 10430 | 2736 | 10430 | 9699 | 10165 | 9923 | 10165 | 1500/ 500* |
| DO | “ | 6.78 | 7.36 | 6.94 | 7.36 | 4.3 | 5.2 | 4.8 | 5.2 | 7.5* |
| BOD ₅ | “ | 1.30 | 5.50 | 2.47 | 5.50 | 2.4 | 3.8 | 2.92 | 3.0 | 0* |
| COD | “ | 1.6 | 14.6 | 8.2 | 13.6 | 32.8 | 62.4 | 51.3 | 62.4 | |
| HCO ₃ | “ | 12.2 | 152.5 | 96.2 | 97.6 | 122 | 165 | 166 | 146 | |
| Na | “ | 102 | 170 | 151.4 | 165 | 124.2 | 158.7 | 145.1 | 124.2 | |
| K | “ | 26.4 | 143.9 | 106.5 | 139.3 | 92.2 | 134.5 | 110.9 | 111.0 | |
| Ca | “ | 31.6 | 57.2 | 43.3 | 44.0 | 49.1 | 59.2 | 54.0 | 59.2 | 200 |
| Mg | “ | 31.2 | 55.3 | 47.9 | 55.3 | 53.3 | 61.2 | 55.8 | 61.2 | 150 |
| Cl ⁻ | “ | 3700 | 17900 | 5566 | 17900 | 6210 | 6650 | 6419 | 6250 | 600/ 250* |
| PO ₄ | “ | 1.60 | 6.15 | 2.27 | 6.15 | 0.98 | 2.34 | 1.62 | 1.26 | <5* |
| NH ₄ N | “ | 1.77 | 2.13 | 1.88 | 1.92 | 0.10 | 0.36 | 0.19 | 0.33 | |
| NO ₂ -N | “ | 1.03 | 1.98 | 1.23 | 1.03 | 0.98 | 2.56 | 1.49 | 1.20 | |
| NO ₃ -N | “ | 2.50 | 3.17 | 2.79 | 2.63 | 1.27 | 3.42 | 1.91 | 1.36 | 10* |
| SO ₄ | “ | 55.8 | 71.4 | 62.4 | 56.5 | 58.4 | 79.5 | 70.0 | 79.5 | |
| THC | “ | 0.02 | 1.05 | 0.41 | 0.31 | 0.15 | 1.30 | 0.53 | 0.15 | |
| TPH | mg/l | 0.001 | 0.022 | 0.013 | 0.001 | 0.002 | 0.018 | 0.008 | 0.003 | 0.3 |
| PAH | µg/l | 0.001 | 0.013 | 0.007 | 0.001 | 0.001 | 0.008 | 0.003 | 0.005 | |
| Benzene | “ | 0.001 | 0.003 | 0.002 | ND | ND | 0.001 | 0.001 | 0.001 | |
| Toluene | “ | ND | ND | ND | ND | ND | ND | ND | ND | |
| Ethylbenzene | “ | ND | ND | ND | ND | ND | ND | ND | ND | |
| Xylene | “ | 0.001 | 0.003 | 0.002 | ND | ND | 0.002 | 0.002 | ND | |
| Phenol | “ | 0.001 | 0.008 | 0.004 | 0.001 | 0.001 | 0.004 | 0.002 | 0.001 | |
| Heavy metals | | | | | | | | | | |
| Fe | mg/l | 1.09 | 1.62 | 1.36 | 1.59 | 0.043 | 0.064 | 0.057 | 0.063 | 1/1* |
| Cu | “ | 0.006 | 0.051 | 0.027 | 0.013 | 0.010 | 0.052 | 0.041 | 0.043 | 1.5/0.1* |
| Mn | “ | 0.024 | 0.069 | 0.047 | 0.069 | 0.001 | 0.164 | 0.028 | 0.015 | 0.5-5/ 0.05-0.5* |
| Zn | “ | 0.018 | 0.073 | 0.039 | 0.053 | 0.012 | 0.095 | 0.029 | 0.012 | 15/5.0* |

| Parameters | Units | WET SEASON | | | | DRY SEASON | | | | DPR/ *FMEnv |
|------------|-------|------------|-------|--------|---------|------------|-------|-------|---------|----------------|
| | | Min | Max | Mean | Control | Min | Max | Mean | Control | |
| Cd | “ | 0.007 | 0.030 | 0.015 | 0.014 | 0.001 | 0.004 | 0.003 | 0.004 | 0.01* |
| Cr | “ | 0.014 | 0.030 | 0.022 | 0.030 | 0.001 | 0.003 | 0.002 | 0.002 | 0.05* |
| Pb | “ | 0.072 | 0.110 | 0.082 | 0.072 | 0.108 | 0.201 | 0.156 | 0.201 | 0.05* |
| Ni | “ | 0.004 | 0.045 | 0.03 | 0.040 | 0.026 | 0.056 | 0.041 | 0.056 | 0.05* |
| V | “ | 0.003 | 0.037 | 0.025 | 0.034 | 0.019 | 0.048 | 0.034 | 0.048 | 0.01* |
| Hg | “ | ND | ND | ND | ND | ND | ND | ND | ND | 0.001* |
| Ba | “ | 0.001 | 0.006 | 0.0036 | 0.005 | 0.001 | 0.005 | 0.003 | 0.002 | 1.0* |

* Limits for potable water sources (FMEnv)

The concentration of the dissolved compounds, such as chloride and alkaline earth metals determine whether the water is fresh, brackish or marine.

A total of nine (9) water samples including a control point were collected from water bodies (creeks and dredge slots) within the Otumara Project area. The detailed physico-chemical results of surface waters are provided in Tables 4.4.1a and b while the summary indicating the minimum, maximum, mean and regulatory limits are reported in Table 4.4.2a. All the water samples in this study were moderately acidic to moderately alkaline in nature. The pH values of the surface water samples ranged from 6.75 to 7.31 (weakly acidic to weakly neutral) in the dry season and 6.8 to 7.0 (weakly acidic to neutral) in the wet season. The pH of the control station (SWC3) was weakly neutral (varying from 7.06 in the dry season to 7.4 in the wet season) due to its more brackish nature.

Water temperature variations follow closely the changes in atmospheric temperatures. The water temperatures in this study ranged from 25.7 °C to 26.6 °C in the wet season and 31.7 to 32.9 °C in the dry season, with a mean of and 32.2 °C for the wet and dry seasons respectively.

Electrical Conductivity (EC), also called specific conductance, is a measure of the ability of a water sample to convey an electrical current and it is related to the concentration of ionized substances in water. The conductivity values recorded in this study ranged from 3039 in the wet season to 20860 µS/cm in the Control station. The mean conductivity value was higher in the dry than in the wet season. These values are characteristic of brackish water environment (Odokuma and Okpokwasili, 1993).

Salinity values ranged from 1.37 ‰ (parts per thousand) to 9.66 ‰ with a mean value of 2.5 ‰ in the wet season and a higher mean of 8.46 ‰ in the dry season. These values are characteristic of brackish water environments. Salinity is not a problem in brackish water environment because the life forms are generally adapted to high salinity.

The colour of water determines the depth to which light is transmitted. This in turn, controls the amount of primary productivity that is possible by controlling the rate of photosynthesis of the algae present (Chapman, 1996). The colour values recorded in this study ranged between 8.9 in the dry season and 18.5 Pt – Co units in the wet season. The presence of humic substances introduced by allochthonous inputs in the wet season could have been responsible for the higher wet season colour. Natural waters can range from <5 in very clear waters to 300 units in dark

peaty waters (Chapman, 1996). The control locations for both dry and wet seasons were not different from the other stations.

The turbidity values in this study ranged from 6.3 NTU in the control to 14.5 NTU (mean, 9.5 NTU) in the wet season. The higher turbidity values in the wet season is expected because of Normal values range from 1 to 1000 NTU and levels can be increased by the presence of organic matter pollution, other effluents or run-off (allochthonous inputs) with high suspended matter content (Chapman, 1996).

The ranges of values of Total Dissolved Solids (TDS) and Total Suspended Solids (TSS) in this study are 1523 – 10430 mg/l and 9.3 – 18.3 mg/l respectively. The TDS and TSS mean values are 2736 and 12.5 mg/l respectively. The level of TDS recorded in this study is characteristic of brackish water environment and followed the same trend with electrical conductivity (EC). The TSS and TDS values for control were 9.5 and 10430 mg/l respectively for the wet season, and 9.3 and 10165 mg/l respectively for the dry season.

Oxygen is essential to all forms of aquatic life, including those organisms responsible for the self purification processes in natural waters. The DO values recorded in this study ranged from 4.3 in the dry season to 7.36 mg/l in the control with a mean of 6.94 mg/l in the dry season. Concentrations below 5 mg/l may adversely affect the functioning and survival of biological communities and below 2 mg/l may lead to the death of most fish (Chapman, 1996). On the other hand, Biochemical Oxygen Demand (BOD) is a measure of the fraction of the organic matter in a water body that is susceptible to biodegradation. The BOD values recorded in this study ranged from 1.30 mg/l to 5.50 mg/l with a mean value of 2.48 mg/l. In the absence of National regulatory limits for these parameters for aquatic life, the EU standard was used. For fisheries and aquatic life, the EU sets a BOD standard of 3 – 6 mg/l (Radojevic and Bashkin, 1999).

The COD is an indirect estimate of the total organic matter in an aquatic system susceptible to chemical oxidation by a strong chemical oxidizing agent such potassium dichromate or potassium permanganate. It is widely used to measure the total organic strength of water samples. The COD values in this study ranged from 1.60 mg/l to 14.6 mg/l in the wet season and 32.8 mg/l to 62.4 mg/l in the dry season. The higher COD values recorded for the dry season can be explained by the higher rate of decomposition and mineralization of introduced organic matters. In the wet season high rainfall produces floods and anoxic environments thereby reducing biodegradation rates. However, Okpokwasili and Odokuma (1993) recorded higher BOD and COD values in the wet season than in the dry season in the New Calabar River in the Niger Delta.

The presence of Bicarbonates (HCO_3^-) influences the hardness and alkalinity of water. The relative of amounts of bicarbonates are related to pH. Bicarbonate values ranged between 12.20 and 165 mg/l (means, 96.2 mg/l and 166 mg/l for wet and dry seasons respectively). Bicarbonate concentrations in surface waters are usually <500 mg/l, and commonly <25 mg/l (Chapman, 1996). The control values for the wet and dry seasons were 97.6 and 146 mg/l respectively.

Sodium (Na), Potassium (K), Calcium (Ca) and Magnesium (Mg), the earth metals in solution constitute the exchangeable cations. In this study, sodium ranged between 102 and 170 mg/l,

potassium (26.4 – 143.9 mg/l), calcium (31.6 – 59.2 mg/l) and magnesium (31.2 – 61.2 mg/l). These values are characteristic of brackish water environment and not different from values obtained for the control station for both the wet and dry seasons. The order of dominance is as follows: Na > K > Mg > Ca.

Chloride values ranged between 3700 and 17900 mg/l during the study. Chloride is not considered as being harmful to human health. Chloride values above 250 mg/l produce a salty taste which makes the water unpalatable. Chloride values in the control were as high as 17900 mg/l because of its nearness to the coast and brackish nature. High chloride values are harmful to plants; some damages may occur at levels as low as 70 – 250 mg/l (Radojevic and Bashkin, 1999).

Sulphate values ranged from 55.8 in the wet season to 79.5 mg/l in the dry season. Sulphate concentrations in natural water are usually between 2 and 80 mg/l; high concentration (>400 mg/l) may make water unpleasant to drink.

Nitrogen compounds are of interest to environmentalists because they are both essential nutrients, beneficial to living organisms, and pollutants with potentially harmful consequences. Ammonia, nitrate and nitrite are indicators of nitrogen loading of waters. The nitrate and nitrite values recorded in this study ranged from 1.27 – 3.42 mg/l and 0.90 – 1.98 mg/l respectively. The $\text{NO}_3^- \text{N}$ and $\text{NO}_2^- \text{N}$ mean values are 2.79 and 1.23 mg/l respectively for the wet season, and 1.91 and 1.49 mg/l respectively for the dry season. The ammonium nitrogen values recorded in this study ranged from 0.10 – 2.13 mg/l in dry and wet seasons respectively. The phosphate content of the waters in this study ranged between 0.98 mg/l and 6.15 mg/l in the dry and wet seasons respectively.

The levels of Total Hydrocarbon (THC), Total Petroleum Hydrocarbon (TPH), Polycyclic Aromatic Hydrocarbon (PAH), BTEX (Benzene, Toluene, Ethylbenzene and Xylene) and Phenol recorded in this study were low, indicating an environment not polluted by petroleum hydrocarbons. The THC values ranged between 0.02 and 1.05 mg/l, TPH values ranged between 0.001 and 0.022 mg/l, while PAH values ranged from 0.001 to 0.013 mg/l. The BTEX and Phenol values ranged from 0.00 to 0.008 mg/l and 0.001 to 0.003 mg/l respectively. These values are below the regulatory limits, especially for TPH.

Natural waters contain very small quantities of several essential metals including zinc (Zn), copper (Cu), Cadmium (Cd), lead (Pb), iron (Fe), Nickel (Ni), chromium (Cr), manganese (Mn), barium (Ba), vanadium (V) and mercury (Hg). These metals, also called trace or heavy metals are required by plants and animals in minute quantities. They are toxic in relatively high concentrations, persistent, easily assimilated and bio-accumulated in the protoplasm of aquatic organisms. The concentrations of heavy metals in the water samples were generally low ranging from 0.00 mg/l (Hg) to 1.69 mg/l (Fe). All heavy metals had mean values less than the regulatory limits, except for Fe and Pb which had values greater than the regulatory limits of DPR (WHO) and FMEnv. High lead levels recorded in this study may be attributed to combustion of lead-containing fuel used in our water crafts (speed boats and barges).

Water Microbiology

The populations of microbial species in the surface water of the study area during the dry and wet seasons are presented in Tables 4.4.3a and 4.4.3b respectively. The populations of total heterotrophic bacteria (THB) and Total fungi (TF) in the study area during the wet and dry seasons were generally in the order of 10^4 cfu/ml. During the dry season, THB in the surface water was in the range of $5.1 - 9.1 \times 10^4$ cfu/ml with a mean of 6.69×10^4 cfu/ml. The control had a population of 4.8×10^4 cfu/ml. Hydrocarbon utilizing bacteria (HUB) ranged from $0.8 - 2.8 \times 10^2$ cfu/ml, with a mean of 1.51×10^2 cfu/ml. Hence, HUB accounted for about 1% of the THB. In the wet season, THB ranged from $6.9 - 9.2 \times 10^4$ cfu/ml with a mean of 7.9×10^4 cfu/ml. The control had a THB population of 5.5×10^4 cfu/ml and HUB population of 0.8×10^2 cfu/ml. Predominant bacterial genera isolated from the surface water include *Bacillus*, *Micrococcus*, *Pseudomonas*, *Enterobacter*, *Serratia*, *Staphylococcus*, *Alcaligenes*, *Norcadia* and *Escherichia*.

Total fungi (TF) during the dry season ranged from $0.7 - 1.4 \times 10^4$ cfu/ml with a mean of 1.0×10^4 cfu/ml. The TF of the control fell within the range of the main samples. Hydrocarbon utilizing fungi (HUF) during the dry season was scanty occurring in only few locations with a population of $0 - 1.0 \times 10^2$ cfu/ml having a mean of 0.3×10^2 cfu/ml. Thus, the proportion of HUF relative to the TF was less than 1% suggesting no hydrocarbon input from petroleum sources. In the wet season, the TF population ranged from $0.4 - 1.8 \times 10^4$ cfu/ml, with a mean of 1.1×10^4 cfu/ml. Hydrocarbon utilizing fungi (HUF) ranged from $0 - 1.2 \times 10^2$ cfu/ml, with a mean of 0.2×10^2 cfu/ml. Results showed that HUF accounted for about 1% of the TF. The control sample had a population of TF of 0.9×10^4 cfu/ml and HUF population of 0 cfu/ml. Predominant fungal genera isolated from the study area include *Mucor*, *Rhizopus*, *Aspergillus*, *Aspergillus* and *Penicillium*.

During the dry season, total coliform ranged from 8 – 20 MPN/100ml with a mean of 14 MPN/100ml while faecal coliform ranged from 4 – 11 MPN/100ml, whereas, at the control station, total coliform was 11 MPN/100ml and faecal coliform was 9 MPN/100ml. The control station values fell within the range of the main samples. Similarly, during the wet season, total coliform ranged from 11 – 20 MPN/100ml with a mean of 15 MPN/100ml while faecal coliform ranged from 6 – 11 MPN/100ml, whereas, at the control station, total coliform was 11 MPN/100ml and faecal coliform was 7 MPN/100ml. Water quality standards are different depending on the use of the water. Drinking water sources should contain no coliform, while natural rivers could contain up to 100 coliforms MPN/100ml.

Table 4.4.3a: Surface water microbial population in the Dry season

| Code | THB 10^4 cfu/ml | HUB 10^2 cfu/ml | Most Predominant Bacterial Isolate | Total Coliform Count MPN/100ml | Faecal coliform MPN/100ml | TF 10^4 cfu/ml | % HUF | Most Predominant Fungal Isolate |
|---------|----------------------|-------------------------|--------------------------------------------------------------------------|-----------------------------------------|---------------------------------|------------------------|----------|-------------------------------------------------------|
| OTUSWC3 | 4.8 | 1.0 | <i>Bacillus</i> sp., <i>Micrococcus</i> sp., <i>Pseudomonas</i> sp | 11 | 7 | 1.2 | 0.0 | <i>Aspergillus</i> sp, <i>Rhizopus</i> sp |
| OTUSW8 | 5.8 | 1.0 | <i>Bacillus</i> sp., <i>Micrococcus</i> sp, <i>Pseudomonas</i> sp, | 17 | 8 | 0.9 | 0.0 | <i>Penicillium</i> sp, <i>Aspergillus</i> sp |
| OTUSW9 | 6.2 | 0.8 | <i>E. coli</i> , | 15 | 9 | 1.2 | 0.0 | <i>Penicillium</i> |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| Code | THB 10 ⁴ cfu/ml | HUB 10 ² cfu/ml | Most Predominant Bacterial Isolate | Total Coliform Count MPN/100ml | Faecal coliform MPN/100ml | TF 10 ⁴ cfu/ml | % HUF | Most Predominant Fungal Isolate |
|---------|-------------------------------|----------------------------------|---------------------------------------------------------------------|-----------------------------------------|---------------------------------|---------------------------------|----------|----------------------------------------------------------|
| | | | <i>Enterbacter sp, E. coli, Enterbacter sp</i> | | | | | <i>sp, Aspergillus sp</i> |
| OTUSW10 | 5.1 | 1.1 | <i>Bacillus sp., Enterobacter aerogenes sp, Micrococcus sp</i> | 11 | 6 | 1.0 | 0.0 | <i>Aspergillus sp, Aspergillus niger</i> |
| OTUSW11 | 7.9 | 1.8 | <i>Bacillus sp., Enterobacter sp., Micrococcus sp, Serratia sp.</i> | 20 | 11 | 1.2 | 0.0 | <i>Penicillium sp., Aspergillus sp.</i> |
| OTUSW12 | 6.2 | 0.8 | <i>Bacillus sp, Enterobacter sp, Staphylococcus sp</i> | 8 | 4 | 1.1 | 3.5 | <i>Penicillium sp, Aspergillus sp, Aspergillus niger</i> |
| OTUSW13 | 5.7 | 1.0 | <i>Bacillus sp, Enterobacter sp,</i> | 11 | 5 | 1.4 | 6.6 | <i>Penicillium sp, Aspergillus sp, Aspergillus niger</i> |
| OTUSW14 | 8.5 | 1.8 | <i>Bacillus sp, Enterobacter sp, E coli</i> | 18 | 7 | 0.7 | 1.8 | <i>Aspergillus sp., Penicillium sp</i> |
| OTUSW15 | 9.1 | 2.4 | <i>Bacillus sp, Staphylococcus sp, Enterobacter sp</i> | 14 | 6 | 0.8 | | <i>Penicillium sp, Aspergillus sp</i> |
| OTUSW16 | 7.1 | 2.8 | <i>Nocardia sp., Pseudomonas sp, Bacillus sp.</i> | 11 | 7 | 0.6 | 0.0 | <i>Aspergillus sp., Penicillium sp</i> |
| MIN | 4.8 | 0.8 | - | 8 | | 0.7 | 0.0 | - |
| MAX | 9.1 | 2.8 | - | 20 | | 1.4 | 6.6 | - |
| MEAN | 6.69 | 1.51 | - | 14 | | 1.0 | 1.7 | - |

Table 4.4.3b: Surface water microbial population in the wet season

| Code | THB 10 ⁴ cfu/ml | HUB 10 ² cfu/ml | Most Predominant Bacterial Isolate | Total ColiForm Count MPN/100ml | Fecal coliform MPN/100ml | THF 10 ⁴ cfu/ml | HUF 10 ² cfu/ml | Most Predominant Fungal Isolate |
|-------------|-------------------------------|----------------------------------|-----------------------------------------------------------------|-----------------------------------------|--------------------------------|----------------------------------|----------------------------------|---------------------------------------|
| OTU SWC3 | 5.5 | 0.8 | <i>E. coli, Enterbacter sp, Bacillus sp, Staphylococcus sp.</i> | 11 | 7 | 0.9 | 0.0 | <i>Penicillium sp, Aspergillus sp</i> |
| OTU SW8 | 6.9 | 2.8 | <i>Enterobacter sp, Staphylococcus sp, Bacillus sp.,</i> | 16 | 6 | 1.3 | 0.0 | <i>Penicillium sp, Aspergillus sp</i> |
| OTU SW9 | 7.5 | 1.6 | <i>Pseudomonas Staphylococcus sp., Enterobacter sp</i> | 19 | 10 | 2.4 | 1.0 | <i>Penicillium sp, Aspergillus sp</i> |

| Code | THB | HUB | Most Predominant Bacterial Isolate | Total ColiForm Count MPN/100ml | Fecal coliform MPN/100ml | THF | HUF | Most Predominant Fungal Isolate |
|----------|------------------------|------------------------|--------------------------------------------------------------------------------------------|--------------------------------|--------------------------|------------------------|------------------------|------------------------------------------------|
| | 10 ⁴ cfu/ml | 10 ² cfu/ml | | | | 10 ⁴ cfu/ml | 10 ² cfu/ml | |
| OTU SW10 | 8.2 | 3.9 | <i>Staphylococcus sp.</i> , <i>Pseudomonas sp.</i> , <i>E coli</i> , <i>Alcaligenes sp</i> | 14 | 7 | 0.4 | 0.0 | <i>Mucor sp.</i> , <i>Aspergillus sp</i> |
| OTU SW11 | 9.2 | 1.8 | <i>Pseudomonas Staphylococcus sp.</i> , <i>Enterobacter sp</i> | 20 | 11 | 0.6 | 0.0 | <i>Penicillium sp.</i> , <i>Aspergillus sp</i> |
| OTU SW12 | 7.5 | 1.3 | <i>Nocardia sp.</i> , <i>Bacillus sp.</i> , <i>Enterobacter sp</i> | 13 | 7 | 0.8 | 0.0 | <i>Penicillium sp.</i> , <i>Aspergillus sp</i> |
| OTU SW13 | 8.7 | 1.6 | <i>Bacillus sp.</i> , <i>Enterobacter sp.</i> , <i>E coli</i> , | 18 | 9 | 0.7 | 0.0 | <i>Penicillium sp.</i> , <i>Aspergillus sp</i> |
| OTU SW14 | 8.6 | 1.5 | <i>Bacillus sp.</i> , <i>E coli</i> , <i>Enterobacter sp</i> | 14 | 8 | 1.8 | 0.5 | <i>Penicillium sp.</i> , <i>Aspergillus sp</i> |
| OTU SW15 | 9.1 | 2.4 | <i>Bacillus sp.</i> , <i>Staphylococcus sp</i> , <i>Enterobacter sp</i> | 14 | 8 | 0.8 | 0.2 | <i>Penicillium sp.</i> , <i>Aspergillus sp</i> |
| MIN | 5.5 | 0.8 | - | 11 | | 0.4 | 0.2 | - |
| MAX | 9.2 | 3.9 | - | 20 | | 1.8 | 1.2 | - |
| MEAN | 7.9 | 2.0 | - | 15 | | 1.1 | 0.2 | - |

Sediment Physico-chemistry

The detailed results of the physicochemical properties of the sediment obtained from Otumara field for the wet and dry seasons are presented in Tables 4.4.4a and 4.4.4b respectively, while a summary of the data is presented in Table 4.4.5. The pH ranged from 4.89 – 5.54 with a mean of 5.34 in the dry season. The pH of the control point was 5.54. The pH data during the wet season had higher variability ranging from 4.2 – 6.8 with a mean of 5.34, whereas the control sample had a pH of 6.8. The seasonal variation in the pH was within the DPR intervention value of 5.5-6.5.

Acidity is sometimes measured as exchangeable acidity. Exchangeable Acidity (EA) ranged from 0.9 – 2.8 meq/100g, with a mean of 1.3 meq/100g in the dry season, whereas the control point has an EA of 1.0 meq/100g. However, during the wet season, the EA was slightly lower, ranging from 0.4 – 2.0 meq/100g with a mean of 1.0 meq/100g and the control point also had an EA of 1.0 meq/100g. It should be noted that the values of the control was within the range recorded for the main samples. Typical values for exchangeable acidity normally range from 0.5 meq/100g to 1.5 meq/100g. The results obtained in both seasons fell within this range.

Electrical conductivity (EC) during the dry season ranged from 2100 – 10680 µS/cm with a mean of 5381 µS/cm, whereas the control site had an EC of 8940 µS/cm. The wet season EC was comparable to that of the dry season ranging from 2030 – 10350 µS/cm, whereas the control point had an EC of 2030 µS/cm. The control points in both seasons were within the ranges reported for the main samples. The high variability of the EC data clearly indicates the different land use types in the study area, with low values occurring in the freshwater areas and high values occurring in the mangrove and salt marshes. The conductivity of the sediment is sometimes an indication of the amount of available nutrients, but it also measures non nutrient salts. Parameters contributing to EC include calcium, magnesium, chlorides, sodium, potassium, sulphate and bicarbonates.

Exchangeable cations studied in this project include calcium, magnesium, sodium, and potassium. During the dry season, sodium ranged from 8.64 – 10.89 meq/100g with a mean of 9.98 meq/100g, whereas 10.21 meq/100g was recorded at the control site. Likewise, during the wet season significantly lower concentration of sodium was recorded, ranging from 4.16 – 7.07 meq/100g with a mean concentration of 6.59 meq/100g, but the control had a concentration of 4016 meq/100g. Calcium concentration was slightly higher than sodium concentration, whereas magnesium concentration was comparable to sodium, but potassium was several orders lower than sodium.

Nitrogen related parameters studied include total nitrogen, ammonium, nitrite and nitrate. Total nitrogen in the sediments during the dry season ranged from 0.08 – 0.67% with a mean of 0.52%, whereas the control had 0.58%. The data obtained in the wet season exhibited higher variability, ranging from 0.34 – 1.09%, with a mean of 0.87%, but the control was 0.34%. During the dry season, nitrate ranged from 2.9 – 14.1 mg/kg with a mean of 8.5 mg/kg, but the control point had higher concentration, 10.4 mg/kg. Roughly, nitrate levels of 2 mg/kg are very low and 20 mg/kg is considered high. The wet season values were similar to that of the dry season without significant differences. Nitrite was slightly lower than nitrate, while ammonium is several orders lower.

Other anions determined included phosphate, chloride and sulphate. Being a brackish environment, chloride and sulphate are more dominant. During the dry season, chloride ranged from 124 – 156 mg/kg with a mean of 136 mg/kg, but the control was 135 mg/kg. Significantly higher concentration was recorded during the wet season ranging from 695 – 2636 mg/kg, with a mean of 1783 mg/kg, but the control was 695 mg/kg. The increased tidal flooding might have resulted in the higher salinity during the wet season. Sulphate exhibited a similar pattern like chloride, being significantly higher during the wet season. During, the dry season, sulphate ranged from 122 – 1252 mg/kg with a mean of 446 mg/kg, while the control was 320 mg/kg. During the wet season, sulphate ranged from 1044 – 6120 mg/kg with a mean of 2808 mg/kg, whereas the control was 1522 mg/kg. The activities of sulphate reducing bacteria have been suggested to be largely responsible for the high sulphate concentration in coastal sediments.

Hydrocarbon related parameters studied includes THC, TPH, PAH, BTEX and phenol. The THC in the sediments during the dry season ranged from 26.9 – 83.2 mg/kg with a mean of 60.0 mg/kg, but the control was 71.6 mg/kg. The wet season THC values ranged from 58.9 – 170.6 mg/kg with a mean of 101.7 mg/kg whereas the control was 62.5 mg/kg. Notwithstanding the relatively high THC values, TPH was significantly lower, occurring in traces generally <1.0 mg/kg. This value was several orders lower than the DPR intervention value of 5000 mg/kg. Other hydrocarbon related parameters including BTEX, PAH and phenol similarly occurred in traces (<1 mg/kg) during both wet and dry seasons. Notwithstanding, the TOC was high, ranging from 0.67 – 5.62 % (mean = 4.36 %) in the dry season and 1.68 – 5.73 % (mean = 4.51%) in the wet season. This therefore suggests that organic matter is largely responsible for the THC and not petroleum sources.

Heavy metals were also studied. Iron was the most abundant metal in the study area. During the dry season, iron ranged from 125.4 – 140.6 mg/kg with a mean of 131.8 mg/kg, but the control was 140.6 mg/kg. The wet season value was slightly higher ranging from 197.6 – 211.6 mg/kg

with a mean of 207.0 mg/kg, but the control was 197.6 mg/kg. The high level of iron in the sediment is not unusual in the Niger Delta coastal sediments. This results from the genesis of the sediment rather than anthropogenic impact. Some metals including lead, copper, manganese, and zinc occurred in the range of 20 – 30 mg/kg. Next in concentration are nickel and vanadium which occurred in the range of 1 – 19 mg/kg, while some metals such as mercury and barium occurred in traces <1 mg/kg.

During the dry season, the texture of the sediment was determined. Sand ranged from 89.5 – 92.4% with a mean of 90.8%, clay ranged from 4.5 – 8.4% with a mean of 2.9%, while silt accounted for the remainder. With these properties, using the textural triangle the sediment samples could be classified as sand. Sandy formation has implication for the migration of contaminants in the benthic environment

Environmental Impact Assessment (EIA) of Otumara AGS Project

Table 4.4.4a: Physicochemical properties of sediment in Otumara during the dry season

| S/N | Parameters | Units | OTU SDC3 | OTU SD9 | OTU SD10 | OTU SD11 | OTU SD12 | OTU SD13 | OTU SD14 | OTU SD15 | OTU SD16 | MIN | MAX | MEAN |
|-----|--------------------------------|----------|----------|---------|----------|----------|----------|----------|----------|----------|----------|-------|-------|-------|
| 1 | pH | | 5.54 | 5.13 | 5.28 | 5.33 | 6.88 | 4.89 | 5.05 | 4.99 | 4.93 | 4.89 | 5.54 | 5.34 |
| 2 | EC | µS/cm | 8940 | 6040 | 2510 | 3550 | 4240 | 10680 | 6790 | 3580 | 2100 | 2100 | 10680 | 5381 |
| 3 | Org. C | % | 4.85 | 5.00 | 4.94 | 5.23 | 5.30 | 5.62 | 5.53 | 2.11 | 0.67 | 0.67 | 5.62 | 4.36 |
| 4 | Total N. | % | 0.58 | 0.60 | 0.59 | 0.63 | 0.64 | 0.67 | 0.67 | 0.25 | 0.08 | 0.08 | 0.67 | 0.52 |
| 5 | Na | meq/100g | 10.21 | 8.69 | 10.45 | 10.18 | 9.96 | 10.89 | 10.09 | 8.64 | 10.69 | 8.64 | 10.89 | 9.98 |
| 6 | K | “ | 7.29 | 5.51 | 7.46 | 8.82 | 3.95 | 7.76 | 6.30 | 5.27 | 7.64 | 3.95 | 7.76 | 6.67 |
| 7 | Ca | “ | 12.30 | 10.50 | 11.21 | 12.08 | 11.38 | 12.29 | 11.93 | 9.60 | 11.55 | 9.60 | 12.29 | 11.43 |
| 8 | Mg | “ | 9.41 | 8.10 | 8.80 | 9.20 | 5.14 | 8.56 | 7.50 | 8.41 | 9.30 | 8.10 | 9.41 | 8.27 |
| 9 | EA | “ | 1.0 | 1.1 | 1.0 | 1.7 | 0.9 | 1.1 | 2.8 | 0.9 | 1.6 | 0.9 | 2.8 | 1.3 |
| 10 | Cl ⁻ | mg/kg | 135 | 127 | 143 | 158 | 140 | 142 | 128 | 126 | 124 | 124 | 158 | 136 |
| 11 | PO ₄ | “ | 4.9 | 4.5 | 3.8 | 5.2 | 11.7 | 4.5 | 2.5 | 7.5 | 5.3 | 2.5 | 11.7 | 5.5 |
| 12 | NH ₄ N | “ | 9.2 | 5.5 | 1.4 | 2.7 | 1.6 | 2.3 | 2.8 | 1.8 | 0.8 | 0.8 | 9.2 | 3.1 |
| 13 | NO ₂ ⁻ N | “ | 6.8 | 4.5 | 2.0 | 10.1 | 4.8 | 2.9 | 6.6 | 12.2 | 9.6 | 2.0 | 12.2 | 6.6 |
| 14 | NO ₃ ⁻ N | “ | 10.4 | 6.9 | 2.9 | 13.5 | 6.8 | 3.3 | 7.3 | 14.1 | 11.4 | 2.9 | 14.1 | 8.5 |
| 15 | SO ₄ | “ | 320 | 350 | 1252 | 314 | 122 | 410 | 422 | 620 | 202 | 122 | 1252 | 446 |
| 16 | Silt | % | 3.1 | 3.2 | 2.3 | 2.3 | 3.1 | 3.2 | 2.0 | 3.9 | 2.7 | 2.0 | 3.2 | 2.9 |
| 17 | Clay | “ | 4.5 | 6.6 | 5.9 | 5.0 | 7.7 | 7.1 | 8.4 | 6.6 | 6.6 | 4.5 | 8.4 | 6.5 |
| 18 | Sand | “ | 92.4 | 90.6 | 91.8 | 92.7 | 90.1 | 89.7 | 89.6 | 89.5 | 90.7 | 89.5 | 92.4 | 90.8 |
| 19 | THC | mg/kg | 71.6 | 53.7 | 76.9 | 25.8 | 76.9 | 80.5 | 83.2 | 26.9 | 44.7 | 26.9 | 83.2 | 60.0 |
| 20 | TPH | “ | 0.396 | 0.664 | 3.189 | 0.903 | 0.796 | 0.367 | 0.116 | 0.336 | 1.764 | 0.116 | 3.189 | 0.948 |
| 21 | PAH | “ | 0.103 | 0.200 | 0.207 | 0.168 | 0.112 | 0.148 | 0.091 | 0.097 | 0.208 | 0.122 | 0.208 | 0.148 |
| 22 | Benzene | µg/kg | 0.015 | 0.023 | 0.128 | 0.105 | 0.066 | 0.027 | 0.014 | 0.059 | 0.301 | 0.015 | 0.301 | 0.082 |
| 23 | Toluene | “ | 0.003 | 0.002 | 0.005 | 0.002 | 0.001 | 0.002 | 0.003 | 0.001 | 0.006 | 0.001 | 0.006 | 0.003 |
| 24 | Ethylbenzene | “ | ND | ND | 0.006 | ND | ND | ND | ND | ND | ND | 0.000 | 0.006 | 0.006 |
| 25 | Xylene | “ | 0.005 | 0.002 | 0.003 | 0.002 | 0.001 | 0.002 | 0.003 | 0.004 | 0.004 | 0.001 | 0.005 | 0.003 |
| 26 | Phenol | “ | 0.011 | 0.025 | 0.039 | 0.013 | 0.014 | 0.002 | 0.008 | 0.017 | 0.014 | 0.002 | 0.039 | 0.016 |

Environmental Impact Assessment (EIA) of Otumara AGS Project

Table 4.4.4b: Physicochemical properties of sediment in Otumara during the wet season

| S/N | Parameters | Units | OTU SDC3 | OTU SD8 | OTU SD9 | OTU SD10 | OTU SD11 | OTU SD12 | OTU SD13 | OTU SD14 | OTU SD15 | MIN | MAX | MEAN |
|-----|-------------------|----------|-------------|------------|------------|-------------|-------------|-------------|-------------|-------------|-------------|-------|-------|-------|
| 1 | pH | | 6.8 | 4.4 | 6.6 | 4.2 | 4.4 | 5.4 | 4.9 | 5.7 | 5.7 | 4.2 | 6.8 | 5.34 |
| 2 | EC | µS/cm | 2030 | 8700 | 3210 | 5770 | 9270 | 8090 | 10350 | 3520 | 6850 | 2030 | 10350 | 6421 |
| 3 | Org. C | % | 1.68 | 5.50 | 4.87 | 4.41 | 5.16 | 3.60 | 5.49 | 5.73 | 4.16 | 1.68 | 5.73 | 4.51 |
| 4 | Total N. | % | 0.34 | 1.06 | 0.94 | 0.85 | 0.99 | 0.69 | 1.05 | 1.09 | 0.79 | 0.34 | 1.09 | 0.87 |
| 5 | Na | meq/100g | 4.16 | 5.98 | 6.04 | 6.84 | 7.07 | 6.92 | 8.39 | 7.01 | 6.90 | 4.16 | 7.07 | 6.59 |
| 6 | K | “ | 1.17 | 2.86 | 3.01 | 2.45 | 4.82 | 2.16 | 4.68 | 3.44 | 2.88 | 1.17 | 4.82 | 3.05 |
| 7 | Ca | “ | 7.48 | 9.50 | 9.60 | 9.84 | 11.2 | 10.5 | 12.4 | 12.7 | 11.2 | 7.48 | 12.7 | 10.5 |
| 8 | Mg | “ | 5.48 | 6.30 | 6.80 | 6.47 | 8.50 | 8.90 | 10.7 | 8.61 | 9.63 | 5.48 | 9.63 | 7.93 |
| 9 | EA | “ | 1.0 | 1.0 | 0.4 | 1.2 | 0.9 | 1.1 | 2.0 | 1.0 | 0.6 | 0.4 | 2.0 | 1.0 |
| 10 | Cl ⁻ | mg/kg | 695 | 2160 | 1024 | 1883 | 2296 | 2109 | 2636 | 1201 | 2042 | 695 | 2636 | 1783 |
| 11 | PO ₄ | “ | 2.4 | 2.8 | 3.6 | 4.0 | 1.2 | 8.8 | 7.2 | 6.4 | 5.2 | 1.2 | 8.8 | 4.6 |
| 12 | NH ₄ N | “ | 14.2 | 12.4 | 17.2 | 10.2 | 11.0 | 19.2 | 8.4 | 7.4 | 18.1 | 8.4 | 18.1 | 13.1 |
| 13 | NO ₂ N | “ | 9.2 | 7.6 | 9.2 | 5.2 | 2.6 | 3.8 | 3.2 | 3.4 | 7.6 | 2.6 | 9.2 | 5.8 |
| 14 | NO ₃ N | “ | 18.6 | 15.8 | 19.2 | 10.2 | 4.6 | 5.2 | 5.4 | 5.8 | 18.2 | 4.6 | 19.2 | 11.4 |
| 15 | SO ₄ | “ | 1522 | 6120 | 4600 | 6120 | 1044 | 1482 | 1240 | 1842 | 1304 | 1044 | 6120 | 2808 |
| 16 | Silt | % | 2.3 | 2.9 | 3.6 | 6.0 | 2.9 | 3.9 | 2.3 | 2.3 | 3.8 | 2.3 | 6.0 | 3.3 |
| 17 | Clay | “ | 3.9 | 9.8 | 7.5 | 10.9 | 7.7 | 5.8 | 6.2 | 9.8 | 8.3 | 3.9 | 10.9 | 7.8 |
| 18 | Sand | “ | 93.8 | 87.3 | 88.9 | 83.1 | 89.4 | 90.3 | 91.5 | 87.9 | 87.5 | 83.1 | 93.8 | 88.9 |
| 19 | THC | mg/kg | 62.5 | 170.6 | 149.1 | 138.5 | 115.5 | 71.8 | 58.9 | 75.5 | 73.1 | 58.9 | 170.6 | 101.7 |
| 20 | TPH | “ | 1.189 | 0.386 | 0.294 | 6.444 | 4.812 | 6.116 | 6.345 | 6.234 | 5.964 | 0.294 | 6.444 | 4.198 |
| 21 | PAH | “ | 0.287 | 0.018 | 0.019 | 0.016 | 0.009 | 0.017 | 0.015 | 0.106 | 0.032 | 0.003 | 0.287 | 0.058 |
| 22 | Benzene | µg/kg | 0.009 | 0.272 | 0.261 | 0.306 | 0.286 | 0.311 | 0.294 | 0.003 | 0.015 | 0.003 | 0.311 | 0.195 |
| 23 | Toluene | “ | 0.001 | 0.002 | 0.001 | 0.003 | 0.002 | 0.001 | 0.003 | 0.001 | 0.003 | 0.001 | 0.003 | 0.002 |
| 24 | Ethylbenzene | “ | ND | ND | ND | ND | ND | ND | ND | ND | 0.002 | 0.000 | 0.002 | ND |
| 25 | Xylene | “ | 0.001 | 0.002 | 0.001 | 0.003 | 0.001 | 0.002 | 0.001 | 0.002 | 0.001 | 0.001 | 0.003 | 0.002 |
| 26 | Phenol | “ | 0.009 | 0.014 | 0.019 | 0.016 | 0.011 | 0.002 | 0.002 | 0.008 | 0.018 | 0.001 | 0.018 | 0.011 |

Environmental Impact Assessment (EIA) of Otumara AGS Project

Table 4.4.5: Summary of the physicochemical and microbiological properties of Otumara area

| Parameters | Units | Dry Season | | | | Wet Season | | | | DPR INTERVENTION LIMITS | TARGET LIMITS |
|-------------------|----------|------------|-------|-------|---------|------------|-------|-------|---------|----------------------------|------------------|
| | | MIN | MAX | MEAN | Control | MIN | MAX | MEAN | Control | | |
| pH | | 4.89 | 5.54 | 5.34 | 5.54 | 4.2 | 6.8 | 5.34 | 6.8 | | |
| EC | µS/cm | 2100 | 10680 | 5381 | 8940 | 2030 | 10350 | 6421 | 2030 | | |
| Org. C | % | 0.67 | 5.62 | 4.36 | 4.85 | 1.68 | 5.73 | 4.51 | 1.68 | | |
| Total N. | % | 0.08 | 0.67 | 0.52 | 0.58 | 0.34 | 1.09 | 0.87 | 0.34 | | |
| Na | meq/100g | 8.64 | 10.89 | 9.98 | 10.21 | 4.16 | 7.07 | 6.59 | 4.16 | | |
| K | “ | 3.95 | 7.76 | 6.67 | 7.29 | 1.17 | 4.82 | 3.05 | 1.17 | | |
| Ca | “ | 9.60 | 12.29 | 11.43 | 12.30 | 7.48 | 12.7 | 10.5 | 7.48 | | |
| Mg | “ | 8.10 | 9.41 | 8.27 | 9.41 | 5.48 | 9.63 | 7.93 | 5.48 | | |
| EA | “ | 0.9 | 2.8 | 1.3 | 1.0 | 0.4 | 2.0 | 1.0 | 1.0 | | |
| Cl ⁻ | mg/kg | 124 | 158 | 136 | 135 | 695 | 2636 | 1783 | 695 | | |
| PO ₄ | “ | 2.5 | 11.7 | 5.5 | 4.9 | 1.2 | 8.8 | 4.6 | 2.4 | | |
| NH ₄ N | “ | 0.8 | 9.2 | 3.1 | 9.2 | 8.4 | 18.1 | 13.1 | 14.2 | | |
| NO ₂ N | “ | 2.0 | 12.2 | 6.6 | 6.8 | 2.6 | 9.2 | 5.8 | 9.2 | | |
| NO ₃ N | “ | 2.9 | 14.1 | 8.5 | 10.4 | 4.6 | 19.2 | 11.4 | 18.6 | | |
| SO ₄ | “ | 122 | 1252 | 446 | 320 | 1044 | 6120 | 2808 | 1522 | | |
| Silt | % | 2.0 | 3.2 | 2.9 | 3.1 | 2.3 | 6.0 | 3.3 | 2.3 | | |
| Clay | “ | 4.5 | 8.4 | 6.5 | 4.5 | 3.9 | 10.9 | 7.8 | 3.9 | | |
| Sand | “ | 89.5 | 92.4 | 90.8 | 92.4 | 83.1 | 93.8 | 88.9 | 93.8 | | |
| THC | mg/kg | 26.9 | 83.2 | 60.0 | 71.6 | 58.9 | 170.6 | 101.7 | 62.5 | | |
| TPH | “ | 0.116 | 3.189 | 0.948 | 0.396 | 0.294 | 6.444 | 4.198 | 1.189 | 5000 | |
| PAH | “ | 0.122 | 0.208 | 0.148 | 0.103 | 0.003 | 0.287 | 0.058 | 0.287 | | |
| Benzene | µg/kg | 0.015 | 0.301 | 0.082 | 0.015 | 0.003 | 0.311 | 0.195 | 0.009 | | |
| Toluene | “ | 0.001 | 0.006 | 0.003 | 0.003 | 0.001 | 0.003 | 0.002 | 0.001 | | |
| Ethylbenzene | “ | 0.000 | 0.006 | 0.006 | ND | 0.000 | 0.002 | ND | ND | | |
| Xylene | “ | 0.001 | 0.005 | 0.003 | 0.005 | 0.001 | 0.003 | 0.002 | 0.001 | | |
| Phenol | “ | 0.002 | 0.039 | 0.016 | 0.011 | 0.001 | 0.018 | 0.011 | 0.009 | | |
| Fe | mg/kg | 125.4 | 140.6 | 131.8 | 140.6 | 197.6 | 211.6 | 207.0 | 197.6 | | |
| Cu | “ | 22.8 | 48.0 | 30.1 | 48.0 | 2.41 | 7.42 | 5.50 | 2.41 | | |
| Mn | “ | 20.4 | 39.8 | 26.7 | 39.8 | 3.25 | 3.66 | 3.53 | 3.41 | | |
| Zn | “ | 15.2 | 30.3 | 24.4 | 30.3 | 3.34 | 11.4 | 9.18 | 3.34 | 720 | |
| Cd | “ | 0.02 | 0.85 | 0.38 | 0.56 | 0.003 | 0.110 | 0.041 | 0.110 | | |
| Cr | “ | 0.27 | 0.71 | 0.35 | ND | 1.48 | 1.61 | 1.57 | 1.50 | 380 | |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| Parameters | Units | Dry Season | | | | Wet Season | | | | DPR | TARGET | – |
|------------|-------|------------|-------|-------|---------|------------|-------|-------|---------|---------------------|--------|---|
| | | MIN | MAX | MEAN | Control | MIN | MAX | MEAN | Control | INTERVENTION LIMITS | | |
| Pb | “ | 1.5 | 30.7 | 21.7 | 19.5 | 1.81 | 5.43 | 4.11 | 1.81 | 530 | | |
| Ni | “ | 8.1 | 19.8 | 13.4 | 13.1 | 3.55 | 5.80 | 4.42 | 3.87 | | | |
| V | “ | 8.8 | 16.9 | 11.5 | 11.1 | 2.44 | 5.16 | 3.67 | 2.44 | | | |
| Hg | “ | ND | ND | ND | ND | ND | ND | ND | ND | | | |
| Ba | “ | 0.001 | 0.004 | 0.002 | 0.003 | 0.001 | 0.004 | 0.003 | 0.003 | | | |

Sediment Microbiology

The results of the sediment microbiological analysis are presented in Tables 4.4.6a and 4.4.6b for the dry and wet seasons respectively. The population of total heterotrophic bacteria (THB) during the dry season was in the range of $2.4 - 3.7 \times 10^5$ cfu/g with a mean of 2.9×10^5 cfu/g. Hydrocarbon utilizing bacteria (HUB) ranged from $0.3 - 1.3 \times 10^5$ cfu/g with a mean of 0.6×10^5 cfu/g. The HUB to THB ratio is therefore $<1\%$, suggesting non-pollution from hydrocarbon sources. During the dry season, the control station had THB of 2.7×10^5 cfu/g and HUB of 0.7×10^3 cfu/g. During the wet season, THB ranged from $2.0 - 3.7 \times 10^5$ cfu/g with a mean of 2.8×10^5 cfu/g. The HUB ranged from $0.1 - 1.2 \times 10^3$ cfu/g with a mean of 0.6×10^3 cfu/g. Thus, the HUB therefore accounted for $<1\%$ of the heterotrophic bacterial population, suggesting non-pollution from petroleum sources, which is in agreement with physico-chemical data. The control station had a THB population of 2.8×10^5 cfu/g and a HUB population of 0.5×10^3 cfu/g. Predominant bacterial genera isolated from the surface water include *Bacillus*, *Micrococcus*, *Pseudomonas*, *Escherichia*, *Enterobacter*, *Klebsiella*, *Staphylococcus* and *Norcardia*.

Total heterotrophic fungi (THF) during the dry season ranged from $0.1 - 2.1 \times 10^5$ cfu/g with a mean of 0.8×10^5 cfu/g. Hydrocarbon utilizing fungi (HUF) population ranged from $0.1 - 0.8 \times 10^3$ cfu/g with a mean of 0.3×10^3 cfu/g. Again, HUF comprise of $<1\%$ of the heterotrophs, indicating non-pollution from petroleum sources. The control sample had a population of THF of 0.3×10^5 cfu/g, and no significant growth of HUF. During the wet season, THF ranged from $0.1 - 3.1 \times 10^5$ cfu/g, with a mean of 1.1×10^5 cfu/g. HUF ranged from $0.1 - 1.0 \times 10^3$ cfu/g with a mean of 0.3×10^3 cfu/g. The control station had a THF population of 0.2×10^5 cfu/g and HUF population of 0.1×10^3 cfu/g. Fungi species isolated from the study area include *Aspergillus* sp and *Penicillium* sp.

Table 4.4.6a Sediment microbial population density during the dry season

| Code | THB | THUB | Most Predominant Bacterial Isolate | TF | HUF | Most Predominant Fungal Isolate |
|---------|--------------|--------------|------------------------------------------------------------------------|--------------|--------------|----------------------------------------------|
| | 10^5 cfu/g | 10^3 cfu/g | | 10^5 cfu/g | 10^3 cfu/g | |
| OTUSDC3 | 2.7 | 0.7 | <i>Pseudomonas</i> sp, <i>Staphylococcus</i> sp., <i>Bacillus</i> sp. | 0.3 | 0.0 | <i>Aspergillus</i> sp, <i>Penicillium</i> sp |
| OTUSD9 | 3.2 | 1.3 | <i>Micrococcus</i> sp, <i>Bacillus</i> sp, | 0.8 | 0.2 | <i>Aspergillus</i> sp |
| OTUSD10 | 2.8 | 0.5 | <i>Micrococcus</i> sp., <i>Bacillus</i> sp, <i>Norcardia</i> sp | 0.2 | 0.1 | <i>Aspergillus</i> sp |
| OTUSD11 | 2.5 | 0.8 | <i>Bacillus</i> sp., <i>Staphylococcus</i> sp | 0.2 | 0.0 | <i>Penicillium</i> sp, <i>Aspergillus</i> sp |
| OTUSD12 | 2.4 | 0.3 | <i>Staphylococcus</i> sp, <i>Pseudomonas</i> sp, <i>Micrococcus</i> sp | 0.1 | 0.1 | <i>Penicillium</i> sp, <i>Aspergillus</i> sp |
| OTUSD13 | 2.7 | 0.0 | <i>Bacillus</i> sp, <i>Micrococcus</i> sp | 2.0 | 0.8 | <i>Aspergillus</i> sp, <i>Penicillium</i> |
| OTUSD14 | 3.7 | 0.7 | <i>Bacillus</i> sp, <i>Staphylococcus</i> sp, <i>Micrococcus</i> sp | 0.3 | 0.0 | <i>Aspergillus</i> sp, <i>Penicillium</i> sp |
| OTUSD15 | 2.4 | 0.3 | <i>Staphylococcus</i> sp, <i>Pseudomonas</i> sp, <i>Micrococcus</i> sp | 0.1 | 0.1 | <i>Penicillium</i> sp, <i>Aspergillus</i> sp |
| OTUSD16 | 2.9 | 0.8 | <i>Staphylococcus</i> sp, <i>Bacillus</i> sp, <i>Micrococcus</i> sp | 2.1 | 0.5 | <i>Aspergillus</i> sp |
| MIN | 2.4 | 0.3 | - | 0.1 | 0.1 | - |
| MAX | 3.7 | 1.3 | - | 2.1 | 0.8 | - |
| MEAN | 2.9 | 0.6 | - | 0.8 | 0.3 | - |

Table 4.4.6b: Sediment Microbial Population Density during The Wet Season

| Code | THB | HUB | Most Predominant Bacterial Isolate | TF | HUF | Most Predominant Fungal Isolate |
|----------|-----------------------|-----------------------|-------------------------------------------------------------------------------|-----------------------|-----------------------|---------------------------------------------------|
| | 10 ⁵ cfu/g | 10 ³ cfu/g | | 10 ⁵ cfu/g | 10 ³ cfu/g | |
| OTU SDC3 | 2.8 | 0.5 | <i>Micrococcus sp.</i> , <i>Bacillus sp.</i> , <i>Nocardia sp</i> | 0.2 | 0.1 | <i>Aspergillus sp</i> |
| OTU SD8 | 2.6 | 0.8 | <i>Pseudomonas sp.</i> , <i>Bacillus sp.</i> , <i>Enterobacter sp</i> | 0.3 | 0.1 | <i>Aspergillus sp</i> |
| OTU SD9 | 2.0 | 0.1 | <i>Bacillus sp</i> | 0.2 | 0.0 | <i>Aspergillus sp.</i> , <i>Penicillium sp</i> |
| OTU SD10 | 2.2 | 0.3 | <i>Bacillus sp.</i> , <i>Klebsiella sp.</i> , <i>Staphylococcus sp.</i> | 0.3 | 0.0 | <i>Penicillium sp</i> |
| OTU SD11 | 3.7 | 0.7 | <i>Bacillus sp.</i> , <i>Staphylococcus sp.</i> , <i>Micrococcus sp</i> | 0.3 | 0.0 | <i>Aspergillus sp.</i> , <i>Penicillium sp</i> |
| OTU SD12 | 2.4 | 0.3 | <i>Staphylococcus sp.</i> , <i>Pseudomonas sp.</i> , <i>Micrococcus sp</i> | 0.1 | 0.1 | <i>Penicillium sp.</i> , <i>Aspergillus sp</i> |
| OTU SD13 | 2.9 | 0.8 | <i>Staphylococcus sp.</i> , <i>Bacillus sp.</i> , <i>Micrococcus sp</i> | 2.1 | 0.5 | <i>Aspergillus sp</i> |
| OTU SD14 | 3.3 | 1.2 | <i>Micrococcus sp.</i> , <i>Bacillus sp.</i> , <i>Nocardia sp.</i> | 3.1 | 1.0 | <i>Aspergillus sp.</i> , <i>Penicillium sp</i> |
| OTU SD15 | 3.0 | 1.0 | <i>Bacillus sp</i> | 2.9 | 0.8 | <i>Penicillium sp.</i> , <i>Aspergillus sp</i> |
| MIN | 2.0 | 0.1 | - | 0.1 | 0.1 | - |
| MAX | 3.7 | 1.2 | - | 3.1 | 1.0 | - |
| MEAN | 2.8 | 0.6 | - | 1.1 | 0.3 | - |

4.5 Hydrobiology

These studies are concerned with the species composition, community structure and diversity of the biotic or living components (phytoplankton, zooplankton and benthic invertebrates) of the environment, their interactions amongst themselves and their relationships with the abiotic or physico-chemical components of the environment. The results of field and laboratory investigations of the ecological communities of the study area are presented below:

Phytoplankton

Phytoplanktons are microscopic chlorophyll containing plants that are found in aquatic ecosystems where they function as primary producers. Majority of phytoplankton have been used for biological monitoring of the environment since they cannot survive in adverse environmental conditions like high turbidity, anoxic state, extreme salinity and low nutrients level. Major important members of the phytoplankton group include the divisions Chlorophyta (green algae), Cyanophyta or Cyanobacteria (blue-green algae) and Bacillariophyta (diatoms).

The wet season phytoplankton flora were represented by thirty eight (38) taxa distributed into five divisions, the Bacillariophyta (diatoms), Cyanophyta (Blue-green algae), Dinophyta (dinoflagellates) Chlorophyta (green algae) and Euglenophyta (Euglenoids) (Table 4.5.1).

The Bacillariophyta was represented by 21 species, constituting 53 % of the total flora; this was followed by the Cyanophyta, represented by 10 species, accounting for 25 %. Dinophyta and Euglenophyta were represented by 3 species each, constituting 8 % each, while the Chlorophyta was represented by only 2 species, accounting for 6 % of the phytoplankton flora. This distribution is shown in Fig. 4.5.1.

Table 4.5.1: List of Phytoplankton Species

| DIVISION | SPECIES (WET) | SPECIES (DRY) |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Bacillariophyta | <i>Achnanthes delicatula</i> , <i>Asterionella formosa</i> <i>Amphora ovalis</i> <i>Biddulphia aurita</i> <i>Bacillaria paradoxa</i> <i>Chaetoceros mulleri</i> <i>Coscinodiscus radiata</i> <i>C. lacustris</i> <i>Cyclotella quadricincira</i> <i>Cyclotella</i> sp <i>Cymbella affinis</i> <i>Diploneis ovalis</i> <i>D. interrupta</i> <i>Ditylum thermalis</i> <i>Gomphonema parvulum</i> <i>Melosira granulata</i> <i>Navicula bacillum</i> <i>N. elegans</i> <i>Nitzschia closterium</i> <i>N. obtusa</i> <i>Pleurosigma elongatum</i> | <i>Achnanthes delicatula</i> , <i>Asterionella Formosa</i> <i>Amphora ovalis</i> <i>Biddulphia aurita</i> <i>Bacillaria paradoxa</i> <i>Chaetoceros mulleri</i> <i>Coccinodiscus radiate</i> <i>Coscinodiscus coincinus</i> <i>C. lacustris</i> <i>Cyclotella quadricincira</i> <i>Cyclotella</i> sp <i>Cymbella affinis</i> <i>Diploneis ovalis</i> <i>D. interrupta</i> <i>Ditylum thermalis</i> <i>Fragilaria javanica</i> <i>Gomphonema parvulum</i> <i>Melosira granulata</i> <i>Navicula bacillum</i> <i>N. elegans</i> <i>Nitzschia closterium</i> <i>N. obtuse</i> <i>Odontella regia</i> <i>Pleurosigma elongatum</i> <i>Terpsinoe musica</i> |
| Cyanophyta | <i>Anabaena cylindrica</i> <i>Anabaena</i> sp <i>Chroccocus</i> sp <i>Oscillatoria limosa</i> <i>O. sancta</i> <i>Phormidium ambiguum</i> <i>P. fragile</i> <i>Spirulina major</i> | <i>Anabaena cylindrica</i> <i>Anabaena</i> sp <i>Chroccocus</i> sp <i>Oscillatoria limosa</i> <i>O. sancta</i> <i>Phormidium ambiguum</i> <i>P. fragile</i> <i>Spirulina major</i> |
| Dinophyta | <i>Ceratium hirudinella</i> <i>Gymnodinum</i> sp <i>Peridinium</i> sp | <i>Ceratium hirudinella</i> <i>Gymnodinum</i> sp <i>Peridinium</i> sp |
| Chlorophyta | <i>Scenedesmus quadricauda</i> <i>Closterium parvulum</i> <i>Volvox africana</i> <i>Volvox aureus</i> | <i>Scenedesmus quadricauda</i> <i>Closterium acerosum</i> <i>Closterium parvulum</i> <i>Pleurotaenium minutum</i> <i>Volvox africana</i> <i>Volvox aureus</i> |
| Euglenophyta | <i>Euglena</i> sp <i>Phacus longicauda</i> | <i>Euglena</i> sp <i>Phacus longicauda</i> |

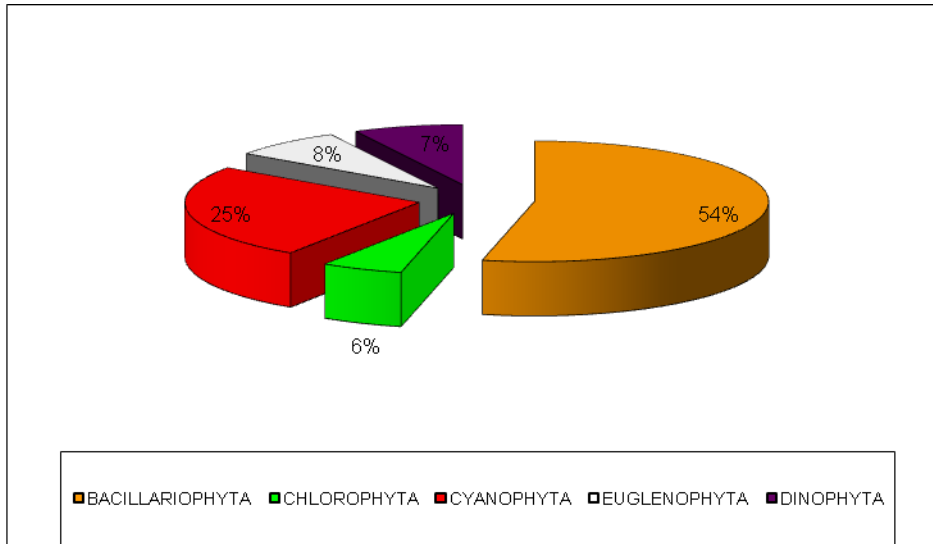


Fig. 4.5.1: Percentage Composition of Phytoplankton Divisions in the Wet Season

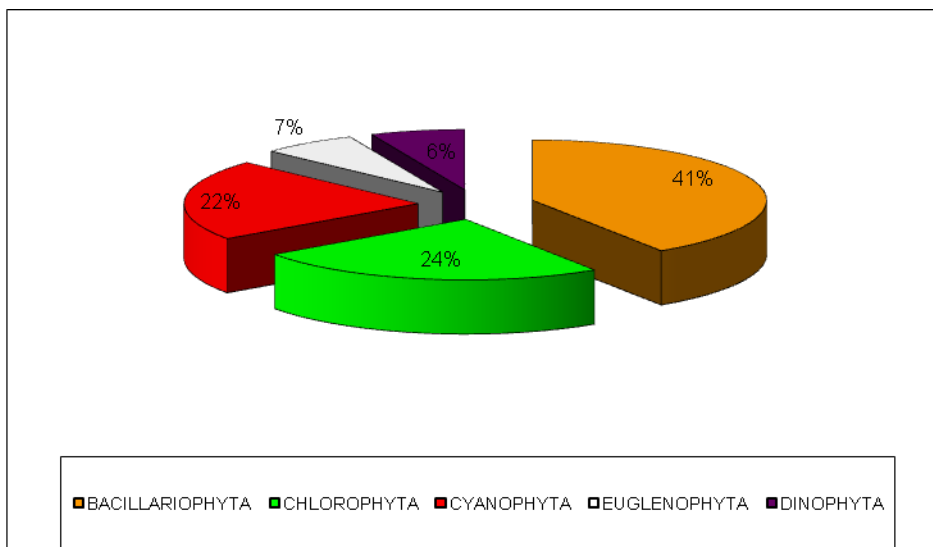


Fig. 4.5.2: Percentage Composition of Phytoplankton Divisions in the Dry Season

The dry season phytoplankton community were represented by forty two (42) species distributed into similar divisions, the Bacillariophyta (diatoms), Cyanophyta (Blue-green algae), Dinophyta (dinoflagellates) Chlorophyta (green algae) and Euglenophyta (Euglenoids) as in the wet season (Table 4.5.1). The diatoms still dominated the population, but followed by Chlorophyta and Cyanophyta (Fig. 4.5.2). Phytoplankton density normally rises during the dry season because of increased illumination and photosynthetic activities.

The major phytoplanktonic organisms identified during both seasons are characteristic of brackish and oligohaline (intermediate zone between freshwater and brackish water) environment. These were *Biddulphia aurita*, *Chaetoceros* sp and *Tabellaria fenestra* for the diatoms; *Anabaena* sp, *Oscillatoria* sp and *Nostoc* sp for the Cyanophyceae; *Gymnodium* sp for the dinoflagellates, *Closterium* sp for the Chlorophyceae and *Euglena* sp for the euglenoids.

The density of phytoplankton varied among the study stations with the highest density occurring in the control station during both wet and dry seasons. In all stations, the density was higher in

the dry season than in the wet season due to increased illumination resulting in higher photosynthetic activity (Fig. 4.5.3).

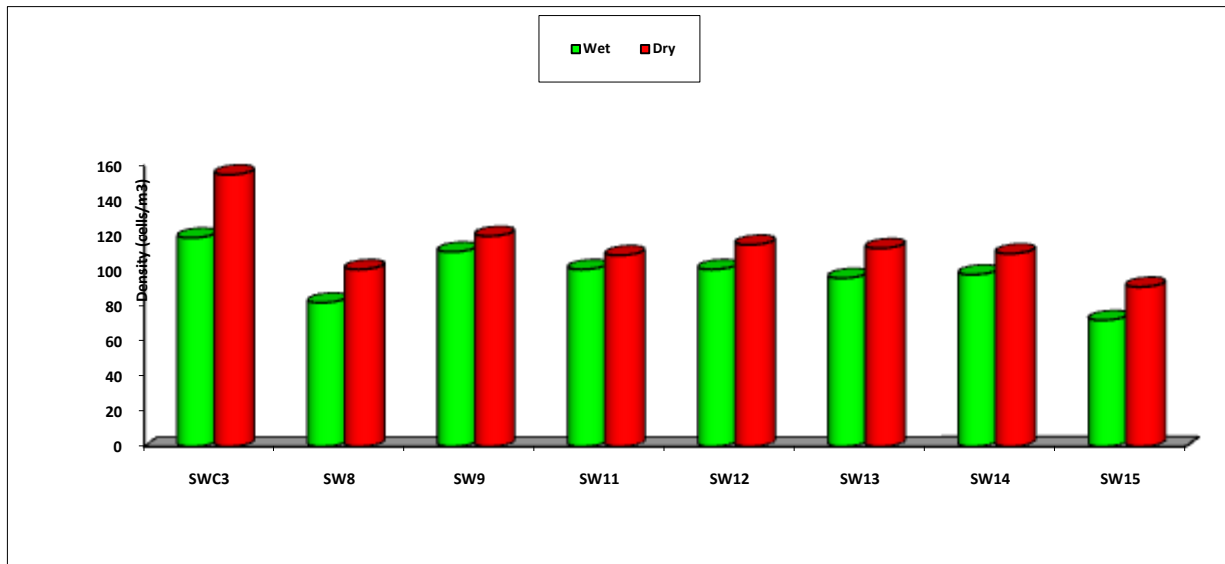


Fig. 4.5.3: Spatial variation in the total density of phytoplankton

Zooplankton

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

In this study, 29 zooplankton taxa were recorded for both wet and dry seasons. These comprised 7 species of Rotifera, 15 species of Cladocera, 5 Copepod taxa, an Ostracoda and a molluscan larva (**Table 4.5.2**). The density and relative contributions of major taxonomic groups to the total population however differed among the seasons. The wet season zooplankton fauna were dominated by Cladocera, with 51.7% composition; this was followed by the Rotifera (24.1%) while Copepoda accounted for 17.2% of the zooplankton fauna. Ostracoda and molluscan larval forms constituted 3.5% each. The percentage composition of the various groups is shown in **Fig 4.5.4a**.

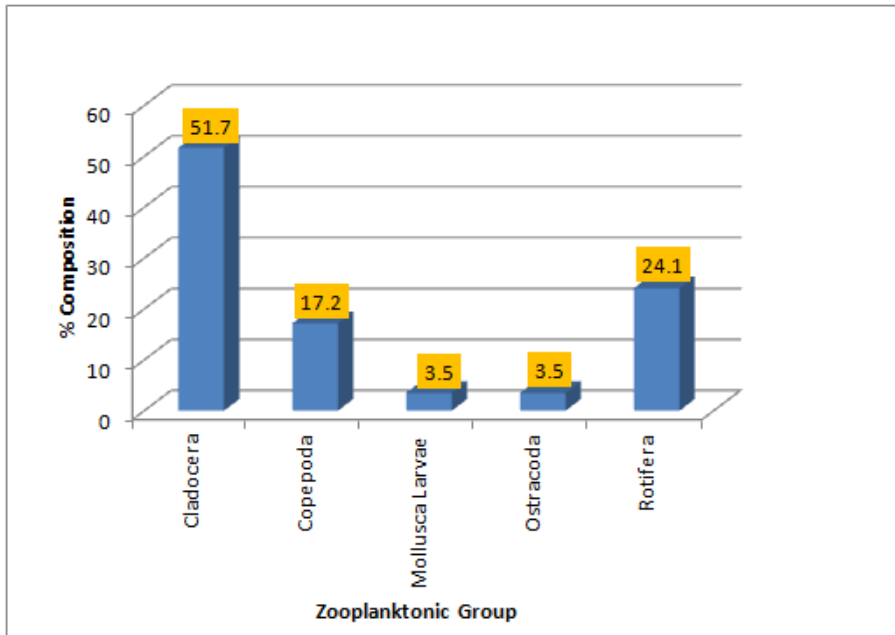


Fig. 4.5.4a: Percentage Composition of Wet season Zooplanktonic Organisms

The dry season zooplankton fauna were dominated by Cladocera, with 53.6% composition; followed by the Rotifera (25.5%), while Copepoda accounted for 20.6% of the zooplankton population density. Ostracoda and molluscan larval forms constituted 7.7% and 7.6% respectively (**Fig 4.5.4b**).

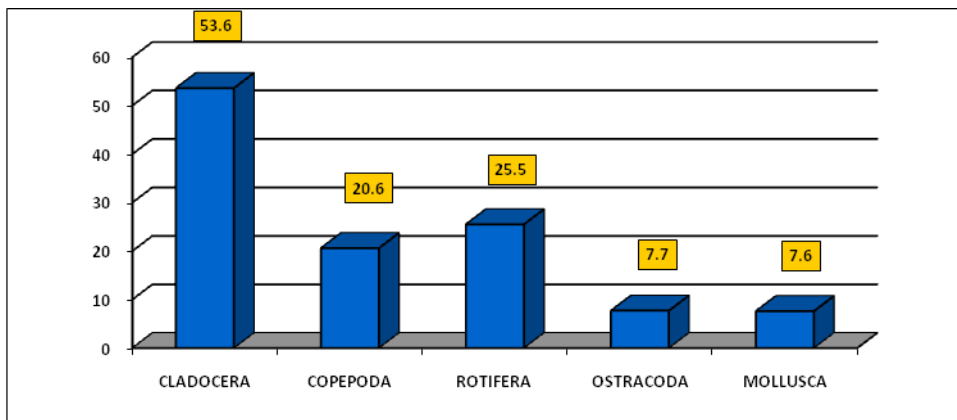


Fig. 4.5.4b: Percentage Composition of Dry season Zooplanktonic Organisms

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

Table 4.5.2: List of Zooplankton Species

| Zooplanktonic Group | Species (Wet) | Species (Dry) |
|----------------------|-------------------------------------|-------------------------------------|
| CLADOCERA | | |
| Family Bosminidae | <i>Bosmina longirostris</i> | <i>Bosmina longirostris</i> |
| | <i>Bosminopsis deitersi</i> | <i>Bosminopsis deitersi</i> |
| Family Chydoridae | <i>Alona affinis</i> | <i>Alona affinis</i> |
| | <i>Alonella excisa excisa</i> | <i>Alonella excisa excise</i> |
| | <i>Chydorus sphaericus</i> | <i>Chydorus sphaericus</i> |
| | <i>C. parvus</i> | <i>C. parvus</i> |
| | <i>C. eurynotus</i> | <i>C. eurynotus</i> |
| | <i>Euryalona orientalis</i> | <i>Euryalona orientalis</i> |
| | <i>Kurzia longirostris</i> | <i>Kurzia longirostris</i> |
| Family Daphnidae | <i>Ceriodaphnia cornuta</i> | <i>Ceriodaphnia cornuta</i> |
| | <i>Daphnia</i> sp | <i>Daphnia</i> sp |
| Family Moinidae | <i>Moina micrura</i> | <i>Moina micrura</i> |
| | <i>Moinodaphnia mecleayi</i> | <i>Moinodaphnia mecleayi</i> |
| Family Sididae | <i>Diaphanosoma excisum</i> | <i>Diaphanosoma excisum</i> |
| | <i>Penilia</i> sp | <i>Penilia</i> sp |
| | | |
| COPEPODA | | |
| | <i>Eucyclops serrulatus</i> | <i>Eucyclops serrulatus</i> |
| | <i>Mesocyclops</i> sp | <i>Mesocyclops</i> sp |
| | <i>Microcyclops varicans</i> | <i>Microcyclops varicans</i> |
| | <i>Thermocyclops decipiens</i> | <i>Thermocyclops decipiens</i> |
| | <i>Thermocyclops neglectus</i> | <i>Thermocyclops neglectus</i> |
| | | |
| ROTIFERA | | |
| Family Asplanchnidae | <i>Asplanchna priodonta</i> | <i>Asplanchna priodonta</i> |
| | | |
| Family Brachionidae | <i>Brachionus calyciflorus</i> | <i>Brachionus calyciflorus</i> |
| | <i>B. caudatus</i> | <i>B. caudatus</i> |
| | <i>B. quadridentata</i> | <i>B. quadridentata</i> |
| | <i>Keratella</i> sp | <i>Keratella</i> sp |
| Family Lecanidae | <i>Lecane curvicornia</i> | <i>Lecane curvicornia</i> |
| | <i>L. luna</i> | <i>L. luna</i> |
| | <i>L. (Monostyla) quadridentata</i> | <i>L. (Monostyla) quadridentata</i> |
| | | |
| OSTRACODA | Ostracoda larva | Ostracoda larva |
| | | |
| MOLLUSCA | Molluscan larva | Molluscan larva |

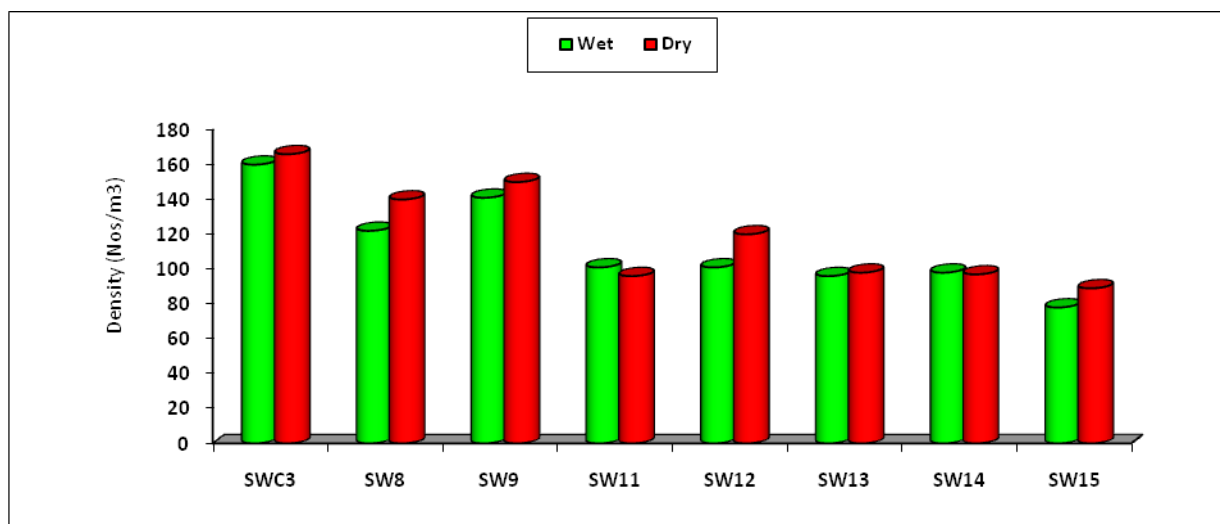


Fig. 4.5.5: Spatial variation in the total density of Zooplankton

Spatially, the density of zooplankton varied among the study stations from a total density of 78 individuals/m³ in SW15 to 166 individuals/m³ in the control station. Local variations in density of zooplankton can be influenced by inherent variability and patchiness in zooplankton distribution, and also food abundance and physico-chemical variables (Ogbeibu and Oribhabor 2011).

Macroinvertebrates

Benthic macrofauna are those organisms which are over 1.0 mm in size, living on or in the substrate. They may be in-fauna (living wholly or partially buried in soft or hard substrates e.g. bottom dwelling annelids, chironomids and bivalve molluscs) (**Plates 4.5.1 and 4.5.2**), or epifauna (living on the surface, either, crawling as mobile benthic inhabitants or attached to different types of substrates (**Plates 4.5.3 and 4.5.4**)). These organisms are economically and ecologically important. They have been used as bioindicators in pollution/impact assessment studies (Webber, 1973; Lee *et al*, 1978; Tsui & McCart, 1981; Ogbeibu & Victor, 1989, Ogbeibu & Oribhabor, 2002; Omoigberale & Ogbeibu 2010, Ogbeibu *et al.*, 2010). The Annelida, Arthropoda (Decapoda and Insecta) and Mollusca constitute majority of the benthic macroinvertebrates of brackish environments.

In this study, 25 (twenty five) benthic taxa, distributed into three phyla (Annelida, Arthropoda and Mollusca) were recorded for both wet and dry seasons. Of these, the phylum Arthropoda, mainly represented by the decapods, constituted 68% of the total benthic taxa encountered. The percentage composition of the various benthic groups for both wet and dry seasons are illustrated in **Fig 4.5.6a and 4.5.6b**, while the species composition is shown in **Table 4.5.3**. There was no significant disparity in the wet and dry season distribution and percentage composition of major taxonomic groups.

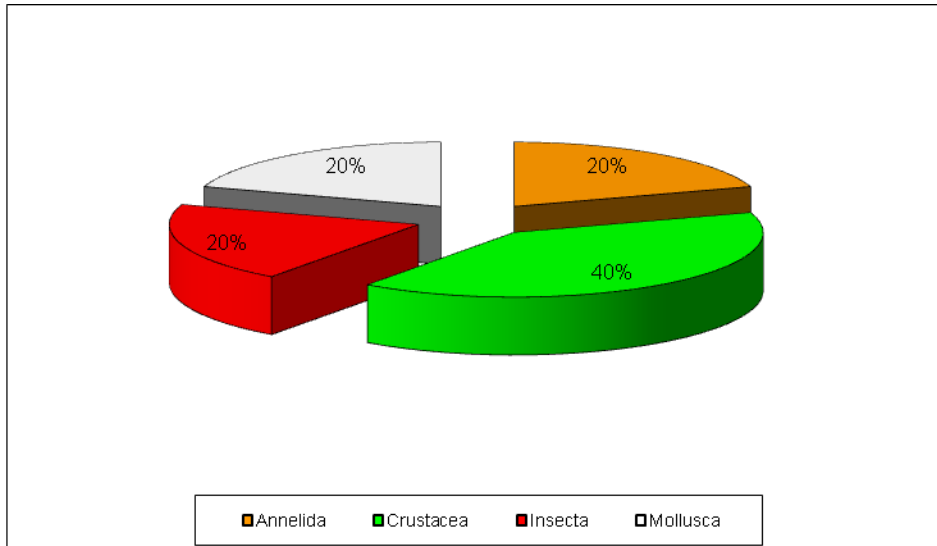


Fig. 4.5.6a: Percentage Composition of Wet Season Macroinvertebrate Fauna

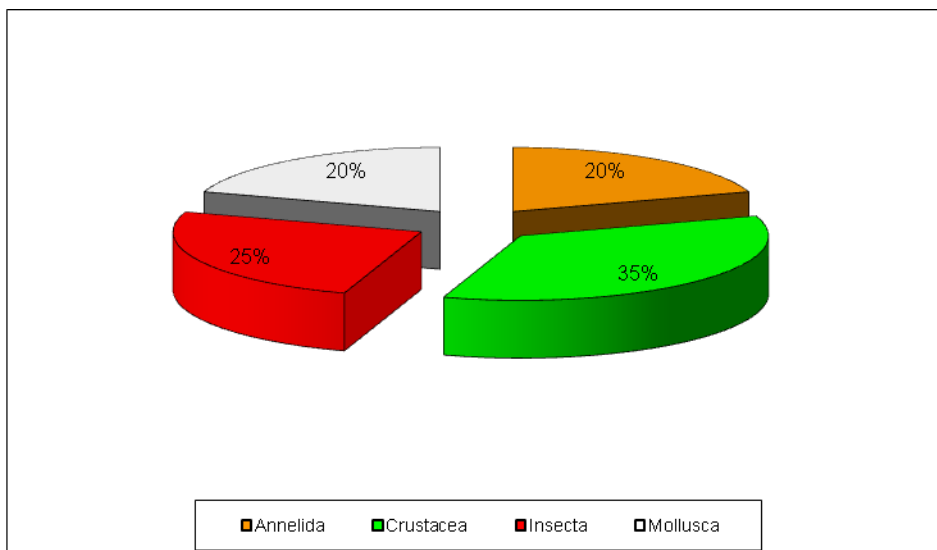


Fig. 4.5.6b: Percentage Composition of Dry Season Macroinvertebrate Fauna

Table 4.5.3: Macroinvertebrates Species Composition

| GROUP | SPECIES OF WET AND DRY SEASONS | COMMON NAME |
|------------|------------------------------------|-----------------|
| ARTHROPODA | | |
| Crustacea | <i>Alpheus pontederiae</i> | Snapping shrimp |
| | <i>Balanus</i> sp | |
| | <i>Callinectes amnicola</i> | Swimming crab |
| | <i>Cardisoma armatum</i> | Rainbow crab |
| | <i>Clibanarius</i> sp | Hermit Crab |
| | <i>Macrobrachium macrobrachion</i> | |
| | <i>Mysis</i> sp | |
| | <i>Palaemon maculatus</i> | |
| | <i>Sesarma elegans</i> | Mangrove crabs |
| | <i>Sesama huzardi</i> | Mangrove crabs |
| | <i>Sesarma alberti</i> | Mangrove crabs |
| | <i>Uca tangeri</i> | Fiddler crab |
| MOLLUSCA | | |
| Gastropoda | <i>Littorina</i> sp | |

| GROUP | SPECIES OF WET AND DRY SEASONS | COMMON NAME |
|-------------------------|--------------------------------|---------------------|
| | <i>Pachymelania aurita</i> | |
| | <i>Thais</i> sp | |
| | <i>Tympanotonus fuscatus</i> | Mud-flat Periwinkle |
| Bivalvia | <i>Crassostrea gasar</i> | Oysters |
| | | |
| ANNELIDA: Polychaeta | <i>Capitella</i> sp | |
| | <i>Nereis</i> sp | |
| | <i>Notomastus</i> sp | |
| | | |
| INSECTA | <i>Baetis</i> sp | Mayfly Larva |
| | <i>Coenagrion</i> sp | Dragonfly Larva |
| | <i>Chironomus</i> sp | |
| | <i>Libellula</i> sp | |
| | <i>Tubifex</i> sp | |



Plate 4.5.1: *Cardisoma armatum* (rainbow crab)



Plate 4.5.2: *Uca tangeri* (Fidler crab)



Plate 4.5.3: *Balanus* sp (attached to wellhead base)



Plate 4.5.4: *Thais* sp (attached to mangrove root)

The variation in the density of benthic macroinvertebrate fauna among the stations is depicted in figure 4.5.7. Faunal density (No/m²) was higher in the dry season than in the wet season in almost all stations. The polychaetes (Annelida), crustaceans and molluscs were more prominent in the more brackish control station (SWC3) than in the fresher zones of lower salinity (Table 4.5.8).

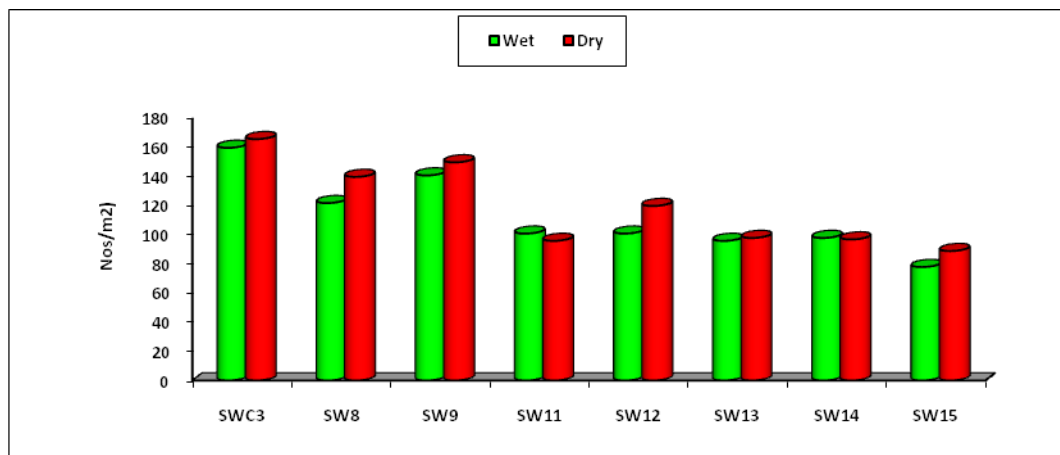


Fig. 4.5.7: Spatial variation in the total density of benthic macroinvertebrates

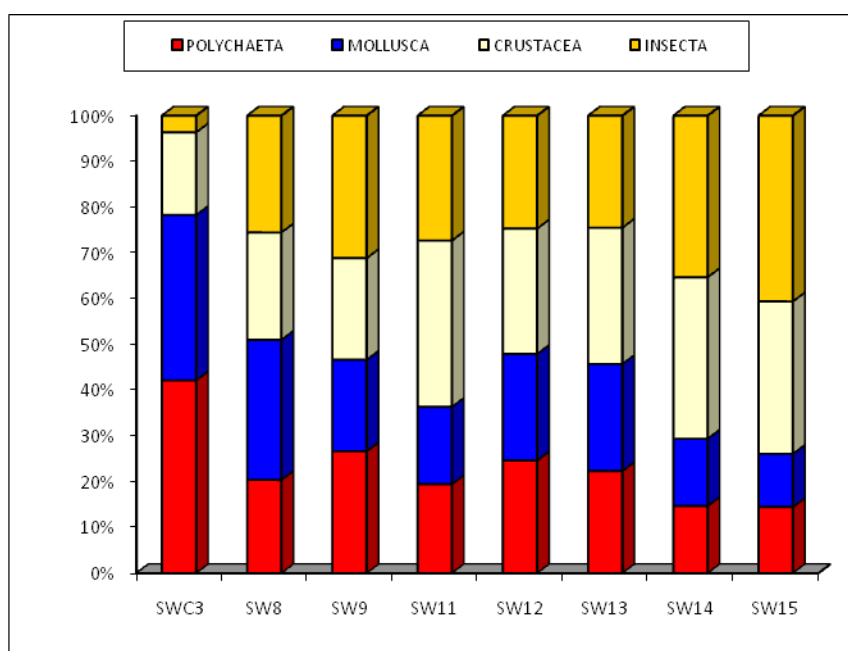


Fig. 4.5.8: Spatial variation in the total density of benthic macroinvertebrates

4.6: Fish and Fisheries

Fishing is one of the traditional occupations of the people in this area. This is carried out in the surrounding creeks, the Escravos River and a few nautical miles into the Atlantic Ocean close to the communities. Fishing gears used include gill nets, (set and drift, Plate 4.6.1), cast nets, long lines, fish stakes and traps. Fin fishes caught by the fishermen are mainly brackish species. Shell fish in this area include the shrimps *Panaeus* sp and *Macrobrachium* spp. Fishing gears include dragnets, cast net and traps.

A total of eighteen (18) species comprising 12 fin fish and 6 shell fish species were recorded (Table 4.6.1). The dominant species were *Pseudotolithus senegalensis*, *Ethmalosa fimbriata*, *Chrysichthys* spp. The health status of the fish was satisfactory and the specimens were of medium size and showed no evidence of pathological deformities. The shell fish component was dominated by *Macrobrachium vollenhovenii*, and the periwinkles, *Tympanotonus fuscatus* and *Pachymelania aurita*. A list of the fin and shell fish from this area is presented in **Table 4.6.1**.

Table 4.6.1: List of Some Fin and Shell Fish from the study area

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



Plate 4.6.1: Local trap for shell fishes (Shrimps and crabs)



Plate 4.6.2: Smoked shrimps caught by local fishermen (ready for sale)

4.7: Vegetation

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

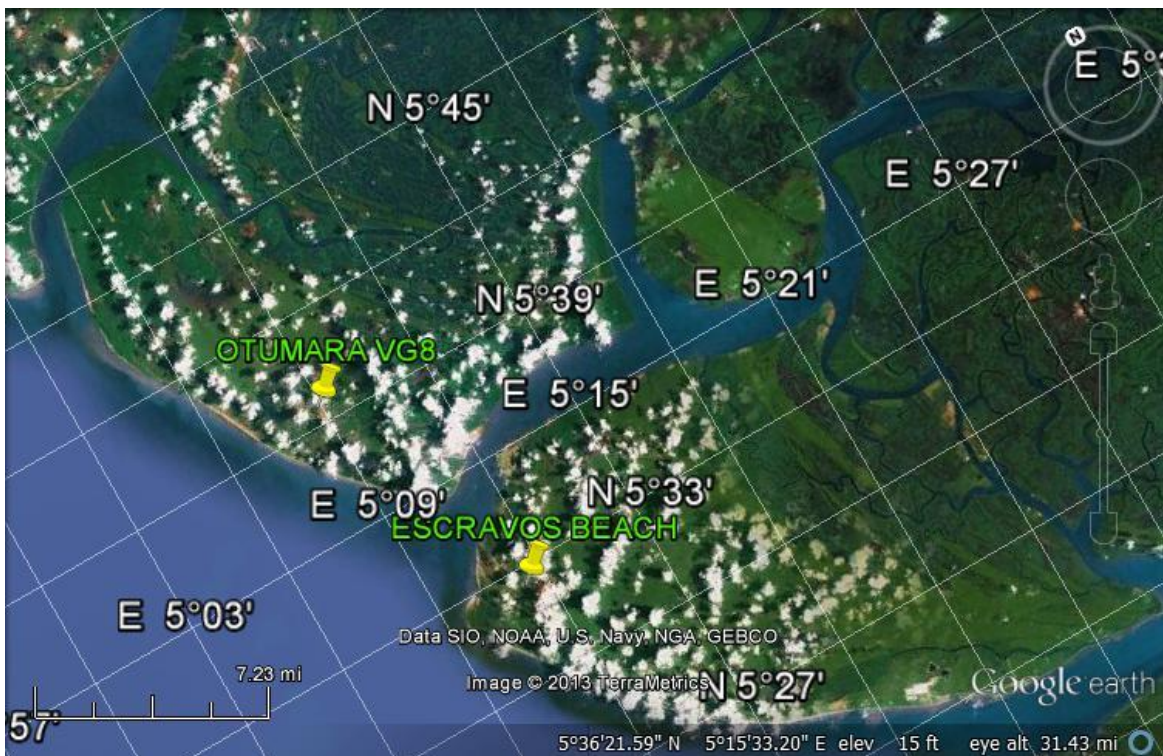


Plate 4.7.1: Satellite view of the various vegetation ecotypes in the study area

Source: Google Earth

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

is much closer to the sea, and on a much lower plain, than Escravos. The differences in ecology, and vegetation, are thus apparently supported by the distinct topography of the two areas despite the shared barrier island terrain.

Cover Characteristics

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

A. Salt Marsh

This describes the Emergent wetland vegetation found in a low-wave-energy tidal marsh environment of estuaries (CMECS, 2012). It is a sensitive wetland with low elevation, close proximity to the sea, and a history of inundation by sea water. Communities here are made up of emergent, halophytic, and herbaceous vegetation which are well suited for this unique difficult environment (woody shrubs are only occasional). These species can endure high salinity, partial inundation, muddy and anaerobic soil conditions.

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

Two subclasses of this wetland ecosystem were observed: (a) Low, and Intertidal Salt Marsh; and (b) High Salt Marsh. Both forms of the Coastal Salt Marsh are predominant in the Otumara area accounting for over 75% of the land cover.

(i) Low and Intertidal Salt Marsh.

This refers to the Tidal Brackish Marsh (Ramsar 1996), which is regularly inundated with quiet waters nearly perennially flooded with depths of up to 1 (one) metre. Water movement in this terrain is largely tidal, and is related to the discharge of river flow through the more or less ‘vegetated lake’, and the regular egress and ingress of tidal waters through the inlets from the sea (Britannica online Encyclopedia, 2012). It was observed that the daily water level in the tidal creeks that supply this terrain falls by up to 1 metre thereby exposing highly silted margins and making navigation difficult.

Generally the low marsh vegetation cover is in near pristine condition. This vegetation is typical of VG 19 area with an *Acrostichum aureum* thicket and vegetation cover of 85-90% while at the control (VGC3), vegetation cover is less than 60% with 2500 – 3000 plants per ha. Average height of vegetation is 2 metres. Sighted here also are a few stands of black mangrove reaching up to 7 metres in height.

Areas sampled were dominated by semi aquatic herbaceous halophytic shrubs and a few more or less clustered trees. The characteristic low drainage and water stagnancy in this ecosystem limits fresh water influx and sustains species dominance pattern. The vegetation community consists mainly of *Acrostichum aureum* (Golden leather / Mangrove fern) interspersed with groves of *Avicennia germinans*; while *Dalbergia ecastaphyllum* and *Rhizophora racemosa* occur as fringe vegetation around VGC3. Generally, *Alchornea laxiflora* dominates the slot margins colonizing the dredge dump lining.

However, it was observed that the dumping of dredge spoil had altered the ecology of the margins of this habitat in a few areas like at sampling location VG15 where a plantain plantation is facilitated by dredge spoils in an area where this vegetation intergrades with the terrestrial upland swamp vegetation (Plate 4.7.2).

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

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



Plate 4.7.2: showing (L-R) the transition zones at VG18 and 8 respectively.

VG18 shows the impact of indigenous settlement and agriculture; at VG 8, the swamp area is ransacked for timber (*Abura*, *Alstonia*, and *Ceiba pentandra*). Both locations coincide with recent, historic pipeline activities, and dredge spoil deposition.

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

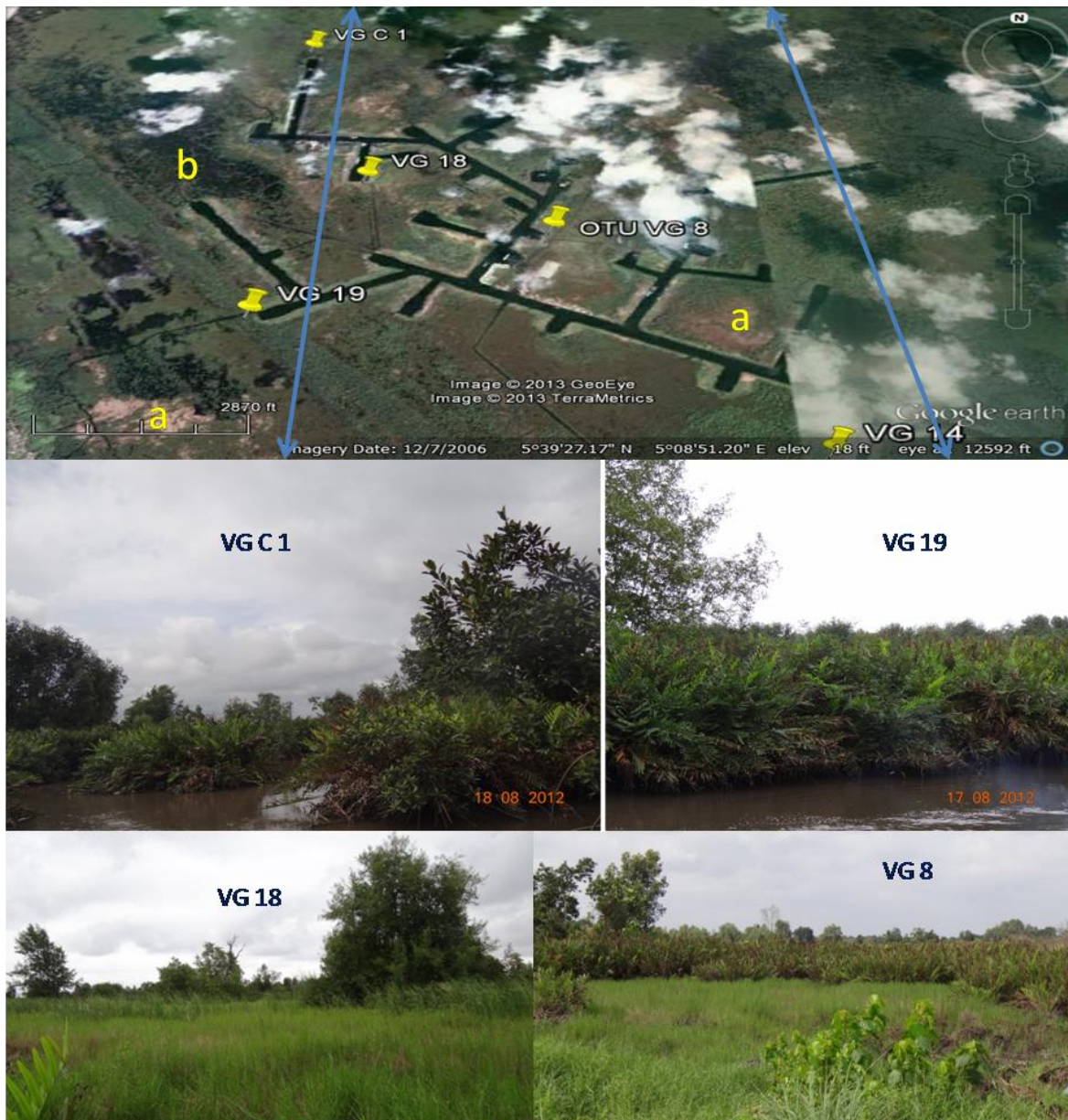


Plate 4.7.3: Showing vegetation zones, and types, present in the Otumara area.

Satellite Image L-R: Low salt Marsh, High salt Marsh (between blue lines), Mangrove vegetation (Right). KEY: a - bare mudflat; b - Sparsely vegetated low salt marsh; VG 19 - thickly vegetated low salt marsh.

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

This vegetation sub-type is extensive in Otumara area. The predominance of the mangrove grass *Paspalum vaginatum* (up to 70% of total veg. cover) and the presence of *Avicennia germinans* (20% or more) as well as clusters of *Acrostichum aureum* indicate the high salinity prevailing in

the soil as is characteristic of salt flats. Plate 4.7.5 above shows both VG18 and 8, dominated by *Paspalum* grass. But *Acrostichum aureum* is virtually absent in the VG18 profile above, while it is significantly present and gregarious in VG8. Around VG18 the population of black mangrove, occurs with tree density of about 35 – 50 trees per ha. In this vegetation cover type, few other mangrove associates were sighted including, *Rhynchospora corymbosa*, and small thickets of *Dalbergia ecastaphyllum*, *Machaerium lunatum* and, *Phyllanthus muellerianus*. Opportunistic species include *Alchornea laxiflora*, *Ludwigia abyssinica*, and *Cassia alata*.

B. Mangrove Swamp

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

(i) Tall Mangrove

This vegetation is seen at VG13. It is suited to the intertidal environment and is found mostly along tidal rivers and creeks in estuaries; elsewhere as fringing the open sea. The possession of stilt roots greatly aids it to withstand the regular changes in water level and the muddy intertidal landscape; it also plays a great role in shoreline protection, and hydrobiological food chain. The vegetation is homogenous and in near pristine condition around VG13 with typically tall *Rhizophora racemosa*.

(ii) Short Mangrove Forest

This short mangrove forest is different from the dwarf mangrove forest; the dominant species here is the *Rhizophora harrisonii* which is suspected to be the putative hybrid between *R. racemosa* and *R. mangle* (Norman and Allen, 2006). This species of red mangrove grows to between 6 and 9 meters in height compared to *R. mangle* which rarely exceeds 5 meters in the Niger delta. The roots also form high tangles and the tree density exceeds that in dwarf mangrove communities. The short mangrove rarely competes with the *R. racemosa* for the tidal river fringes and is mostly seen immediately behind the tall mangrove belt and before the dwarf mangrove which is further inland in basin forest.



Plate 4.7.4 showing tall Mangrove (above); and the short mangroves (below)

(iii) Dwarf Mangrove Swamp forest.

The vegetation is dominated by *Rhizophora mangle*. Near pristine conditions occur at Otumara, while in some areas, the vegetation is currently being ravaged by the indigenes for fuel wood.



Plate 4.7.5: Showing the dwarf mangrove vegetation at Otumara and a pile of twigs harvested from it for fuel wood.

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

C. Fresh Water Swamp Vegetation

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

(i) Transition Fresh Water Swamp Vegetation

This type occurs in the transition vegetation zone where the estuarine swamp vegetation intergrades with the terrestrial vegetation: thus it is transition vegetation. It is found in Otumara area on the land ward margins of the Salt Marsh Vegetation. This area coincides with the most disturbed area as the soil here is most arable, especially where it is stabilized by dredge dump. It is also close to the Otumara community and contains several economic tree species. Typical representation of this vegetation was found at VG15 and VG8. Vegetation cover is over 60%. Typical swamp tree species present here are *Fleroya ledermanii* (1,000 trees pa ha), *Alstonia boonei* (148 trees pa ha), *Ceiba pentandra* (50 trees pa ha) and *Anthocleista djalonensis* (80 trees pa ha). These species make up over 80% of the tree population. Average height of vegetation is

13 meters with *Fleroya* spp and *Alstonia* spp reaching 15-17 metres. The dominant shrub is *Alchornea laxiflora*.

(ii) Fresh Water Swamp Vegetation

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

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



Plate 4.7.6: Showing a section of the fresh water swamp forest

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



Plate 4.7.7: Showing a disturbed patch of the Palm dominated swamp vegetation; *Tabanaemontana pachysiphon*.

D. Phoenix Swamp Forest

This vegetation type occurs at VGC3 (Control) on a flat muddy terrain flanking the Ogidigben tidal river as it drains into the Escravos River near Madagho-ajeda. This woodland is dominated by an uneven distribution of *Avicennia germinans*, and *Phoenix reclinata*: the latter often forming dense bushy clumps. Height of vegetation is about 6 metres while species density is an average of 3800 trees per ha. Black mangrove trees (120 trees per ha), and a few oil palm trees, emerge above this *Phoenix* canopy reaching heights of 8-12 metres. The *Acrostichum aureum* shrub layer is only sparsely vegetated in most areas. Total vegetation cover here is over 60 – 70%. Light thickets of *Dalbergia ecastaphyllum*, *Phyllanthus muellerianus*, *Hibiscus tiliaceous*, and *Endodesmia calophylloides* are present. This unique vegetation provides a habitat for the

red-river hogs during the rainy season while the ripe fruits provide food for birds and monkeys. A checklist of plant species at Otumara field is presented in Table 4.7.1.



Plate 4.7.8: Showing a *Phoenix reclinata* swamp with *Avicennia germinans*, Oil palm and *Acrostichum aureum* associations at VGC 3, near Madagho– ajeda.

Table 4.7.1a: Checklist of plant species present at Otumara Field

| S/N | Plant Species Present | Growth Form | Economic Importance | Common Name |
|-----|--------------------------------|-------------|----------------------------|----------------------|
| 1 | <i>Acrostichum aureum</i> | H | Used for trapping crayfish | Golden leather fern |
| 2 | <i>Aframomum melegueta</i> | H | Medicinal | Aligator Pepper |
| 3 | <i>Alchornea cordifolia</i> | S | Medicinal | Xmas tree |
| 4 | <i>Alchornea laxiflora</i> | S | Medicinal | Low veld bead string |
| 5 | <i>Alstonia boonei</i> | T | Timber/Medicinal | Cheese wood |
| 6 | <i>Anthocleista</i> spp. | T | - | Forest fever tree |
| 7 | <i>Axonopus compressus</i> | G | - | Carpet grass |
| 8 | <i>Baphia nitida</i> | T | Chewing stick/Medicinal | Camwood |
| 9 | <i>Calamus</i> spp | CL | Basket weaving/Furniture | Sweet sedge |
| 10 | <i>Carapa procera</i> | T | Furniture | Carapa |
| 11 | <i>Celtis zenkeri</i> | T | Timber | Diana (Ohia) |
| 12 | <i>Chromolaena odorata</i> | H | Medicinal | Siam weed |
| 13 | <i>Phyllanthus amarus</i> | H | Medicinal | Carry me seed |
| 14 | <i>Emilia coccinea</i> | H | - | Flora's Paint brush |
| 15 | <i>Solanum torvun</i> | S | - | Devil's fig |
| 16 | <i>Setaria</i> sp | G | - | Bristle Grass |
| 17 | <i>Cocos nucifera</i> | T | Food | Dwarf Yellow Coconut |
| 18 | <i>Costus afer</i> | H | - | Ginger Lily |
| 19 | <i>Cyperus articulatum</i> | H | - | Guinea Rush |
| 20 | <i>Cyperus ligularis</i> | H | - | Mbew |
| 21 | <i>Dalbergia dendo</i> | T | - | East Indian Rosewood |
| 22 | <i>Dalbergia ecastaphyllum</i> | S | - | Coinvine |
| 23 | <i>Dispyros dendo</i> | T | - | Blackwood |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| S/N | Plant Species Present | Growth Form | Economic Importance | Common Name |
|-----|---------------------------------------|-------------|---------------------|-------------------------|
| 24 | <i>Machaerium lunatus</i> | S | Medicinal | Manatee bush |
| 25 | <i>Elaeis guineensis</i> | T | Food/wine | African Oil Palm |
| 26 | <i>Funtumia elastica</i> | T | Rubber | Silk Rubber |
| 27 | <i>Glyphaea brevis</i> | S | - | Bola Pane |
| 28 | <i>Ipomoea involucrata</i> | H | - | Close to the ground |
| 29 | <i>Irvingia gabonensis</i> | T | Food | African Mango |
| 30 | <i>Lophira alata</i> | T | Timber | Ekki (Azobe) |
| 31 | <i>Mariscus ligarus</i> | G | - | Not Documented |
| 32 | <i>Memecylon afzelii</i> | S | - | Not Documented |
| 33 | <i>Musanga cecropioides</i> | T | - | African Apple |
| 34 | <i>Rottboellia cochinchinensis</i> | G | - | Alligator weed |
| 35 | <i>Trema occidentalis</i> | S | - | Pigeon wood |
| 36 | <i>Ageratum conyzoides</i> | H | - | Goat weed |
| 37 | <i>Ceiba pentandra</i> | T | Timber | Silk cotton tree |
| 38 | <i>Mitragyna stipulosa</i> | T | Timber | Abura |
| 39 | <i>Myrianthus arborea</i> | T | Vegetable/Food | Not documented |
| 40 | <i>Nauclea diderrichii</i> | T | Timber | Opepe |
| 41 | <i>Palisota birsuta</i> | H | - | Sheeps Knee |
| 42 | <i>Panicum maximum</i> | G | - | Guinea Grass |
| 43 | <i>Paspalum orbiculare</i> | G | - | Rice Grass |
| 44 | <i>Paspalum vaginatum</i> | G | - | Biscuit Grass |
| 45 | <i>Pennisetum purpureum</i> | G | - | Elephant Grass |
| 46 | <i>Pentaclethra macrophylla</i> | T | Food | Old Oil bean tree |
| 47 | <i>Pycnanthus angolensis</i> | T | Timber | Akomu |
| 48 | <i>Raphia hookeri</i> | T | Wine | Wine Palm |
| 49 | <i>Rauvofia vomitoria</i> | S | Medicinal | Poisons Devils Pepper |
| 50 | <i>Sporobolus pyramidalis</i> | G | - | Giant Rat's Tail Grass |
| 51 | <i>Terminalia superba</i> | T | Timber | Afara |
| 52 | <i>Vernonia amagydalina</i> | S | Food | Bitter leaf |
| 53 | <i>Vitex rivularis</i> | T | - | Antelopes Garden Egg |
| 54 | <i>Ficus trichopoda</i> | T | - | Swamp fig |
| 55 | <i>Lygodium sp</i> | CL | - | Climbing fern |
| 56 | <i>Chrysophyllum gigantum</i> | T | Timber | Abure |
| 57 | <i>Psydrax subcordata</i> | T | - | Not documented |
| 58 | <i>Zanthoxylum gillettii (Fagara)</i> | T | Timber/Medicinal | African satin wood |
| 59 | <i>Musa sapientum</i> | T | Food | Dwarf Banana |
| 60 | <i>Musa paradisiaca</i> | T | Food | Plantain |
| 61 | <i>Xanthosoma sp</i> | H | Food | Cocoyam |
| 62 | <i>Manihot esculenta</i> | S | Food | Cassava |
| 63 | <i>Capsicum annum</i> | H | Food | Hot pepper |
| 64 | <i>Terminalia catapa</i> | T | Ornamental | Indian Almond (Ebelebo) |
| 65 | <i>Erythrophleum suaveolens</i> | T | Timber | Red water tree |
| 66 | <i>Spondias mombin</i> | T | Food | Tropical plum |
| 67 | <i>Mormodica charanthia</i> | CL | Medicinal | Bitter melon |
| 68 | <i>Ormocarpus verrucosum</i> | S | - | Raphia Palm |
| 69 | <i>Ipomoea pes-capre</i> | CL | - | Railroad vine |
| 70 | <i>Antiaris Africana</i> | T | Timber | False Iroko |
| 71 | <i>Assystasia gigantean</i> | H | - | Burny vine |
| 72 | <i>Elaeocharis sp</i> | G | Mat weaving | Lawn Sedge |

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

Phytochemistry

Table 4.7.1b below shows the results of the phytochemical screening carried out on the leaf tissue samples obtained during the field survey, to ascertain any chemical contamination. Elements screened for included heavy metal mainly associated with oil and gas activities. The toxic non essential Heavy metals screened for Include Cu, Cd, Pb, Hg, Va, Ni, Zn, and Cr. Only

copper occurred in all the samples. Although there were elevated levels of copper in few samples from Otumara area, those levels were just around the lower limit (5.0 mg/kg) of the normal range of concentration in plants. Generally concentrations in leaves sampled, were below normal levels. Although Zinc levels were very normal for plant survival, only samples from VG13 and 8 can be said to contain levels that are safe for human consumption at one kilogram of leaf consumed per day.

Other stations had concentrations of cadmium mostly below detectable levels while few samples where within the normal range. Leaves of plants sampled from nine points in Otumara (VG8,12,13,14,15,20,21,C3) had non-detectable levels of cadmium while in nine other points, there was very toxic concentrations ranging from 4.5 mg/kg (VG16, 17) to 10.5mg/kg (VG19) in leaves of *Acrostichum aureum*.

Generally lead (Pb) concentrations in leaves sampled were very normal (1.0 – 10.5 mg/kg) when compared with the normal concentration range for Pb in angiosperm leaves which is 2.0 – 20mg/kg. In the study area, concentrations of Pb were at non-detectable levels in six samples (VG8, 13, 17, 18 and 19). At VG 14 the leaf sampled from *Alchornea laxiflora* had the highest concentration (10.5 mg/kg) found within the study area, while samples from the other areas had concentrations of lead in the range of 2.5 – 7.5 mg/kg with mean concentration of 5.6 mg/kg.

Some of the samples from the study area had Nickel concentrations below detectable levels. Average concentration from the following points (VG 8, 12, 13, 14, 16, 20 and 21) was 9.5 mg/kg with a range of 4.5 – 18 mg/kg. Thus Nickel concentration in plants was far above the normal range of 0.02 – 5 mg/kg.

Leaf samples from six stations in Otumara (VG12,13,14,16, 20, and 21) had vanadium concentrations below detectable levels while the other samples had a mean concentration of 12.9 ± 4.3 mg/kg. In Otumara area, Chromium levels were below detectable levels in samples from VG13 and 17. The other samples had mean level of 6.4 (± 2.4) mg/kg, which is normal.

Among the micro nutrient elements, there were critical levels of Fe in samples VG13, 15, 17 and C3 with concentration ranging between 540 (VG13) – 730 (VGC3) mg/kg. With the exclusion of these points, average concentration was 287 mg/kg; well within the normal concentration range of Fe in leaves.

Table 4.7.1b: Results of Phytochemical Screening.

| Code \ Parameter | Fe | Cu | Mn | Zn | Cd | Cr | Pb | Ni | V |
|------------------|-------|------|------|------|-----|------|------|------|------|
| | mg/kg | | | | | | | | |
| VEG 8 | 230 | 4.65 | 5.15 | 25.5 | 4.0 | 6.5 | ND | 6.5 | 5.1 |
| VEG 9 | 130 | 1.80 | 4.90 | 25.5 | 2.5 | ND | 4.0 | 5.0 | 4.2 |
| VEG 12 | 275 | 3.40 | 4.65 | 29.0 | ND | 7.5 | 5.0 | ND | ND |
| VEG 13 | 255 | 3.00 | 4.25 | 30.0 | ND | 6.5 | ND | ND | ND |
| VEG 14 | 290 | 3.70 | 3.50 | 30.5 | ND | 7.5 | 10.5 | ND | ND |
| VEG 15 | 605 | 5.80 | 4.55 | 25.5 | ND | 10.5 | 7.5 | 4.5 | 3.2 |
| VEG 16 | 450 | 2.55 | 3.80 | 25.5 | 4.5 | 5.5 | 2.5 | ND | ND |
| VEG 17 | 435 | 1.65 | 4.80 | 33.0 | 6.5 | 2.5 | 2.5 | 16.0 | 12.0 |
| VEG 18 | 140 | 2.55 | 4.95 | 30.0 | 5.0 | 2.5 | ND | 8.5 | 7.1 |

| Parameter Code | Fe | Cu | Mn | Zn | Cd | Cr | Pb | Ni | V |
|-------------------|-----|------|------|------|------|-----|-----|------|------|
| VEG 19 | 280 | 1.85 | 3.30 | 38.0 | 10.5 | 6.5 | ND | 15.0 | 13.4 |
| VEG 20 | 290 | 3.65 | 4.65 | 29.2 | ND | 8.0 | 7.5 | ND | ND |
| VEG 21 | 275 | 3.58 | 4.44 | 29.0 | ND | 7.5 | 5.5 | ND | ND |
| VEG C3 | 730 | .80 | 3.30 | 30.0 | ND | 2.0 | 6.5 | 6.5 | 5.6 |

Pathology

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

4.8 Wildlife

Wildlife Composition

Otumara field is in a protected area (Fig. 4.8.1). The wildlife diversity and distribution pattern observed in the Otumara field reflects the uniqueness of this area in terms of terrain and vegetation cover. Generally it is not possible to provide specific numbers for the population size of the different wildlife categories, due to the time and scope constraints of this study; as random sighting especially of the amphibians and primates decreases with the increase in human activities within the area at any particular moment. However sighting was possible through chance encounters that proved the presence of the listed species.

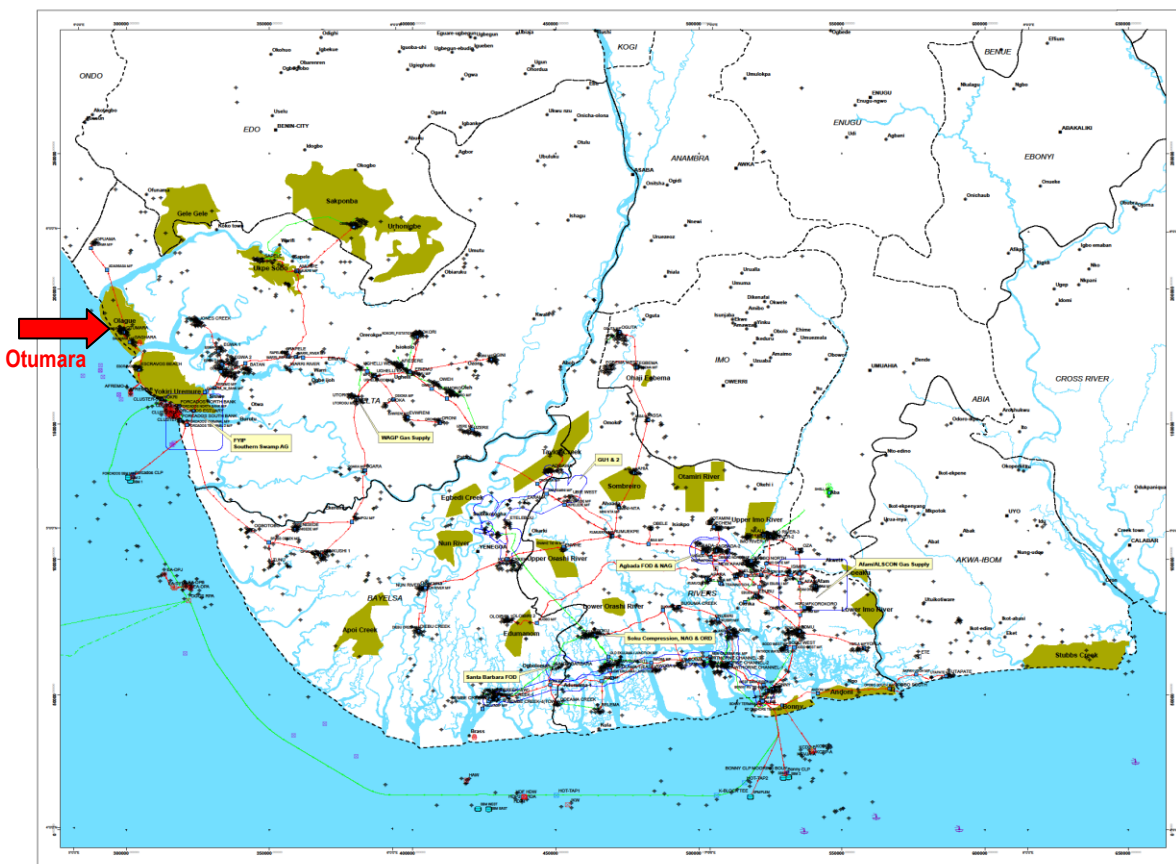


Fig. 4.8.1: Map of Niger Delta showing Protected Areas (Olague Forest Reserve which harbours the Otumara Field is proposed but yet to be gazetted)

The wildlife composition and species diversity in the Otumara area is low. This is traceable to the predominance of the High and low salt marsh in the Otumara axis which does not support land animals; hence the predominance of amphibians generally. Amongst the reptiles, the slender snouted crocodile, the African dwarf Crocodile and python species were common across the entire area. There are fewer snakes in Otumara. The Mona monkey was the only species reported in the Otumara node.

A check list of the wildlife spectrum in the four major categories of Mammalia, Aves, Reptilia, and Amphibia is presented in Table 4.8.1.

Table 4.8.1: Checklist of Mammals found in the project site

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

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

Table 4.8.2: Checklist of Birds (Aves) found in the project site

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

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

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

Table 4.8.3: Checklist of Reptiles found in the project site

| S/N | REPTILES | | STATUS | | |
|-----|-----------------------------|------------------------------|----------|------------|--------|
| | | | Local | IUCN | Dcr 11 |
| | Family Varanidae | | | | |
| 1 | Forest/Ornate Monitor | <i>Varanus ornatus</i> | Abundant | | |
| | Family Boidae | | | | |
| 2 | African Rock python | <i>Python sebae</i> | Common | | 1 |
| | Family Elapidae | | | | |
| 3 | Black Cobra | <i>Naja melanoleuca</i> | Common | | |
| 4 | Spitting Cobra | <i>Naja nigricollis</i> | Common | - | |
| 5 | Jameson's mamba | <i>Dendroaspis jamesoni</i> | Common | | |
| | Family Crocodylidae | | | | |
| 6 | Nile Crocodile | <i>Crocodylus niloticus</i> | Common | | 1 |
| 7 | African Dwarf Crocodile | <i>Osteolaemus tetraspis</i> | Common | Vulnerable | 1 |
| | Family Pelomedusidae | | | | |
| 8 | W.Afr. Black Forest Turtle | <i>Pelusios niger</i> | Common | | |
| | Family Testudinidae | | | | |
| 9 | Home's Hinge-back tortoise | <i>Kinixys homeana</i> | Common | | |

It was observed that the parrots migrate to the Saghara axis in the morning and return to the Escravos area at night. Several other migratory birds were observed including the White breasted cormorant, Slender billed curlew, and the Great white Egret.

4.9 Geology and Hydrogeology

4.9.1 Geology and Geomorphology

The study area (Otumara) and the adjoining fields (Saghara and Escravos) are part of the geologic sequence of the Quaternary and Tertiary formations of the Niger Delta, consisting of three main geological formations – the Benin formation (the topmost unit), the Agbada and the Basal Unit, the Akata formations. Lithological units of the study area are generally composed of sands, silty sands and clays (Short and Stauble 1967).

The land surface of the study area is characterized by low lying plains typical of the modern Niger Delta. These plains have swamps that are commonly flooded during the peak of the rainy season. The area slopes imperceptibly in the South direction towards the Atlantic Ocean and is drained by a network of Escravos River and the adjoining creeks, mangrove swamps, marshes and dredge slots.

4.9.2 Hydrogeology

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

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

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

Recharge to this system is mainly from rainfall, while discharge sources include run-offs from the basin and abstraction through boreholes. Table 4.9.1 below shows the aquifer prospectivity of the Niger Delta Basin.

Table 4.9.1: Stratigraphic sequence of the Niger Delta Basin with aquifer prospectivity

| | Stratigraphic Units | Lithologic Description | Aquifer Prospect |
|------------|--------------------------------------------------|------------------------------------------------------------------|---------------------|
| QUATERNARY | ALLUVIUM | Gravelly sands, sands, silt and clays | Good |
| | MEANDER BELT DEPOSIT | Gravelly sands, sands with thin clay units. | Good |
| | WOODED BACK SWAMPS & FRESH-WATER SWAMPS DEPOSITS | Mainly silt and silty clays with clayey intercalations | Poor |
| | MANGROVE SWAMPS DEPOSIT | Fine sands to silt and silty clays and clays with organic matter | Poor (Saline water) |
| | SOMBREIRO-DELTAIC PLAIN SEDIMENTS | Coarse to fine grained sands, silts and clays | Medium |

| | Stratigraphic Units | Lithologic Description | Aquifer Prospect |
|-------------------|---------------------|-------------------------------------------------------------------------|------------------|
| MIOCENE TO RECENT | BENIN FORMATION | Mainly coarse-medium grained sands, lenticular with clay and shaly lens | Prolific Aquifer |

(Source: Olobaniyi *et al.*, 2006)

4.9.3 Aquifer Characteristics

Four (4) boreholes including one control were drilled within the study area using percussion drilling method. The lithostratigraphy of the Otumara axis where the three monitoring boreholes were drilled is made up of dark brownish micaceous humic loam material at the surface. The clay content of the lithology increases from about one metre (1m) from the surface level down to a depth of six meters (6m) This clay material overlies a fine silty-clay material that is about two metres (2m) thick. Underlying this fine silty-clay material is a higher proportion of silt mixed with sand (sandy-silt) that stretches down to a depth of ten metres (10 m). The sandy silt materials are followed by fine sand materials that become coarser with increasing depth, and joins the aquifer (water-bearing lithology) at about fifteen metres (15 m) depth. The formation materials become lighter in colour with increasing depth (Fig 4.9.1).

Otumara Area

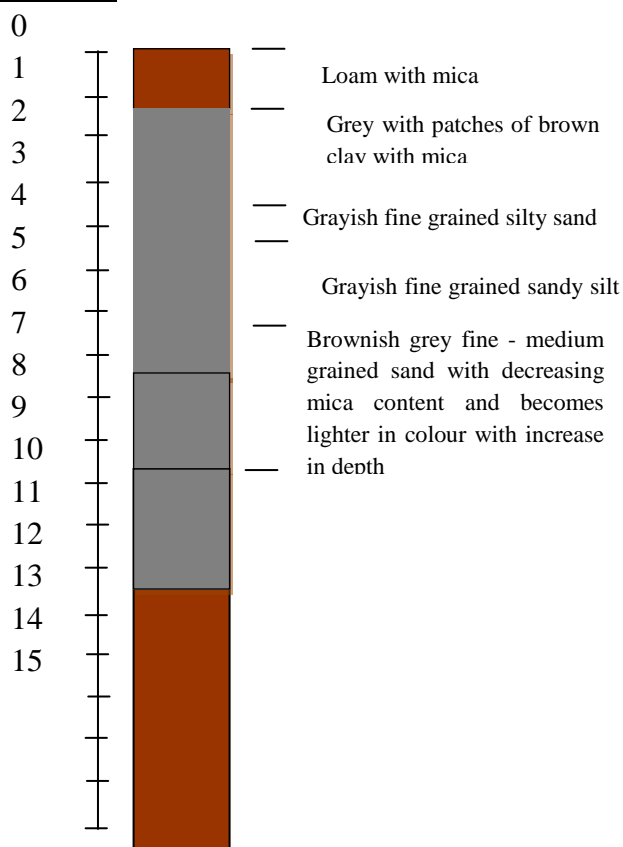


Fig 4.9.1: Average typical Litholog of the boreholes of the study areas

Water Level

The water level measured in the boreholes, ranges from 1.2 m in borehole 1, to 1.9 m in borehole 4 in Otumara.

Groundwater Flow Direction

Groundwater flow direction in the area was determined using the data from the 3 boreholes. The data shows that the groundwater flow direction in the area is from Northeast to Southwest (Fig. 4.9.2). This is in conformity with the regional groundwater flow direction in Niger Delta, which is from Northeast towards the coast in the South. Thus if there is any pollution of groundwater in the area, those South of the point of pollution are most likely to be affected.

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

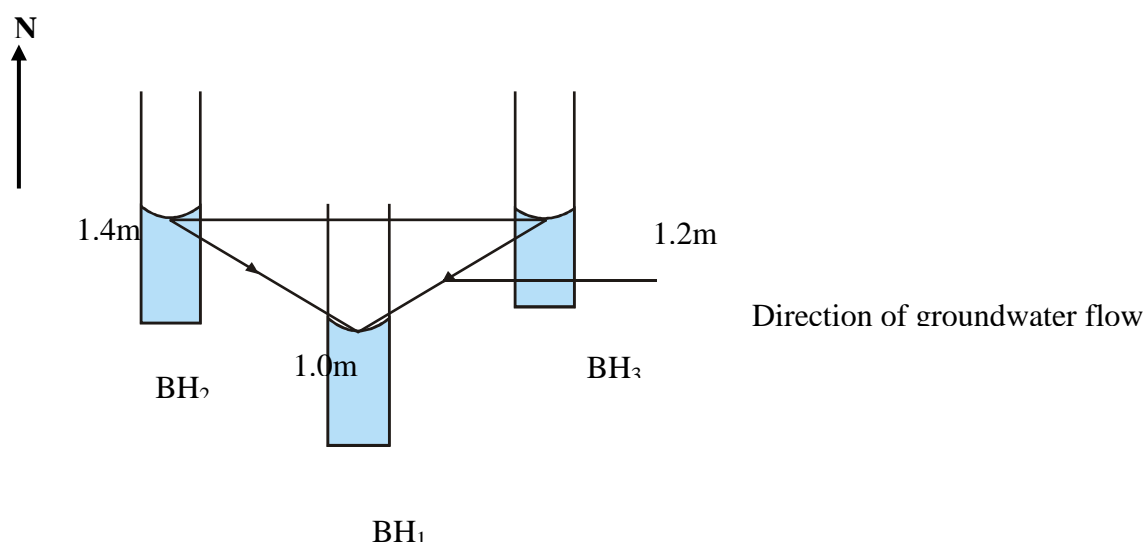


Fig 4.9.2: Groundwater flow direction in the study area Otumara

Ground Water Quality

The quality of any water resources is its suitability for the intended use. Thus, this is a function of the physical, chemical and biological (bacteriological) characteristics of the water which in turn depend on the geology of the area and impacts of human activities. The wet and dry season results of laboratory analysis of the groundwater samples obtained from these boreholes are presented in Tables 4.9.2a and b for physico-chemical parameters, while Tables 4.9.3 gives the summary of minimum, maximum, mean values and the regulatory standards.

Table 4.9.2a: Physico-chemical qualities of Otumara Borehole Samples (Wet Season 2012)

| S/N | Parameters | Units | OTU BHG C1 | OTU GW1 | OTU GW2 | OTU GW3 | MIN | MAX | MEAN |
|-----|------------|----------------|------------------|------------|------------|------------|------|------|------|
| 1 | pH | | 7.2 | 7.9 | 7.2 | 7.3 | 7.2 | 7.9 | 7.4 |
| 2 | Temp | ⁰ C | 26.5 | 27.8 | 26.8 | 27.6 | 26.5 | 27.8 | 27.2 |
| 3 | EC | μS/cm | 4020 | 3770 | 4640 | 4680 | 3770 | 4680 | 4278 |
| 4 | Salinity | g/l | 1.81 | 1.71 | 2.10 | 0.21 | 0.21 | 1.81 | 1.46 |
| 5 | Col. | Pt.Co | 12.5 | 14.3 | 20.9 | 10.3 | 10.3 | 20.9 | 14.5 |
| 6 | Turbidity | NTU | 9.4 | 10.9 | 14.5 | 7.7 | 7.3 | 14.5 | 10.6 |
| 7 | TSS | mg/l | 10.7 | 8.3 | 14.1 | 9.0 | 9.0 | 14.1 | 10.5 |
| 8 | TDS | “ | 2010 | 1600 | 2310 | 2340 | 1600 | 2340 | 2065 |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| S/N | Parameters | Units | OTU BHW C1 | OTU GW1 | OTU GW2 | OTU GW3 | MIN | MAX | MEAN |
|---------------------|-------------------|-------|------------------|------------|------------|------------|-------|-------|-------|
| 9 | DO | “ | 4.6 | 5.6 | 4.8 | 5.1 | 4.6 | 5.6 | 5.0 |
| 10 | BOD ₅ | “ | 3.3 | 3.5 | 3.2 | 3.5 | 3.2 | 3.5 | 3.4 |
| 11 | COD | “ | 209.6 | 2.4 | 1.6 | 86.4 | 1.6 | 209.6 | 75 |
| 12 | HCO ₃ | “ | 189.1 | 183.0 | 134.2 | 109.8 | 109.8 | 189.1 | 154.0 |
| 13 | Na | “ | 97.3 | 115.9 | 137.2 | 124.2 | 97.3 | 137.2 | 118.7 |
| 14 | K | “ | 20.3 | 121.4 | 119.9 | 67.2 | 20.3 | 121.4 | 82.2 |
| 15 | Ca | “ | 13.7 | 68.6 | 122.3 | 104 | 13.7 | 122.3 | 77.2 |
| 16 | Mg | “ | 21.6 | 53.8 | 58.3 | 47.2 | 21.6 | 58.3 | 45.2 |
| 17 | Cl ⁻ | “ | 3820 | 13360 | 2660 | 3380 | 2660 | 13360 | 5805 |
| 18 | PO ₄ | “ | 2.40 | 1.41 | 1.35 | 2.05 | 1.35 | 2.40 | 1.80 |
| 19 | NH ₄ N | “ | 1.88 | 2.00 | 1.84 | 1.81 | 1.81 | 2.00 | 1.88 |
| 20 | NO ₂ N | “ | 1.03 | 0.98 | 1.20 | 1.20 | 0.98 | 1.20 | 1.10 |
| 21 | NO ₃ N | “ | 3.95 | 3.61 | 3.66 | 4.83 | 3.61 | 4.83 | 4.01 |
| 22 | SO ₄ | “ | 53.9 | 56.9 | 60.3 | 54.9 | 53.9 | 60.3 | 56.5 |
| 23 | THC | “ | 0.14 | 0.10 | 0.03 | 0.04 | 0.04 | 0.14 | 0.08 |
| 24 | TPH | “ | 0.002 | 0.002 | 0.003 | 0.002 | 0.001 | 0.003 | 0.002 |
| 25 | PAH | µg/l | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.002 | 0.001 |
| 26 | Benzene | “ | ND | ND | ND | ND | ND | ND | ND |
| 27 | Toluene | “ | ND | ND | ND | ND | ND | ND | ND |
| 28 | Ethylbenzene | “ | ND | ND | ND | ND | ND | ND | ND |
| 29 | Xylene | “ | ND | ND | ND | ND | ND | ND | ND |
| 30 | Phenol | “ | 0.001 | 0.001 | 0.002 | 0.001 | 0.001 | 0.002 | 0.001 |
| Heavy metals | | | | | | | | | |
| 1 | Fe | mg/l | 1.69 | 0.11 | 0.14 | 0.15 | 0.11 | 1.69 | 0.52 |
| 2 | Cu | “ | 0.025 | 0.018 | 0.022 | 0.032 | 0.018 | 0.032 | 0.024 |
| 3 | Mn | “ | 0.073 | 0.008 | 0.016 | 0.007 | 0.007 | 0.073 | 0.026 |
| 4 | Zn | “ | 0.018 | 0.012 | 0.011 | 0.008 | 0.008 | 0.018 | 0.012 |
| 5 | Cd | “ | 0.007 | 0.010 | 0.009 | 0.007 | 0.007 | 0.010 | 0.008 |
| 6 | Cr | “ | 0.018 | 0.006 | 0.016 | 0.003 | 0.003 | 0.018 | 0.011 |
| 7 | Pb | “ | 0.072 | 0.008 | 0.010 | 0.072 | 0.008 | 0.072 | 0.041 |
| 8 | Ni | “ | 0.016 | 0.010 | 0.013 | 0.040 | 0.010 | 0.040 | 0.020 |
| 9 | V | “ | 0.010 | 0.006 | 0.010 | 0.032 | 0.006 | 0.032 | 0.015 |
| 10 | Hg | “ | ND | ND | ND | ND | ND | ND | ND |
| 11 | Ba | “ | 0.001 | 0.001 | 0.001 | 0.002 | 0.001 | 0.002 | 0.001 |

Table 4.9.2b: Physico-chemical qualities of Otumara Borehole Samples (Dry Season 2013)

| S/N | Parameters | Units | OTU GW1 | OTU GW2 | OTU GW3 | Min | Max | MEAN |
|-----|------------------|-------|------------|------------|------------|-------|-------|-------|
| 1 | pH | | 7.45 | 7.26 | 7.32 | 7.26 | 7.45 | 7.34 |
| 2 | Temp | °C | 32.5 | 32.8 | 32.4 | 32.4 | 32.8 | 32.6 |
| 3 | EC | µS/cm | 20900 | 30300 | 10730 | 10730 | 30300 | 20643 |
| 4 | Salinity | g/l | 9.45 | 13.7 | 4.85 | 4.85 | 13.7 | 9.33 |
| 5 | Col. | Pt.Co | 13.2 | 15.4 | 17.0 | 13.2 | 17.0 | 15.2 |
| 6 | Turbidity | NTU | 11.3 | 10.2 | 12.1 | 10.2 | 12.1 | 11.2 |
| 7 | TSS | mg/l | 12.8 | 15.6 | 13.7 | 12.8 | 15.6 | 14.0 |
| 8 | TDS | “ | 11077 | 16059 | 5687 | 5687 | 16059 | 10941 |
| 9 | DO | “ | 4.0 | 4.1 | 4.2 | 4.0 | 4.2 | 4.1 |
| 10 | BOD ₅ | “ | 2.0 | 3.0 | 3.5 | 2.0 | 3.5 | 2.8 |
| 11 | COD | “ | 72.0 | 68.8 | 66.4 | 66.4 | 72.0 | 69.1 |
| 12 | HCO ₃ | “ | 180 | 220 | 130 | 130 | 220 | 177 |
| 13 | Na | “ | 148.3 | 108.0 | 153.4 | 108.0 | 153.4 | 136.6 |
| 14 | K | “ | 81.7 | 15.5 | 136.6 | 15.5 | 136.6 | 77.9 |
| 15 | Ca | “ | 61.8 | 23.9 | 76.6 | 23.9 | 76.6 | 54.1 |
| 16 | Mg | “ | 52.0 | 22.5 | 59.4 | 22.5 | 59.4 | 44.6 |
| 17 | Cl ⁻ | “ | 5250 | 7040 | 4600 | 4600 | 7040 | 5630 |
| 18 | PO ₄ | “ | 6.37 | 7.11 | 5.82 | 5.82 | 7.11 | 6.43 |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| S/N | Parameters | Units | OTU GW1 | OTU GW2 | OTU GW3 | Min | Max | MEAN |
|---------------------|-------------------|-------|------------|------------|------------|-------|-------|-------|
| 19 | NH ₄ N | “ | 0.87 | 0.20 | 0.02 | 0.02 | 0.87 | 0.36 |
| 20 | NO ₂ N | “ | 0.99 | 1.20 | 1.11 | 0.99 | 1.20 | 1.10 |
| 21 | NO ₃ N | “ | 1.13 | 1.94 | 1.37 | 1.13 | 1.94 | 1.48 |
| 22 | SO ₄ | “ | 80.3 | 89.6 | 56.7 | 56.7 | 89.6 | 75.5 |
| 23 | THC | mg/l | 0.30 | 0.27 | 0.38 | 0.27 | 0.38 | 0.32 |
| 24 | TPH | “ | 0.003 | 0.002 | 0.002 | 0.002 | 0.003 | 0.002 |
| 25 | PAH | µg/l | 0.002 | 0.001 | 0.001 | 0.001 | 0.002 | 0.001 |
| 26 | Benzene | “ | ND | ND | ND | ND | ND | ND |
| 27 | Toluene | “ | ND | ND | ND | ND | ND | ND |
| 28 | Ethylbenzene | “ | ND | ND | ND | ND | ND | ND |
| 29 | Xylene | “ | ND | ND | ND | ND | ND | ND |
| 30 | Phenol | “ | 0.002 | 0.002 | 0.002 | 0.001 | 0.002 | 0.002 |
| Heavy metals | | | | | | | | |
| 1 | Fe | mg/L | 1.842 | 2.342 | 1.291 | 1.291 | 2.342 | 1.825 |
| 2 | Cu | “ | 0.042 | 0.051 | 0.074 | 0.042 | 0.074 | 0.056 |
| 3 | Mn | “ | 0.106 | 0.211 | 0.092 | 0.092 | 0.211 | 0.136 |
| 4 | Zn | “ | 0.167 | 0.153 | 0.111 | 0.111 | 0.167 | 0.144 |
| 5 | Cd | “ | 0.023 | 0.021 | 0.016 | 0.016 | 0.023 | 0.020 |
| 6 | Cr | “ | 0.002 | 0.004 | 0.001 | 0.001 | 0.004 | 0.002 |
| 7 | Pb | “ | 0.431 | 0.538 | 0.168 | 0.168 | 0.538 | 0.379 |
| 8 | Ni | “ | 0.074 | 0.096 | 0.067 | 0.067 | 0.096 | 0.079 |
| 9 | V | “ | 0.061 | 0.081 | 0.058 | 0.058 | 0.081 | 0.067 |
| 10 | Hg | “ | ND | ND | ND | ND | ND | ND |
| 11 | Ba | “ | ND | ND | ND | ND | ND | ND |

Table 4.9.3: Summary of Physico-chemical qualities of Otumara Borehole water Samples

| S/N | Parameters | Units | WET SEASON | | | DRY SEASON | | | DPR/ *FME _{env} |
|-----|-------------------|----------------|------------|-------|-------|------------|-------|-------|-----------------------------|
| | | | MIN | MAX | MEAN | Min | Max | MEAN | |
| 1 | pH | | 7.2 | 7.9 | 7.4 | 7.26 | 7.45 | 7.34 | 6.5-9.2/ 6.5-8.5* |
| 2 | Temp | ⁰ C | 26.5 | 27.8 | 27.2 | 32.4 | 32.8 | 32.6 | 30 |
| 3 | EC | µS/cm | 3770 | 4680 | 4278 | 10730 | 30300 | 20643 | |
| 4 | Salinity | ‰ | 0.21 | 1.81 | 1.46 | 4.85 | 13.7 | 9.33 | |
| 5 | Colour | Pt.Co | 10.3 | 20.9 | 14.5 | 13.2 | 17.0 | 15.2 | |
| 6 | Turbidity | NTU | 7.3 | 14.5 | 10.6 | 10.2 | 12.1 | 11.2 | 1.0* |
| 7 | TSS | mg/l | 9.0 | 14.1 | 10.5 | 12.8 | 15.6 | 14.0 | <10* |
| 8 | TDS | “ | 1600 | 2340 | 2065 | 5687 | 16059 | 10941 | 1500/ 500* |
| 9 | DO | “ | 4.6 | 5.6 | 5.0 | 4.0 | 4.2 | 4.1 | 7.5* |
| 10 | BOD ₅ | “ | 3.2 | 3.5 | 3.4 | 2.0 | 3.5 | 2.8 | 0* |
| 11 | COD | “ | 1.6 | 209.6 | 75 | 66.4 | 72.0 | 69.1 | |
| 12 | HCO ₃ | “ | 109.8 | 189.1 | 154.0 | 130 | 220 | 177 | |
| 13 | Na | “ | 97.3 | 137.2 | 118.7 | 108.0 | 153.4 | 136.6 | |
| 14 | K | “ | 20.3 | 121.4 | 82.2 | 15.5 | 136.6 | 77.9 | |
| 15 | Ca | “ | 13.7 | 122.3 | 77.2 | 23.9 | 76.6 | 54.1 | 200 |
| 16 | Mg | “ | 21.6 | 58.3 | 45.2 | 22.5 | 59.4 | 44.6 | 150 |
| 17 | Cl ⁻ | “ | 2660 | 13360 | 5805 | 4600 | 7040 | 5630 | 600/ 250* |
| 18 | PO ₄ | “ | 1.35 | 2.40 | 1.80 | 5.82 | 7.11 | 6.43 | <5* |
| 19 | NH ₄ N | “ | 1.81 | 2.00 | 1.88 | 0.02 | 0.87 | 0.36 | |
| 20 | NO ₂ N | “ | 0.98 | 1.20 | 1.10 | 0.99 | 1.20 | 1.10 | |
| 21 | NO ₃ N | “ | 3.61 | 4.83 | 4.01 | 1.13 | 1.94 | 1.48 | 10* |
| 22 | SO ₄ | “ | 53.9 | 60.3 | 56.5 | 56.7 | 89.6 | 75.5 | |
| 23 | THC | “ | 0.04 | 0.14 | 0.08 | 0.27 | 0.38 | 0.32 | |
| 24 | TPH | “ | 0.001 | 0.003 | 0.002 | 0.002 | 0.003 | 0.002 | 0.3 |

| S/N | Parameters | Units | WET SEASON | | | DRY SEASON | | | DPR/ *FMEnv |
|--------------|--------------|-------|------------|-------|-------|------------|-------|-------|------------------|
| | | | MIN | MAX | MEAN | Min | Max | MEAN | |
| 25 | PAH | µg/l | 0.001 | 0.002 | 0.001 | 0.001 | 0.002 | 0.001 | |
| 26 | Benzene | “ | ND | ND | ND | ND | ND | ND | |
| 27 | Toluene | “ | ND | ND | ND | ND | ND | ND | |
| 28 | Ethylbenzene | “ | ND | ND | ND | ND | ND | ND | |
| 29 | Xylene | “ | ND | ND | ND | ND | ND | ND | |
| 30 | Phenol | “ | 0.001 | 0.002 | 0.001 | 0.001 | 0.002 | 0.002 | |
| Heavy metals | | | | | | | | | |
| 1 | Fe | mg/l | 0.11 | 1.69 | 0.52 | 1.291 | 2.342 | 1.825 | 1/ 1* |
| 2 | Cu | “ | 0.018 | 0.032 | 0.024 | 0.042 | 0.074 | 0.056 | 1.5/ 0.1* |
| 3 | Mn | “ | 0.007 | 0.073 | 0.026 | 0.092 | 0.211 | 0.136 | 0.5-5/ 0.05-0.5* |
| 4 | Zn | “ | 0.008 | 0.018 | 0.012 | 0.111 | 0.167 | 0.144 | 15/5.0* |
| 5 | Cd | “ | 0.007 | 0.010 | 0.008 | 0.016 | 0.023 | 0.020 | 0.01* |
| 6 | Cr | “ | 0.003 | 0.018 | 0.011 | 0.001 | 0.004 | 0.002 | 0.05* |
| 7 | Pb | “ | 0.008 | 0.072 | 0.041 | 0.168 | 0.538 | 0.379 | 0.05* |
| 8 | Ni | “ | 0.010 | 0.040 | 0.020 | 0.067 | 0.096 | 0.079 | 0.05* |
| 9 | V | “ | 0.006 | 0.032 | 0.015 | 0.058 | 0.081 | 0.067 | 0.01* |
| 10 | Hg | “ | ND | ND | ND | ND | ND | ND | 0.001* |
| 11 | Ba | “ | 0.001 | 0.002 | 0.001 | ND | ND | ND | 1.0* |

* Limits for potable water sources (FMEnv)

The groundwater is slightly basic with mean pH values ranging from 7.4 to 7.34 in the wet and dry seasons respectively (Table 4.9.3). These values fall within the regulatory requirement of 6.5 to 8.5 for groundwater. The pH is influenced by the brackish nature of the environment, with salinities varying from 1.46 to 9.33 ‰ and conductivity from 4278 in the wet season to 20643 µS/cm in the dry season.

The groundwater colour (14.5 – 15.5 Pt.co.), total suspended solids (TSS) and dissolved solids (TDS) are high for both wet and dry seasons, exceeding the regulatory limits of 1.0 NTU, <10 mg/l and 500 mg/l for turbidity, TSS and TDS respectively for potable water. These high values are typical of areas experiencing salt water intrusion. The TDS values are a general indicator of the suitability of groundwater for various uses (Mazor, 1991): *Potable water*: up to 500 mg/L; *Slightly saline water*, adequate for irrigation: 501 to 1,000 mg/L *Medium saline water*: may be used for some crops and Aquaculture: 1,000 to 2,500 mg/L; *Saline water*: adequate for aquaculture and industrial use: 2,500 to 5,000 mg/L; *Brackish water*: 5,000 to 35,000 mg/L (the salinity of seawater); *Brine*: TDS greater than 35,000 mg/L

The concentration of Chloride ranged from 1440 – 10800 mg/l. The entire study area has values of Cl that exceed permissible limits. There are no health-related standards for chloride. FMEnv and WHO have set a regulatory limit of 250 mg/L for domestic water. Chloride content of 40mg/l and above is indicative of salt water intrusion.

The dissolved oxygen (4.1 – 5 mg/l) and biochemical oxygen demand 2.8 – 3.4 mg/l) were low, but are not critical parameters in groundwater quality assessment. The cations include metals present in non trace quantities such as calcium, magnesium, potassium and sodium. Many of these ions are major contributors to the overall salinity of groundwater. Extremely high concentrations of these species make water unfit for human consumption and for many industrial

uses. The health related problems are not as those caused by the other contaminant groups. However, high concentrations of even relatively non toxic salts, for example, sodium, can disrupt cell or blood chemistry with serious consequences.

The cations were dominated by sodium (Na), followed by K, Ca and Mg. This order of dominance is characteristic of groundwater in the brackish environment with high chloride (5630 – 5805 mg/l).

The nitrate-nitrogen level (1.48 – 4.01 mg/l) was low and fell within the regulatory limit of 10 mg/l for potable water. Higher concentrations can lead to Methaemoglobinemia (Blue Baby Syndrome) in infants, where the oxygen-carrying ability of the child's blood is severely reduced. The concentration of sulphate ranged from 56.5 – 75.5 mg/L. There are no health-related standards for sulphate. The WHO have set a limit 40mg/L for sulphate because water containing more than this amount has an unpleasant taste that makes it unsuitable for domestic use.

The volatile organic compounds (VOC's) benzene, ethylbenzene, toluene, and xylenes can have serious health effects if they are consumed in drinking water. Natural sources such as crude oil seeps are rare. Any detected amounts of these refined volatile organic chemicals most likely indicate groundwater contamination. VOC occurrences are not primarily controlled by bedrock geology, physiography, or major river watershed. Volatile organic compounds may be present in groundwater at very low concentrations. The laboratory results for the organic contaminants in the groundwater samples (i.e. Benzene, Ethylbenzene, Toluene, and Xylenes) were all below detectable limits of 0.001 mg/l.

Most of the heavy metals fell below regulatory limits, except for Fe, Pb and V which were slightly higher than the set limits especially during the dry season. The concentrations of V are generally higher in unfiltered water samples rather than in filtered samples, suggesting an association between these metals and suspended particulate material. **Iron** (Fe) is a naturally occurring metal that is widely present in groundwater. Iron can exist in either an oxidized (ferric) or reduced (ferrous) state. At normal groundwater pH values, ferric iron is rapidly precipitated as an iron oxide, iron hydroxide, iron oxyhydroxides (rust), or poorly crystalline to amorphous material. Under reduced conditions, however, ferrous iron is stable and will remain in groundwater. There are no serious health threats posed by Fe, but concentrations above the set limit may produce objectionable odour, taste, colour, staining, corrosion, and scaling.

Groundwater Microbiology

The population of total heterotrophic bacteria (THB) was high in the groundwater during the dry and wet seasons (Tables 4.9.4a and 4.9.4b). During the dry season, THB ranged from $2.0 - 6.8 \times 10^4$ cfu/ml with a mean of 4.3×10^4 cfu/ml. The result obtained during the wet season was similar to that of the dry season. It ranged from $4.7 - 5.8 \times 10^4$ cfu/ml with a mean of 5.2×10^4 cfu/ml. The control was within the same order, 3.5×10^4 cfu/ml. Hydrocarbon utilizing bacteria (HUB) during the dry season ranged from $0.4 - 1.0 \times 10^2$ cfu/ml with a mean of 0.7×10^2 cfu/ml. Thus, HUB accounted for nearly 1% of the heterotrophic population in both seasons, suggesting non pollution from petroleum sources. Predominant bacteria genera isolated from the study area include *Staphylococcus*, *Alcaligenes*, *Enterobacter*, *Citrobacter*, and *Micrococcus*.

The population of Total Fungi (TF) in the wet and dry seasons were in the order of 10^4 cfu/ml, whereas hydrocarbon utilizing fungi (HUF) was scanty and virtually absent in the dry season, but it is generally in the order of 10^2 cfu/ml in the wet season. Thus, HUB accounted for nearly 1% of the heterotrophic population in the wet season, suggesting non pollution from petroleum sources. Predominant fungal genera isolated from the study area include *Aspergillus* and *Penicillium*.

Total coliform in the dry season was in the range of 11 – 17 MPN/100ml with a mean of 14 MPN/100ml, while faecal coliform was in the range of 7 – 10 MPN/100ml. Total coliform was higher during the wet season, ranging from 18 – 20 MPN/100ml, while faecal coliform ranged from 9 – 11 MPN/100ml. The control borehole water had a total coliform population of 8 MPN/100ml and faecal coliform population of 3 MPN/100ml. WHO guidelines recommend that no faecal coliform should be present in drinking water sources.

Table 4.9.4a: Groundwater microbial population in the Dry season

| Code | THB 10^4 cfu/ml | HUB 10^2 cfu/ml | Most Predominant Bacterial Isolate | Total Coliform Count | Faecal coliform | TF 10^4 cfu/ml | HUF 10^2 cfu/ml | Most Predominant Fungal Isolate |
|------------|-------------------------|-------------------------|------------------------------------------------------------------------------------|-------------------------|--------------------|------------------------|-------------------------|---------------------------------------------------------------|
| | | | | MPN/100ml | MPN/100ml | | | |
| OTU GW1 | 3.7 | 0.7 | <i>Staphylococcus sp.</i> , <i>Staphylococcus sp.</i> , <i>Alcaligene sp</i> | 11 | 11 | 3.2 | 0.0 | <i>Aspergillus clavatus</i> <i>Aspergillus niger</i> , |
| OTU GW2 | 2.0 | 1.0 | <i>Micrococcus sp.</i> , <i>Enterobacter sp.</i> , <i>Bacillus sp</i> | 17 | 7 | 6.4 | 0.0 | <i>Penicillium sp</i> |
| OTU GW3 | 6.8 | 0.4 | <i>Staphylococcus sp</i> , <i>Bacillus sp.</i> , | 14 | 10 | 0.9 | 0.0 | <i>Aspergillus clavatus</i> |
| MIN | 2.0 | 0.4 | - | 11 | 7 | 0.9 | 0.0 | - |
| MAX | 6.8 | 1.0 | - | 17 | 11 | 6.4 | 0.0 | - |
| MEAN | 4.3 | 0.7 | - | 14 | 9.3 | 3.6 | 0.0 | - |

Table 4.9.4b: Groundwater microbial population in the wet season

| Code | THB 10^4 cfu/ml | HUB 10^2 cfu/ml | Most Predominant Bacterial Isolate | Total Coliform Count | Faecal coliform | TF 10^4 cfu/ml | HUF 10^2 cfu/ml | Most Predominant Fungal Isolate |
|------------------|-------------------------|-------------------------|-----------------------------------------------------------------------------------------------------------------------|-------------------------|--------------------|------------------------|-------------------------|-----------------------------------------------------------------------------------------|
| | | | | MPN/100ml | MPN/100ml | | | |
| OTU BHW C1 | 3.5 | 1.0 | <i>Staphylococcus sp.</i> , <i>Bacillus sp.</i> , <i>Proteus sp.</i> | 8 | 3 | 0.5 | 0.0 | <i>Penicillium sp.</i> , <i>Aspergillus niger</i> , <i>Aspergillus clavatus</i> , |
| GW 1 | 4.7 | 1.2 | <i>Bacillus sp.</i> , <i>Pseudomonas sp.</i> , <i>Micrococcus sp</i> | 20 | 10 | 0.9 | 0.3 | <i>Penicillium sp.</i> , <i>Aspergillus niger</i> , |
| GW 2 | 5.8 | 1.8 | <i>Staphylococcus sp.</i> , <i>Bacillus sp</i> <i>Enterobacter aerogenes</i> | 18 | 9 | 0.4 | 0.0 | <i>Penicillium sp.</i> , <i>Aspergillus niger</i> , |
| GW 3 | 5.5 | 2.1 | <i>Alcaligenes sp.</i> , <i>Bacillus sp.</i> , <i>Staphylococcus sp.</i> , <i>Citrobacter freundii.</i> | 20 | 11 | 5.8 | 0.5 | |
| MIN | 3.5 | 1.0 | - | 8 | 9 | 0.4 | 0.0 | - |
| MAX | 6.3 | 2.1 | - | 20 | 11 | 5.8 | 0.5 | - |

| Code | THB 10 ⁴ cfu/ml | HUB 10 ² cfu/ml | Most Predominant Bacterial Isolate | Total Coliform Count | Faecal coliform | TF 10 ⁴ cfu/ml | HUF 10 ² cfu/ml | Most Predominant Fungal Isolate |
|------|----------------------------------|----------------------------------|------------------------------------------|----------------------------|--------------------|---------------------------------|----------------------------------|------------------------------------|
| | | | | MPN/100ml | MPN/100ml | | | |
| MEAN | 5.2 | 1.4 | | 16 | 10 | 2.2 | 0.2 | |

4.10 Description of the Socioeconomic Environment

Project Location, Stakeholder Communities and Settlement Patterns

Ugborodo, Ugboegungun and Deghele are the three host communities of the proposed Otumara AGS Project. These communities are located geographically to the north, northwest and east respectively in a distance of no less than 8km away from the project site. Under these communities however, are subsumed several satellite settlements which owe allegiance to the host communities. These include Agogboro, Otumara camps, Aruton, Agokutu, Ugbogbeleneji, Okitimekpe (Ogborodo), Obe Ugborodo, Ugborodo Camp and Ubagboro. With the exception of a few migrants of Yoruba, Ilaje, Urhobo, Isoko and Ijaw origin living along dotted settlements in the area, the Itsekiris are the landowners and major ethnic group in the project environment.

Religion, Customs, Belief Systems and Heritage

There is an overwhelming affiliation (81%) to Christianity by the sampled respondents of the Otumara Field communities. The remainder 19% laid claim to the practice of the African Traditional Religion (ATR). The reality on ground however, is that traditional worship is rooted in the culture of the communities and even acclaimed Christians participate in the festivals at different levels of commitment. Consequently, virtually all communities in the study area have communal deities and shrines, sacred bushes, sacred streams and waters (see Table 4.10.1). 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, practised in each community. These annual festivals are considered important for warding off evil, promoting fertility in marriages and profitable enterprise with fishing, farming and other activities. Sacred groves are located far away from the SPDC acquired land and none are likely to be defiled during the project execution phase of Otumara AG Solution project. Emotional and religious attachments forbid open discussions about some deities, their activities and abodes.

Table 4.10.1: List of common local deities and festivals in the Project communities

| Locations | Deities/sacred groves | Festivals |
|----------------|--------------------------------------------------------------------------|--------------------|
| Ugborodo | | Ise Festival |
| Deghele | Osankporo; Chief priest: Komama; sacred grove: Ugboosankporo, Agbokhoma. | Osankporo Festival |
| Otumara | Osaogun | |
| Ugbogbeleneji. | Omiresan | |

The major language groups and ethnic nationalities in Delta State are the Urhobo, Igbo (Anioma) Ijaw, Isoko and Itsekiri. Basically they have identical customs, beliefs and culture. This cultural identity is manifested in their festivals, traditional religion and marriage ceremonies while some of them claim common ancestry as many of the ethnic groups are said to have migrated from

Benin, the heart of the ancient Benin Empire. Their systems of traditional administration are similar, so are the folklore, dances, arts, crafts and mode of dressing.

Population and Socio-Demographic Characteristics

Population Size, Growth and Distribution

The 1991 census revealed that Delta State had a population of 2,590,491, made up of 1,271,932 males and 1,318,559 females, distributed into about 573,042 households. Encompassing a landmass or area of over 16,600 km²; this translates to an average density of 156 persons per km². When the population was projected forward at the recommended annual growth rate of 2.83%, the State's population was expected to be 3,158,066 in 1998, distributed among the now expanded 25 LGAs (NPC 1991, 1994, 1998; Delta State Statistical Year Book, 1999).

As the 2006 census now reveals, Delta State, like the nation Nigeria, has witnessed tremendous increase in her population; with a total population of 4,098,391, (4,112,445 in 2009 Delta State Statistical Year Book) Delta State ranks the 12th most populous State in the country and the 2nd most inhabited among the nine oil producing States that make up the Niger Delta Region. The population is also estimated to be growing at an annual growth rate of 3.2%, exactly as that of the entire country (FGN, Official Gazette, 2007).

Table 4.10.2: Population of the state and LGA

| COMMUNITY | 1991 | | | 1996 | 2006 | 2011 | 2016 |
|----------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| | Males | Females | Total | Total | Total | Total | Total |
| Warri South-West LGA | 17,172 | 16,202 | 33,374 | 38,371 | 116,538 | 136,416 | 159,685 |
| Delta State | 1,271,932 | 1,318,559 | 2,590,491 | 2,984,245 | 4,098,391 | 4,797,466 | 5,615,784 |

Source: NPC, 1991, 1998; Delta State Statistical Year Book 1999 and FGN Official Gazette, (2007). Projections at 3.2% annual exponential growth rate and base year is 1996)

The provisional census results released for the Country, States and LGAs (that of the enumeration areas/individual communities are yet to be published) also indicated that the constituent parts of the State have experienced growth in their populations. The Warri South-West LGA in which all the affected Otumara AGS project communities are located is now a densely inhabited area in Delta State. There were a total of 116,538 persons in the LGA in 2006, up from just 33,374 in 1991 (a 71.4% growth in 15 years or an annual growth rate of 4.8%). With the reconstitution of the LGAs and without any documented Government publication, it is difficult to say how many villages and towns actually make up the present Warri South-West LGA. The Warri South LGA with a landmass of 2036 square kilometre (sq.km.) had a population density of 116 persons per km². Much of the landmass by providence is actually made up of more water than land and hence available land for habitation in the area remains a challenge.

Table 4.10.3: Population of Otumara AGS Project Communities

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

(Source: NPC, 1991, 1994, 1998; Delta State Statistical Year Book 1999 and FGN Official Gazette, 2007) Projections at 3.2% annual exponential growth rate and base year is 1996)

Otumara project communities are characterized by inadequate land for habitation. Specifically, Ugborodo, Ugboegungun and Agogboro (Satellite community) had the largest number of persons while quite few persons inhabited Ugbogbeleneji satellite community. The Nigeria 2006 Census puts the population of the communities at 21,961 with males constituting 54% (11,954) and females 46% (10,007) but with a population growth rate of 3.2% the population figure is estimated to be about 26,905 comprising 56% (15,911) males and 44% (10,994) females as at 2012 (Table. 4.10.3). This suggests an increase in population of the study area with implications on increased demand on social amenities. As usual in the Niger Delta region it is noted that there are slightly more males than females. Sex ratio is the ratio of males to females in a given population, usually expressed as the number of males for every 100 females (Haupt and Kane, 2004).

Sex distribution of the population in the study environment reveals a male dominant structure in the ratio of approximately about 2:1. According to the 2006 population census, the males are more than the females, constituting 52.4 percent of the Warri South West LGA's population as opposed to the females' 47.6 percent. The sex structure of the LGA is also slightly higher than that of the state; the male-female ratio is almost equal at 50.6% males to 49.4% females, giving a sex ratio of 102.5, slightly lower than the Nigeria average of 105 (FGN Official Gazette, 2007). For every 100 females therefore, there are to be found only 103 males, i.e. 3 more males in Delta State. Surveys carried out in the course of the Niger Delta Master Plan development process show that there are actually more males (54%) than females (46%) in the Region.

Household Composition, Marital status and household size

About 81% of the communities' members are married while 10%, 8% and 1% are single, widowed and divorced respectively (Fig. 4.10.1). For the married, polygamy is a common

feature in the community as most men have between 2-4 wives. The low level of divorced household heads in the area is an indication that the indigenes valued marriage.

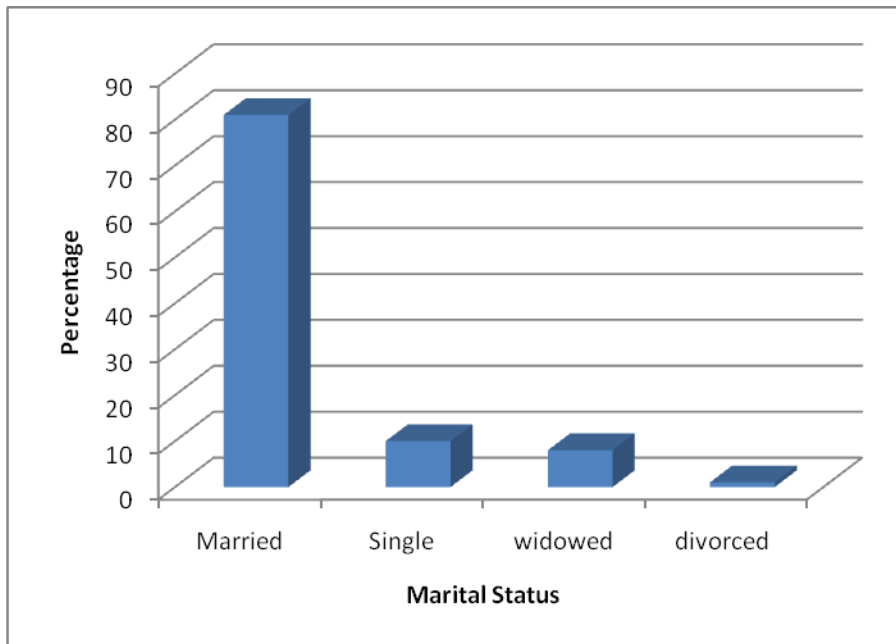


Fig. 4.10.1: Marital status of the Households in the study area.

The size of families differ from community to community, influenced in large measure by the cultural attitude of the people, economy of the settlement and educational status/awareness of the resident population amongst other factors. Field survey shows an average of 8 persons per dwelling unit with about 37% households having between 7 and 10 persons in a family. (Fig. 4.10.2).

A total of 3,919,364 households were enumerated during the preparation of the Niger Delta Regional Master Plan Development with an average household size of 7.46, but with more than 70% of them having an average of 8 occupants. Large households were found more prevalent in the rural areas (NDDC 2006).

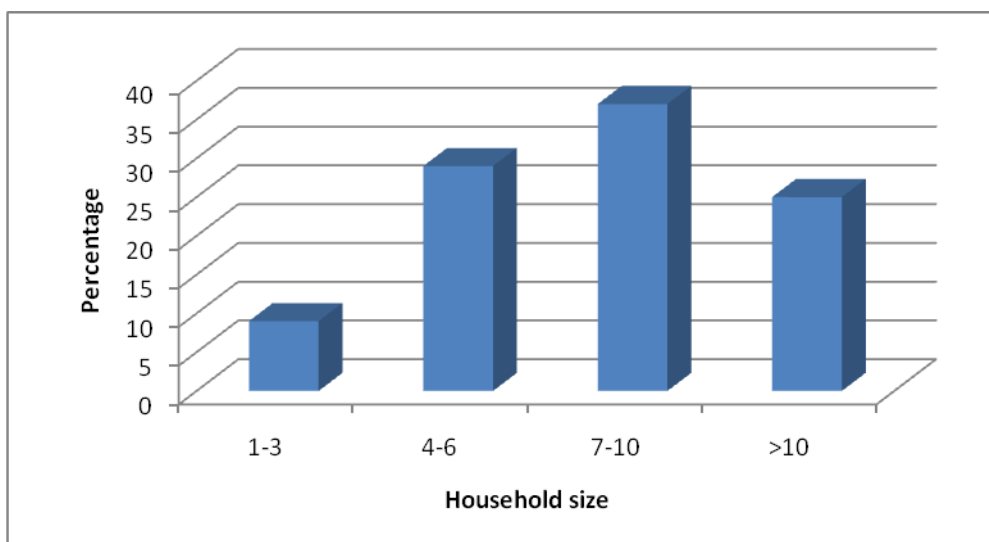


Fig. 4.10.2: Family size in surveyed Otumara community

Population structure: age/sex distribution

A majority of respondents at the Otumara settlement (75%) were adults aged 30 years and above (Fig. 4.10.3), although an appreciable proportion (21%) were also aged <30 years. Household age composition was observed to conform to the overall Delta State and Niger Delta and indeed Nigeria’s pyramidal structure. Population is rather overwhelmingly loaded from the lower age-cohorts with the bulk of the population made up of persons below 18 years old, effectively classified as children (NPC 2002). About 47.3% of the population is aged 0-14 years and another 48.6% are within the productive workforce of 15-64 years while those aged 65 years and above are fewest, constituting less than 4.1% (Fig. 4.10.4). The communities therefore, have a high dependency ratio typical of Delta State. Child dependency ratio (age group of 0-14 years) was found to be 31.23%, disaggregated into 16.37% (males) and 14.86% (females). The same source reported old age dependency (60 years and above) for both sex at 5.06% (Delta State Household Survey, 2006).

The overall implication of the age profile is that the population is young and growing and places a heavy burden on the adult population. More importantly, the State Government needs to commit more resources in the provision of socioeconomic infrastructure, particularly in the area of educational facilities as well as employment opportunities and other social welfare scheme required for the preparation of the dependent young population to become productive when they move into the productive age group.

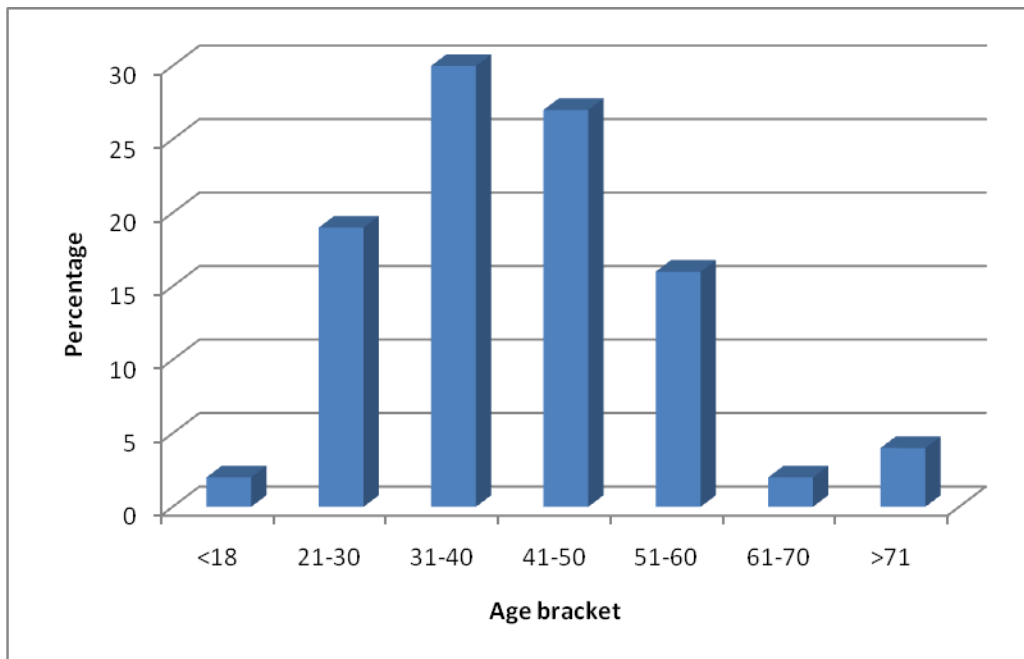


Fig. 4.10.3: Age Structure of sampled respondents at Otumara Community

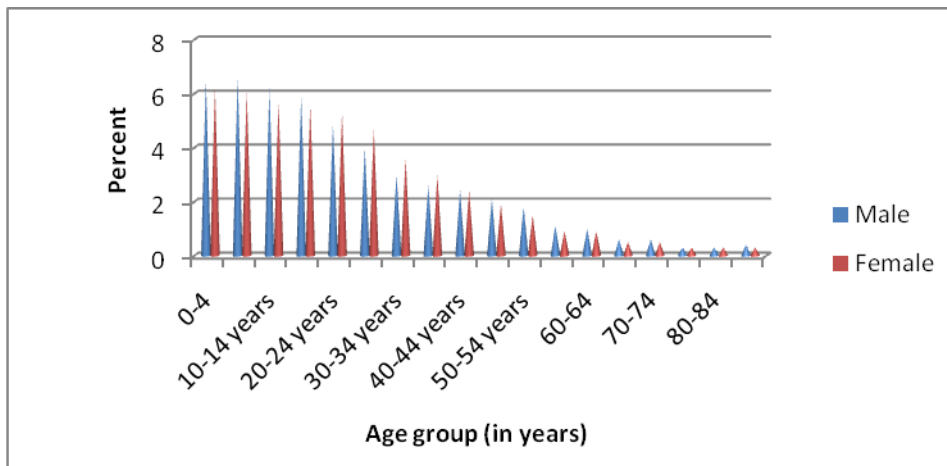


Fig. 4.10.4: Age-sex structure of Delta State population (2006)

Educational Attainment/ Literacy Level

Education is a key determinant of the lifestyle and societal status an individual enjoys. Studies have consistently shown that educational attainment has a strong effect on health behaviours and attitudes. An appreciable proportion of the sampled population has received some formal educational training indicating a satisfactory literate society. The modal educational attainment amongst the population in the communities is primary educational level. About 67% of the sampled population have post primary education and 10% have some forms of tertiary education. The low level of those with tertiary/post secondary education may be because of limited job opportunities in the past, coupled with limited access to the creeks due to water transportation problem and predominantly fishing occupation of the indigenes. About 5% reported having No Formal Education (NFE) and this is particular with the aged members of the communities and mostly those living in the fishing settlements (Fig. 4.10.5). This is commendable considering that educational facilities are relatively absent and not within easy reach of those desirous of this necessary service.

A structural classification of the educational statistics of Delta State according to 2006 Household Survey carried out by the Ministry of Economic Planning found 30% of respondents' children enrolled at the kindergarten (KG) level (0-5 years). The Warri Southwest recorded 30.4% in KG classes (37.5% males to 26.7% females). Also, 83% of school attendance was reported for children in primary schools (aged 6-11 years), up from 80% in 2003 survey. The male-female analyses also revealed no significant percentage difference; 82% to 84% male-female enrolment. Secondary school enrolment (12-17+ years) found 88% attendance (88% male to 89% female) with the Warri South West having the highest enrolment of 98%. At the tertiary level, 24% of children were found enrolled with more males (26%) attending schools than their female counterparts (23%).

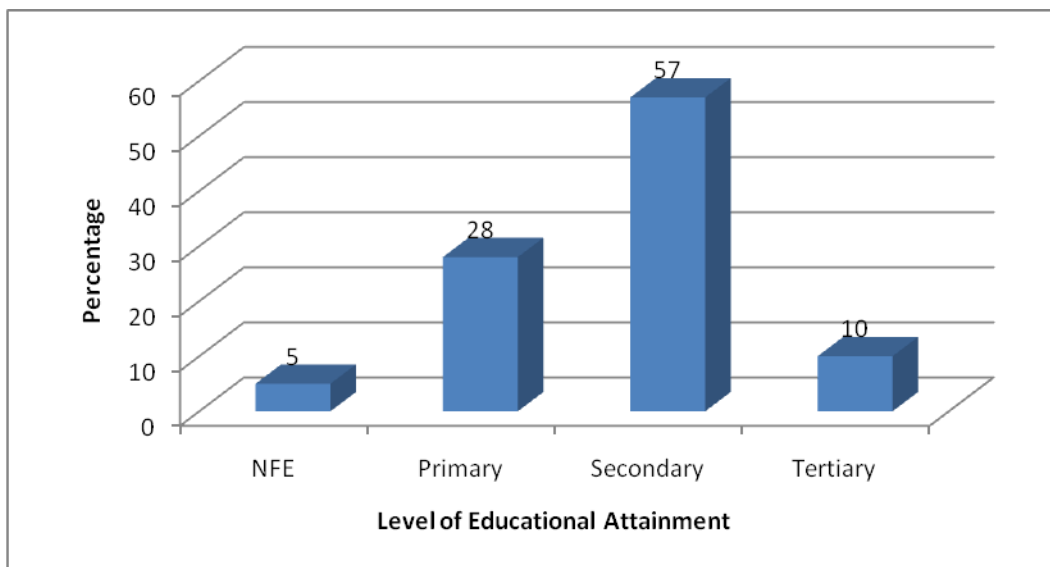


Fig. 4.10.5: Educational attainment of respondents

The literacy level of Delta State according to the 2006 Household Survey revealed that 91% of the young adults (15-29 years) were literate (92% males to 90% females). For the middle aged and elderly (30 years and above), the survey found 78% of this group literate, with an increase of 9% compared with 2003 household survey. Gender analysis indicated 83% for males as against 71% for the females. The overall adult literacy rate (15 years +) for the State was 84% with an increase of 16% when compared with 2003 survey which was 68%. There was no difference between the sexes at 87% each. Delta State has been long recognised as an educationally advantaged State as was confirmed by the Human Development Index (HDI) report of the UNDP (2006). The State's overall HDI of 0.615 was the highest in the Niger Delta and Educational Index of 0.636 came second only after that of Akwa Ibom (UNDP 2006; The Guardian of September 2, 2006). Statistical estimates have put the proportion of children attending primary school in the Niger Delta region at 80 per cent (which compares favourably with the estimated national average of 54 per cent) (UNDP 2006).

Institutional arrangements/ Community Leadership and Governance

Like most Nigerian communities, the governing system in the Otumara AGS Project communities is of two types; formal and traditional. At the formal level, the communities are subsumed under the Warri South-West LGA Council with headquarters in Ogbe-Ijoh. The traditional governing system is structured into hierarchies. At the clan level, the Olu of Warri Kingdom is the traditional head and paramount ruler of the Itsekiri ethnic nationality and all of the constituent villages and settlements that make up the clan. There are actually four clans in the LGA; Warri, Gbaramatu, Isaba and Ogbe-Ijoh. The LGA also has twenty (20) wards duly represented in the council administration.

At the individual Itsekiri villages/communities, there are about five (5) functional governance structures/organs (Fig. 4.10.6). There is the council of elders at the apex of community governance, made of the compound elders from the constituent quarters are at the helm of affairs. The oldest man of the council acts as chairman and is addressed as the '*Olare-Aja*'. Here, the principle of gerontocracy applies. Each community has also a functional executive, drawn from the constituent quarters of each of the communities called '*the trust body*'. The

Trust EXCO has a tenure of 4 years and is equivalent to the popularly known Community Development Council (CDC). The EXCO are in charge of the day-to-day administration of the community and reports to the council of elders, who are the custodian of the tradition and culture. There is also a vibrant youth council in each of the communities, which has a central organisation. Then there is the women body headed by women leaders and found to be very vocal within the study area. Of course, the chief priest (*Okparamale*) is also counted as part of the local administration for he is in charge of the tradition of the community (shrines and sacred places and festivals).

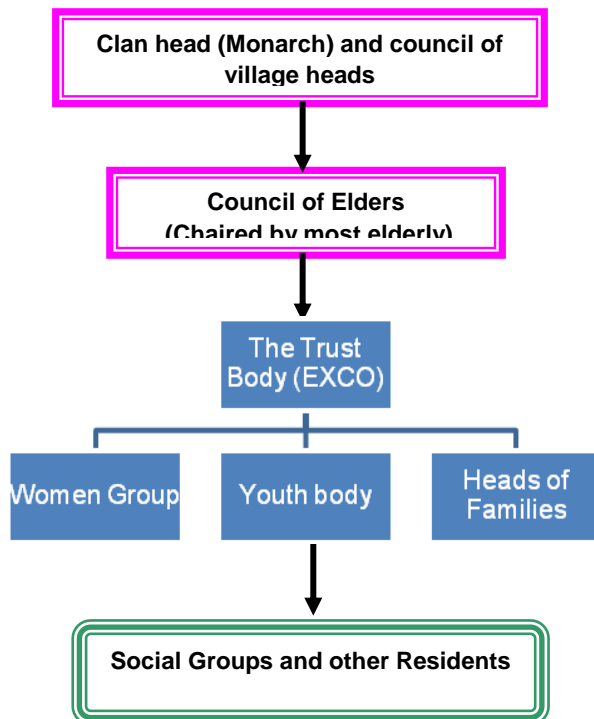


Fig. 4.10.6: Power Structure and Governance in Communities/Settlements

The communities' administrative organs play different roles in the day-to-day administration in the Otumara AGS project communities. The village council is at the apex of traditional governance in the communities and in collaboration with the CDC plays the key roles in community mobilization, decision-making and conflict resolution, including community development, advocacy and supervision of oil and gas matters in the area. The council of elders keeps an eye on the customs and tradition and peaceful coexistence of all, advisory in most matters and the women and youth carry out the various development agenda, while the enforcement of law and order rests with the youths.

The roles played by the elders, the Trust EXCO, Youth Council and women commonly overlap and vary slightly from one community to another, depending on the dynamism of transition from the previous dictatorial pattern of governance to a more democratic mode. As with most settlements in the Niger Delta, communities in the study area are in a process of transition from the past leadership style, whereby leadership was shrouded in secrecy and superstition to a more democratic indigenous political system based on representative participation, disclosure and the fair sharing of power.

Conflicts and Resolutions

Conflict is common in the Niger Delta region as a whole and in the study area as well. Types of conflict include:

- Conflict between communities and companies
- Conflict between communities
- Conflict within communities and
- Conflict between communities and government

Conflict in the Niger Delta generally as well as in the study area predates the advent of crude oil exploitation, most of which were related to issues of land ownership, especially of palm oil bearing land, quests for autonomy and struggles for leadership. However, conflict today is either directly caused by issues surrounding crude oil exploitation or fuelled by them. In other words, crises have been magnified by oil and gas exploitation in the Niger Delta over the years.

Causes of conflict between communities and companies include:

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

Before the late 1990s, the conflict resolution strategies of communities in the study area were through dialogue in special meetings summoned by the elders-in-council, council of chiefs, elders and chiefs assembly, religious leaders, juju priests, youth council and women groups. Issues could either be discussed at the lower levels of family, age grade and women or taken directly to the community leadership. In addition, appeals and summons are common processes utilized at community level. Issues are referred to the police and courts, when they are criminal offences that are mandatory to be reported and when the resolution of the conflict overwhelms community leadership. Conflict resolution at community level could attract penalties such as fines, seizures of assets and ostracisation.

The above conflict resolutions strategies came to halt however, beginning with the well-known Warri crisis of 1997 with the nomination of Ogidigben as Local Government Area headquarters of the Warri Southwest LGA. The Otumara Field communities and settlements were part of the Warri Crisis because of the ethnic colouration. The ethnic war created by this political miscalculation later led to the attacks and destruction of villages and properties, killing, maiming and disrupted travel on the waterways, as well as stopped oil production in the area for a long time. Although the violence abated somewhat when the local government headquarters relocated

to Ogbe-Ijoh in 1999, the area remained part of militancy in the he-days which combined with oil pilfering and theft (sabotage and illegal bunkering). The effects are still much around as several of the villages were deserted, destroyed or abandoned. The Otumara settlement also witnessed the series of crises; first in 1997 then, in 2001. The entire area had to be deserted. Strangely though, the SPDC's oil and gas assets (flowstation and gas plant) were untouched up to the time of their return in 2004. According to the settlers, the station was later awarded the "Golden Flowstation" because of the peaceful nature of the area. Ugbeogungun community also boasted of having remained intact all through the critical times. But Ugborodo was not so lucky; relics of destroyed properties can still be found in the community, most notably the community's market structures which were greatly affected (burnt down) and have crippled the usual trading activities up to this moment.



Plate 4.10.1: Destroyed market structures at Ugborodo

Although peace has returned and normal economic activities have resumed across the communities, very few people actually inhabit the settlements and communities and in most part only the vulnerable group; women and children and aged parents are the ones left behind while the youth and able-bodied members live outside, mostly in Warri. Most members come home during festive periods or when oil and gas activities bring some benefits to be shared or to be taken care of.

Livelihood and Micro-Economy of Project Area

Occupation and employment in project area

The occupational distribution (Fig. 4.10.7) of the people in the studied area reveals that majority (58%) were fisher folks, 10% were into trading while about 15 % were into crop farming as a major occupation. The findings suggest different occupation or income generating activities exist in the communities. Fishing is conducted along the surrounding creeks, Escravos River, slots/canals and deep into the Atlantic Ocean. Fish catch is seasonal and depends on tides. The major species caught include tilapia, scale fish, shrimps, crayfish, oysters. Crabs and periwinkles abound in the area, although these are not given much attention. Fishing implements are artisanal, yet quantities caught more than meet domestic requirements, hence there is a large scale trade in fish. It is widely claimed that implements are expensive. This is in line with the EIA SSAGG Project of 2003 which noted that fishing was the major occupation of community

members residing in the creeks of Niger Delta. Fishing techniques employed remains largely unchanged from the baseline condition and includes hooks, lines, cast nets, drag nets, sweep nets, fish traps and conical baskets.

Although by providence the area is not endowed with large arable lands to encourage large scale farming activities, the agricultural lands in the Project communities support plantain farming and other staple crops like cassava, melon, vegetables and maize. These crops are grown for home consumption and for sales in the market. Some forms of hunting are also carried out in the area by about 5% of the respondents and game hunted includes the antelopes, bush pig, iguana and alligator (wrongly identified as crocodile).

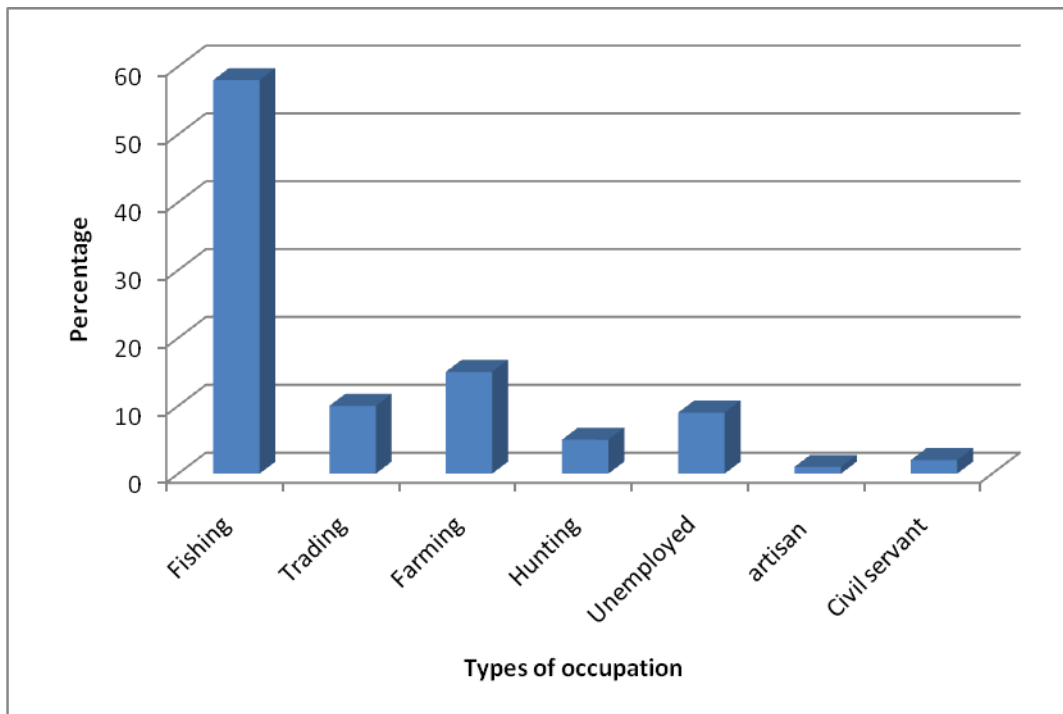


Fig. 4.10.7: Primary occupation of respondents in Otumara community

Trading is the third most important income-generating activity in the area, and in all cases, the females do more of the petty trading. Women marketers take their processed fisheries to Warri, Sapele, Koko and other major communities, where there are large markets for the disposal of the fisheries products and return with manufactured goods/articles. Some traders also come in from Warri to buy the agricultural produce, including fisheries and related products. A ready market for fisheries was also observed to be workers in the SPDC's facilities. A negligible proportion (1%) of the respondents were also observed to be engaged in crafts/service provision, especially those related to boat making and repairs, and boat engine servicing. Others include sale and mending of nets, weaving of traps and baskets, firewood collection for fish processing, fashion designing and hair-dressing. However, 9% of the household heads were not involved in any income generating activities and this is an indication of high level of employment in the project area.

Respondents appeared to be quite experienced in their occupation as shown in Table 4.10.4. About 51% had more than one decade experience in their jobs while about 11% had between 1

and 5 years of working experience. An interesting implication of this is that the individuals would be quite familiar with the challenges associated with their current economic activities.

Table 4.10.4: Working experience of respondents

| s/n | Experience (Years) | Percentage |
|--------------|--------------------|------------|
| 1 | Unemployed | 9 |
| 2 | 1-5 | 11.0 |
| 3 | 6-10 | 29.0 |
| 4 | 11-20 | 31.0 |
| 5 | 21-30 | 18.7 |
| 6 | >30 | 1.3 |
| Total | | 100 |



Plate 4.10.2: Fishing gears used in the Otumara study environment, bagged periwinkles

Income Level of Population

Income is an important variable that influences socio-economic status of individuals and its distribution pattern has the potential of influencing other demographic variables. However, personal income levels of self-employed rural households 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-endeavors.

Table 4.10.5 shows the weekly income distribution of the respondents based on the specific income generating activities common in the area. Most fishers (59.6%) in the area earn below N5,000 in a week while about 35% of the fishers earned between N5,000 and N10,000 in a week from fishing activities. In a similar vein, about 65% of the respondents who are engaged in farming earned less than N3,000.00 in a week while about 38% of those engaged in other income generating activities earned less than N5,000.00 weekly. Therefore on the average, weekly income to fishers, farmers and other income earners is estimated to be about N3,560.00,

N2,310.00 and N2,450.00 respectively. The low income levels in the study area were predicated on the stagnant rural economies, wherein indigenes depend mainly on low-technology-driven exploitation of natural resources at subsistence levels and with unsustainable practices.

Table 4.10.5: Income distribution of the respondents

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

Household Expenditure and Consumption Pattern and Savings

Quantitative information obtained on household expenditures and consumption profile of the resident population as expressed by heads of household revealed that 22% of the households spend between N2,500-N3,000 on their families on a weekly basis. Some 16% of the households spend between N1000 and N1,500 as weekly family expenses, while about 4% and 9% spend less than N500.00 and greater than N3,500.00 respectively weekly (Fig. 4.10.8). The expenditure pattern observed was consistent with what have been found as household spending priorities in other rural areas of the Niger Delta. Feeding was listed as the most important spending item (51%), while medicare was considered the least important item of expenditure of the households. Interestingly, the proportion of household income spent on communication and transport is over 20%; this may not be unconnected to the increasing use and popularity of mobile telecommunication among the people coupled with the high cost of transport fare associated with marine transport reported variously in the riverine communities of Niger Delta (Table 4.10.6).

Table 4.10.6: Expenditure Profile of households in the area

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

Even though there are no banking facilities in the area, the residents of the area have engaged in some forms of saving using local institutions. Specifically about 34.6% of the respondents reported to have been saving portions of their income with local thrift institutions and cooperative societies where they are members. The average annual savings is reported to be between N10,000 and N20,000 in a year (Fig. 4.10.9). There are a number of unregistered social groups, trade associations and cooperative societies in the surveyed communities. At least one active and registered co-operative group was reported at Otumara settlement: Otumara Agro-Allied Multipurpose Co-operative Society Limited, with registration number 828. The Cooperatives perform mostly thrift, and multipurpose functions. The pool of funds from members is available in large sum at specified period. This is often invested in business for expansion. The societies in addition to providing cash also distribute equipment relevant to the vocation of members, and supervise marketing activities.

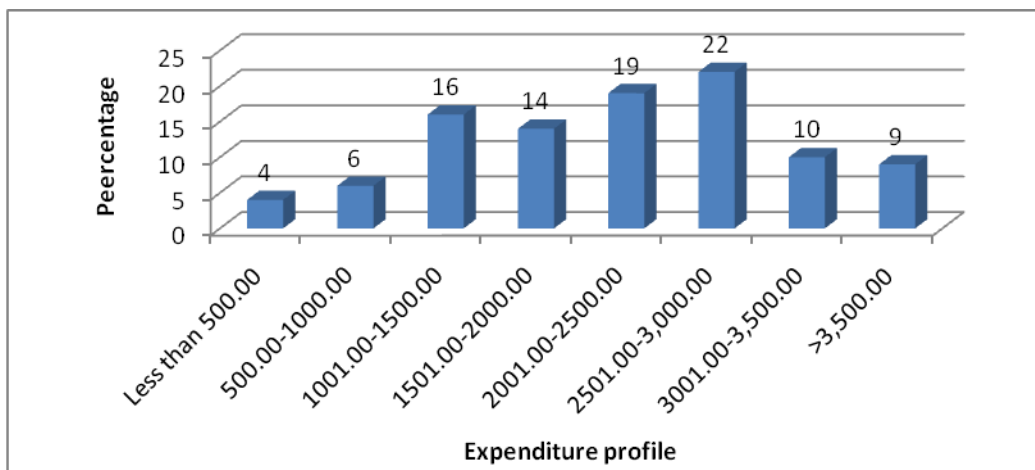


Fig. 4.10.8: Weekly expenditure profile of families in surveyed Otumara community

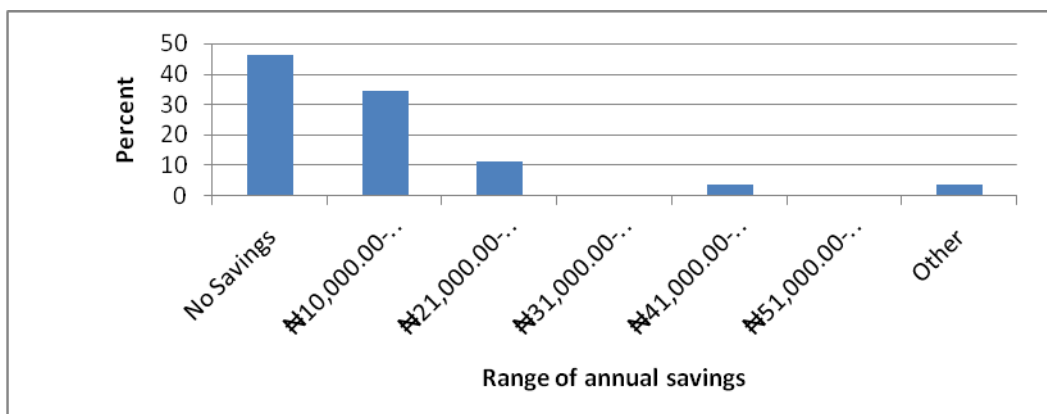


Fig. 4.10.9: Annual savings of respondents

Natural Resource Acquisition, Ownership and Management

Land Ownership, Tenure, Use and Management

There is limited land in the Otumara project area due mainly to the presence of many water-bodies leaving very limited land space either for habitation or cultivation. Dry lands are scarce and many of the settlements are hemmed in by water, making community expansion difficult. Consequently, the land available is very valuable to the communities. Two forms of land ownership are common in the area under study, namely, family and communal land ownership.

By historical antecedents, the mainland permanent communities own lands that fall within their territory while the “temporary smaller fishing ports/camps” also belong to the parent communities, and those dwelling in them and carrying out some form of economic activity on the “land” owe allegiance to the community and “pay nominal fees or rent” to the land-owning community as the case may be. In the Otumara Flowstation/Gas Plant operational areas, the issue of land is exclusively that of Ugborodo, Ugbeogungun and Deghele and thus, inhabitants of Otumara settlement, Agor and such farming and fishing settlements in the area owe allegiance to the three. While the communities own most of the land, individuals and families own the land on which they have built their residence. The family lands are held in perpetuity and under traditional titles that allow for them to be transferred from one generation to another. In other words, the transfer of land ownership is mainly by inheritance.

Responses from administered questionnaires confirmed nature of landownership to be through family inheritance; approximately 96% claimed to have personal land as opposed to 4% that claimed communal landownership. Majority of landowners (78.6%) have pieces of land measuring 0-1 hectares (ha). Some 10.7% of respondents have lands of the size 6-7 ha while the remainder 10.7% also have lands measuring between 2 and 5 ha (Fig. 4.10.10).

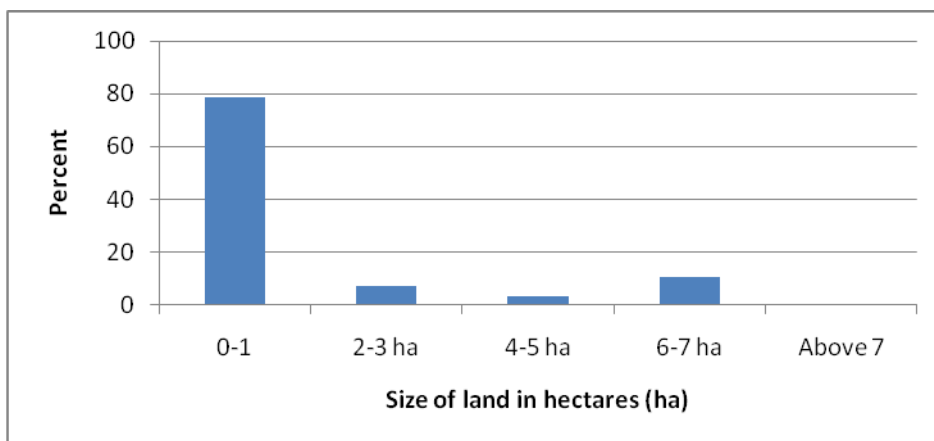


Fig. 4.10.10: Size of land owned by respondents

Natural Resources and Land Use

Forests and swamps provide households in the Project Footprint with important livelihood resources. Non-timber products are used for food, as poles for building or for making fish traps and for herbalism. The forest areas serve as important sources of soft and hard wood and provide income for those engaged in the logging trade. The forests also provide ready source of income for hunters. Abundant swamps provide a rich source of shellfish and snails and mangrove tree. These economic trees produce resins and dyes that can be useful in textile manufacture for both local and international markets. Canoe building, which is extensively carried out in the region thrives on the basis of these trees found in the forest. Plantain cultivation is produced on dredge spoils. As a result of its extensive cultivation, it has become a major source of income and food for the inhabitants. Despite the fact that this area has been proposed as a protected forest, lumbering and indiscriminate felling of trees for fuel purposes are depleting the forest. Generally communal land and natural resources overlap and it is difficult to determine precisely the boundaries of any individual settlement’s communal land.

Socio-Economic Infrastructures/Amenities and Quality of Life

Nigerian rural areas are noted for lack of basic and necessary social amenities. In the areas where some infrastructures can be found, these usually have low capacity, either non-functional or are in deplorable conditions requiring some form of rehabilitation. Field studies show that the population in the Otumara AGS Project communities generally lack basic infrastructures and amenities; educational institutions are inadequate, no reliable potable water, access to primary health care services, electricity and even transport means to access the communities and settlements are lacking. While the government's patronage in the area has been low, the efforts of the oil and gas operating companies, particularly that of SPDC and Chevron Nigeria Limited (CNL) have made significant contributions to infrastructural development in the area (Table 4.10.9).

Educational Facilities

Communities in the study area are however, poorly endowed with educational institutions. There are three (3) public primary schools distributed among the 3 permanent communities in the area located at Ugborodo, Ugbeogungun and Deghele respectively. There are no educational institutions in Otumara settlement nor in any of the farming and fishing settlements; children and wards attend school at either the nearest permanent communities or at mainland towns of Warri and Sapele. Recent and renovated structures of the primary schools at Ugbeogungun and Ugborodo were provided by the State government through the Delta State Oil Producing Area Development Commission (DELSOPADEC). However, the older structures were built by the SPDC and Chevron respectively (Plates 4.10.3 and 4.10.4). Housing, i.e., accommodation for the teachers are also provided at Ugbeogungun, although these were observed to be fast deteriorating and may need rehabilitation.

There is no single post primary institution (secondary school) in the Otumara field studied communities. This has created problems for children of secondary school age. Children at Ugborodo pay as much as N500-1000 on school days (N15,000 monthly) as transport fare to be able to access the school located at Ogidigben, the nearest neighbour but separated by the physical barrier of the Escravos River Estuary. Generally however, children of secondary school age travel to towns and cities such as Warri and Sapele to achieve secondary education.



Plate 4.10.3: Sign post showing Otseyen Primary School, Ugbeogungun



Plate 4.10.4: Primary school structures for the Ekperi Primary School, Ugborodo Community

Electricity Supply

Ugborodo in the Otumara AGS Project area is the only community that has access to regular electricity supply from the Chevron's tank-farm facilities in addition to a standby giant generator that provides electricity to the population (Plate 4.10.5). Ugbeogungun community have limited access to electricity supply via two giant generators provided by the SPDC and DESOPADEC respectively. As at the time of study however, one of the generators was no longer functional (that of the SPDC-sponsored) but both fuelling and maintenance cost of the functional generator are borne by the SPDC (Plate 4.10.5).



Plate 4.10.5: Two giant generators supplied by SPDC and DESOPADEC at Ugbeogungun community

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

Transportation and Communication

Surrounded by water, the project area is only accessible through water; transportation is through hand-dug canoes (by residents in the villages/fishing camps for inter/intra community movement) and the popular fibre or outboard engine boats. Transportation of agricultural products, including processed fisheries, and other bulky items are undertaken by the cargo boats which travel at lower speeds and also charge lower fares (Plate 4.10.6). The project area can be accessed from Warri, Sapele and Koko. Marine transport to the project area communities and other proximate villages can therefore be cumbersome, risky and costly; travel time varies from

about an hour to more than 1½ hours depending on the location of the community within the area.

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

Although good landing jetties are as important to marine transport as parks and bus stops for land transport, most communities have no functional concrete landing jetties. Only Ugbeogungun community has a concrete jetty (Plate 4.10.6) while wooden jetties are commonly used in the other settlements and communities in the area.

Access to public communication facilities like the telephone and postal services in the communities was also found to be greatly limited. The new mode of telephony, the GSM common to most Nigerian communities was found to be less effective in the study area. Depending on one's location, connectivity is limited to one of the three networks of MTN, Airtel and Globacom.



Plate 4.10.6: Boat and concrete jetties at Ugbeogungun community

Civic Gathering Places, Recreational Facilities, Security and Safety

The Otumara AGS project communities are much organised, social and hospitable. There are therefore, available in the permanent communities' places for community meetings and social events. Ugbeogungun and Ugborodo were found to have town halls built by the SPDC and CNL respectively (Plate 4.10.7). Most of the fishing settlements and communities in the area use improvised structures and places to receive visitors. For example, in the Otumara settlement, communal gatherings and meetings are held in the improvised building belonging to the Agro-allied Cooperative Society. Communal activities such as football, dancing, masquerade displays, etc. are organized for recreation during festive periods in the studied communities. Common recreational activities among youngsters include football and playing of snooker games, found common at the Otumara settlement. Several drinking parlours and local restaurants also abound in the communities.

The study area was acclaimed to be generally very peaceful until the inter-communal crisis of the late 90s which devastated the communities. During that crisis, the few social and infrastructural facilities available were damaged. Lives and property were lost and the result was destitution.

Presently, the communities have managed to resettle and resume their normal activities. Occasional fears are still being entertained because of the sporadic nature of attack in the Niger Delta generally. The reported social vice in the area include: piracy, pipeline vandalism, petty stealing and prostitution.



Plate 4.10.7: Modern Town Halls for Ugbeogungun and Ugborodo communities

Water Supply facilities

Potable water is available in Ugborodo, Ugbeogungun, Deghele settlement and Ubegelemeji only. The first two communities are connected to the reticulation water facilities of Chevron Nigeria Limited (CNL) from the tank-farm. The population at the Otumara settlement sources water from SPDC's water facility, with points located by the facility's fence, close to the military sentry. Noticeable irregularity in supply was also observed as many receptacles/containers were left behind by households at the tap unfilled. Also, rain water harvesting appears to be common, indicating reliance on this water source (Plate 4.10.8). In fact, an overwhelming majority (96%) acknowledged this as source of water supply. Inhabitants in other settlements and communities in the area are forced to drink water fetched from the rivers and other sources that are not entirely potable. Settlers often besiege oil installations to fetch drinking water, while most indigenes have sunk wells from where they obtain drinking water.

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

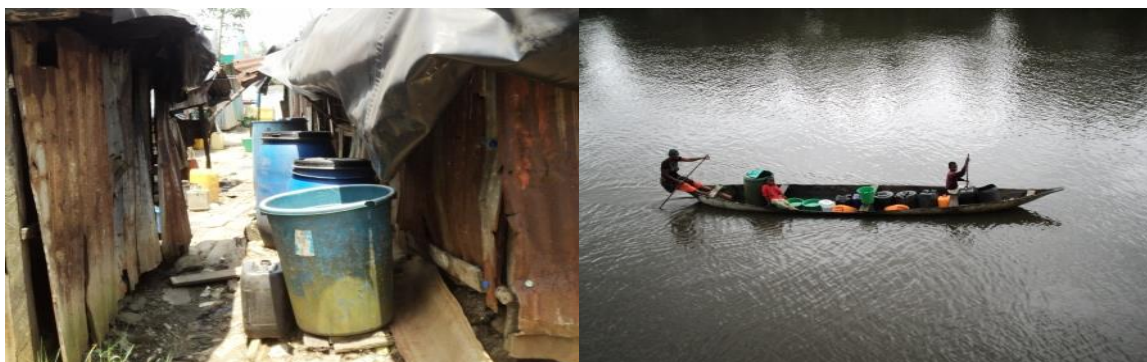


Plate 4.10.8: Water receptacle for rain water harvesting. Community members travelling long distance to fetch water in jerrycans

Health Care Facilities

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

Housing Types and Ownership

Many houses in the study area except at Ugbeogungun were destroyed during the Ijaw/Itsekiri inter-ethnic clashes. Virtually all the structures, including houses were either burnt down or destroyed. In the permanent communities, public housing are not available until recently when DESOPADEC and CNL's-Community development strategy led to the housing projects being undertaken by the Itsekiri Regional Development Council (RDC). Common private living housing types are constructed mostly of brick walls and corrugated zinc roofing (Ugbeogungun mostly) with several also built with unreliable materials such as reeds, thatch and wood/planks (Plate 4.10.9, Plate 4.10.10 and Plate 4.10.11).

Housing structures in the Otumara settlement and other fishing and farming settlements in the area are mainly built with ephemeral forest materials, e.g. raffia palm fronds, bamboos and plank/wood, with modal roofing materials being of thatched materials and a few roofed with zinc. Over a third (38.5%) of surveyed respondents own and live in houses constructed of wood wall and has zinc roofing. Some 23.1% prefer to describe their housing as 'other' while equal percentages of the respondents own and live in houses made of mud with thatch roofing (wattle and daub type) and those of block with zinc roofing respectively (Fig. 4.10.11).



Plate 4.10.9: Modern housing in Ugborodo constructed by NDDC and RDC



Plate 4.10.10: Typical housing in Otumara AGS community



Plate 4.10.11: Private modern Housing in Ugbeogungun

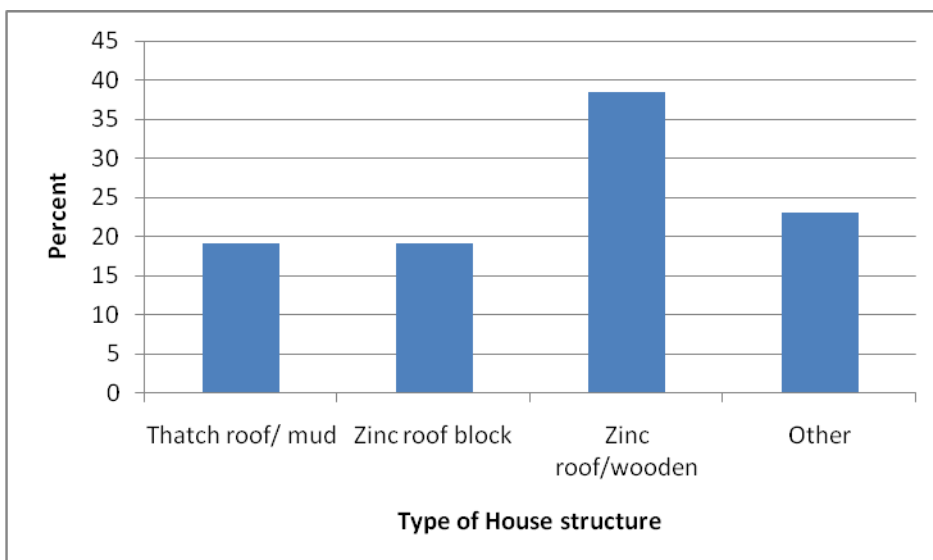


Fig. 4.10.11: Housing ownership and type in Otumara community

Table 4.10.7: Status of Infrastructural Amenities and Quality of Life in Otumara AGG Solution Project Communities

| Settlement/Community | Education | Energy/Electricity | Transportation/Jetty/Communication | Water and Sanitation | Health | Housing/Recreation/Market/Others |
|-------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Otumara settlement/community | <ul style="list-style-type: none"> ▪ Settlement has no public or private primary and secondary schools within domain ▪ Children and wards attend school outside the immediate environment, mostly in Warri, Sapele and Koko. | <ul style="list-style-type: none"> ▪ Community not connected to any national grid. ▪ Few individuals have privately-operated generators for energy supply. ▪ Majority uses the local hurricane lanterns for illumination | <ul style="list-style-type: none"> ▪ Access to community is through HP-operated fibre boats and local hand-pulled dug-out canoes. ▪ No concrete landing jetty; population uses several wooden jetties. ▪ Transport cost very exorbitant; about N1,500-N2,000 to and from Warri and charter N50,000 | <ul style="list-style-type: none"> ▪ Source of water for population is SPD's provided potable water from F/S but fetching points are close to military; complaints about harassment common. | <ul style="list-style-type: none"> ▪ There is no primary health care (PHC) facility within immediate domain of community. ▪ Population travel to Warri and other mainland towns for medical treatment but emergency medical care provided at nearby SPDC's facility. ▪ High alcoholic consumption and drug use (marijuana). | <ul style="list-style-type: none"> ▪ Housing typically rural and riverine; houses built with unreliable ephemeral materials such as reeds and thatch. ▪ Over-crowding and poor ventilation an obvious problem; an average occupancy of 5 persons per hut (house) of one/ two small rooms. ▪ Local restaurants, drinking parlours abound and snooker for recreation also available. |
| Ugbeogungun | <ul style="list-style-type: none"> ▪ Community has a primary school; Otseyen Primary School, founded in 1989. ▪ Two blocks of 9-classrooms with 2 offices on ground; school have 150 pupils enrolled and 6 teachers. Both pupils and teachers' desks and chairs/tables needed ▪ Two (2) blocks of 5 flats as teachers quarters provide accommodation for teachers | <ul style="list-style-type: none"> ▪ Not connected to the national grid of PHCN. ▪ Electricity supplied by means of two generators, provided by both SPDC and DESOPADEC (one is non-functional) and diesel for fuelling supply and maintenance taken care of by SPDC. ▪ Electricity provided only at night ▪ Private generators and | <ul style="list-style-type: none"> ▪ Community accessible via water, using engine-powered fibre boats and local canoes. ▪ Concrete jetty built by Chevron available ▪ Access to modern GSM telephony is erratic as network connectivity limited | <ul style="list-style-type: none"> ▪ Population has access to potable water supply provided directly from Chevron's Tank-farm facilities. | <ul style="list-style-type: none"> ▪ Community has no PHC; access to primary health care services limited. ▪ Nearest health care facility sponsored by CNL and located at Madangho, Escravos Beach burnt down during communal lashes in 1999. ▪ Population seeks medical treatment from local | <ul style="list-style-type: none"> ▪ Housing types consists of brick/zinc type (dominant) with a few constructed of ephemeral materials (thatch and planks and zinc). ▪ Community has a Town Hall for communal meetings and other civic/social gatherings provided by SPDC. ▪ Marketing structures built by SPDC long ago on ground but presently unused/under-utilised |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| Settlement/ Community | Education | Energy/Electricity | Transportation/Jetty/ Communication | Water and Sanitation | Health | Housing/Recreation/Market/ Others |
|--------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | <ul style="list-style-type: none"> Community does not have a secondary school; children attend at Warri and other upland communities. | <ul style="list-style-type: none"> local hurricane lanterns used for illumination. Wood fuel also used as alternative source of energy for cooking. | | | <ul style="list-style-type: none"> chemists, traditional medicine healers and hospitals located in Warri. | |
| Ugborodo | <ul style="list-style-type: none"> Ugborodo community has a public primary school; Ekperi Primary School founded in 1954 and located at Aruntun axis of community. School buildings greatly enhanced/built by Chevron and pupil enrolment >200. Community has no public secondary school; children attend at Ogidigben across the Escravos River Estuary or travel to Warri, Sapele and Koko to achieve secondary education. Private nursery/primary and secondary school available in community. | <ul style="list-style-type: none"> Population has access to electricity; community connected to CNL's system. Fuel-wood energy for cooking | <ul style="list-style-type: none"> Community also accessible via water only using outboard engine boats. Cost of travel very high; N1,500-N1,800 per trip. No concrete landing jetty; improvised wooden structures as jetties Modern GSM telephony available through two of the networks (MTN and Airtel) but connectivity problematic | <ul style="list-style-type: none"> Potable has access to potable water supply; population sources water from Chevron-sponsored water system. Pier toilets common sewerage system | <ul style="list-style-type: none"> Two functional health care facilities in the area; patients also travel to Warri to seek medical attention but self medication and traditional medication common. Nearest health facility provided by CNL at Madangho long destroyed by Company's River Boat Clinic (RBC) provides some primary health care services every 2 weeks. Deliveries undertaken mostly by TBAs and complicated cases taken to Warri. | <ul style="list-style-type: none"> Most houses also destroyed during last Ijaw/Itsekiri crisis. Housing characteristically rural and riverine, constructed of ephemeral materials. Some new housing units of concrete and corrugated zinc have been built under CNL-Community's Itsekiri Regional Development Council (RDC) and DESOPADCE respectively. Restaurants, drinking parlours and snooker games abound as well as playing of football for recreation. Community has a Town Hall; first built by Gulf, predecessor of Chevron and recently renovated for use. Marketing structures suffered serious destruction from Ijaw-Itsekiri communal crises, have affected trading activities. |
| Deghele | <ul style="list-style-type: none"> Community also has a public primary school within domain; | <ul style="list-style-type: none"> Deghele is also not connected to any national grid so has no | <ul style="list-style-type: none"> Community is accessible through water on engine- | <ul style="list-style-type: none"> Access to potable water is also limited; population | <ul style="list-style-type: none"> One PHC to service the entire area; thus the | <ul style="list-style-type: none"> Deghele also suffered seriously from the Ijaw/Itsekiri crisis; most |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| Settlement/ Community | Education | Energy/Electricity | Transportation/Jetty/ Communication | Water and Sanitation | Health | Housing/Recreation/Market/ Others |
|--------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | <p>Iye Primary School, founded in 1954.</p> <ul style="list-style-type: none"> ▪ Deghele has no post primary school within its domain; children attend school at Warri, Koko and Sapele. | <p>access to electricity.</p> <ul style="list-style-type: none"> ▪ Population uses local hurricane lanterns and fuel-wood for cooking. | <p>powered boats and hand-dug-canoes.</p> <ul style="list-style-type: none"> ▪ Population has limited access to modern GSM telephony as connectivity is erratic. | <p>sources water from freshwater creeks and shallow hand-dug wells.</p> | <p>population has limited access to modern health care services; the sick usually travel to Warri and other mainland towns to get help</p> | <p>houses were burnt down.</p> <ul style="list-style-type: none"> ▪ Housing type is mostly of stilts, bamboo, thatch and zinc. ▪ The Gbogbodu market in Deghele has been burnt down |

Lifestyle and Social Vices

Alcohol and Drug Use

Based on the opinion of key informants, about 87% of the community members drink alcohol especially local dry gin and about 55% of the young male smoke cigarettes. Alcoholism has become a lifestyle in the community as well as smoking of cigarettes, Indian hemp especially among the youths. It is common to see youths smoking and drinking strong beverages opening in the public places.

Discrimination against Women

Some community members interviewed reported some level of discrimination against women, especially with respect to no inheritance rights to land/buildings. However, they are allowed to contest or hold some political positions. The observation at the community level was that women leadership role is expressed within women groups. Only few respondents agreed (34%) that women are indeed given the freedom to contest political positions. Some community members interviewed noted that women do not wield real power at the community level.

Child Labour

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

Sex Trade (Prostitution)

As in the case of other Niger Delta communities, there is a high rate of prostitution in the communities probably due to poverty and hunger or high sexual appetite of the sexually active youths of the area. It is also widely believed that people living in the coastal areas have high sexual appetite; it is still subject to debate.

Crime Rate and anti-social activities

The level of crime is moderately high. The commonest crime in the area is crude oil theft. Across the Otumara AGS Project communities, the lack of employment opportunities for the teeming youth members was a constant complaint. Statistically, approximately 90% of respondents confirmed this as the most challenging social problems in the area, which is representative of the human landscape. The number of youths observed to hanging around the Otumara facilities attested to the prevalence of the problem. Lack of gainful employment can effectively account for youth delinquency and other anti-social activities such as the rampant stealing and illegal bunkering activities in the area. It was therefore, not surprising that some youth members were very aggressive towards the study team.

Domestic/Motor Vehicle Accident

Motor accident is not a problem in the study communities due to lack of road transport system. However, accidents do occur at home due to their dilapidated and make-shift houses and from fish processing, fishing gears, firewood cutting and due to improper, unsanitary waste

management practices and improper housekeeping. Accidents also occur due to boat mishap and fuel explosion.

Physically Challenged People

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

Perceptions, concerns and social needs/expectations of the population

Interaction with the population in the Otumara Field project environment during Focus Group Discussions (FGDs) revealed a mix of perceptions on how the operations of SPDC have impacted the human and physical environments. The people perceived that the following have occurred since oil and gas development activities intensified in the area:

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

Perceptions of impacts of proposed AGS Project activities

The general population in the Otumara AG Solution project area has a mixed outlook on the proposed project. While many perceived the potential impacts of the project in the negative light, a few were hopeful that increased employment opportunities and social infrastructural development could accrue from the increased development activities if properly executed and these will more than compensate for the negative impacts.

Majority of the population (85%) in the project area fear that the proposed project activities shall impact on the livelihood system in more ways than one. These shall include damage to their agricultural land (31%), pollution of fishing grounds (28%) and loss of residential homes (26%). About one-tenth (14%) also fear that noise nuisance shall increase during project implementation and further impact on their health (Fig. 10.20).

Table 4.10.8: Perceived Fears entertained by respondents about proposed project

| People's perceived fears | Percentage of response |
|------------------------------|------------------------|
| Damage to agricultural land | 31.0 |
| Pollution of fishing grounds | 28.0 |
| Loss of residential homes | 26.0 |
| Noise nuisance | 14 |
| Damage to cultural site | 1 |
| Total | 100 |

Community Expectations and needs on proposed AG Solution Project Development

Community members in the Otumara area have high expectations regarding the proposed AGS project activities with particular reference to the associated benefits and/or positive effects; overall social issues, including increased and more permanent employment opportunities to indigenes at the skilled, semi-skilled and unskilled levels as company's operations enlarges and as opportunities emerge, economic empowerment of youth and women group through skills training/acquisition and micro-credit programs; vendor services/minor supplies (contractor), compensation for resource losses, scholarships and provision of infrastructures, e.g., educational, health, electricity, water, among others are expectations of the communities. Statistically, all of the positive expectations have equal weight by respondents at the Otumara settlement (Fig. 4.10.21). The individual community expectations and needs are as set out in the table below.

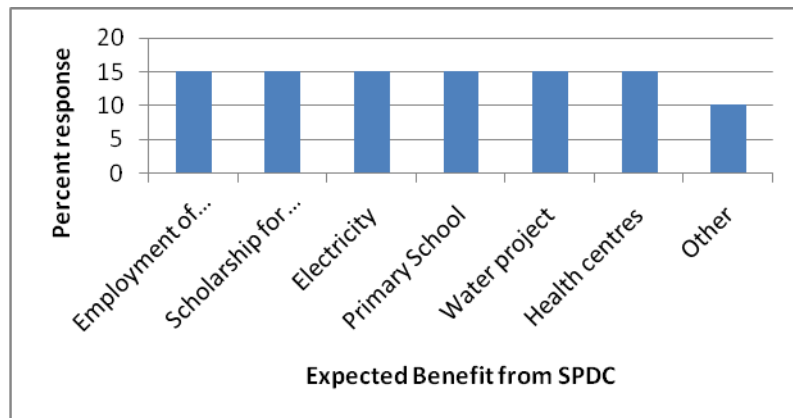


Fig. 4.10.12: Benefits expected from SPDC's AGG Solution Project

Table 4.10.9: Expectations and Priority Needs of SPDC's Otumara AGG Solution Project Communities

| Communities and Settlements | Needs/Demands and Expectations |
|-----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Otumara | <ul style="list-style-type: none"> • Women group particular about provision of health care facility • Relocation to better place with requisite amenities • Potable water, primary school, electricity, toilet facilities. |
| Ugbeogungun | <ul style="list-style-type: none"> • SPDC has promised community several things in time past and yet unfilled including: • Community facing subsidence and most times subject to flooding, hence need sand-filling and shoreline protection/embarkment • Access to and out of community is via creeks, now seriously silted up; dredging to make for easier navigation needed • Direct electricity connection from SPDC's flowstation |

| Communities and Settlements | Needs/Demands and Expectations |
|-----------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | <ul style="list-style-type: none"> • Functional health centre; OMPADEC’s initiated project abandoned and SPDC promised a new cottage hospital • Need additional landing jetty for embarking/disembarking and berthing of boats • Public toilets • Youth group particular with job opportunities, skills acquisition, empowerment and development schemes; SPDC, CNL and Government had people trained in skills and abandoned, wants a difference • Women seeks for empowerment and assistance in economic opportunities • Fulfilment of promises to restore confidence on SPDC |
| Ugborodo | <ul style="list-style-type: none"> • Since unemployment is the single most worrisome social problem facing the area, the provision of more employment opportunities for the teeming youths shall be greatly appreciated; • Involving the youth in youth training and skills acquisition programmes; • The building of a cottage hospital in immediate domain to serve greater number of the local population in the area; • Provision of more educational infrastructures; • Encouraging small scale fishing and agricultural productivity-provision of nets and engine boats, granting of credit facility, provision of farm seedlings, agro-chemicals and capacity building programmes are amongst things that could enhance company-community relations in the Otumara AGG Solution Project operating environment. • Above all, fulfillment of past promises and contents of an agreed GMoU shall restore community confidence on SPDC’s corporate image |

4.11 Health Studies

The determinants of health among the population in Otumara AGS Project communities are similar to those of the other rural and semi-urban riverine communities in Delta State and South-South Nigeria; they include demographic, environmental and behavioural factors.

Demographic Factors

The communities are mainly rural and the people are mainly of the Itsekiri ethnic group. The population structure of the communities is consistent with those of similar communities in the Niger Delta (UNDP, 2006). Permanent residents in the communities were mostly the elderly, fisher-folks and traders while several younger members, particularly males in the 20 – 39 year age range reside in Warri. In some of the communities, a sizable number of young girls and traders derive their livelihood from their proximity to the oil facility. The implications of this for commercial sex work and its consequences for transmission of sexually transmitted diseases (STI) and HIV as well as other social vices such as smoking, drug and alcohol abuse, and violence should be considered.

Environment

Water Sources and Access

Access to potable water is an important determinant of health and one of the Millennium Development Goals (MDGs). Most members of the project communities were able to meet the daily per capita water requirement of 20 – 40 litres although from a variety of potentially contaminated sources.

The sources of drinking water in the various communities are as shown in Fig. 4.11.1. Tanker water (supplied by SPDC) and sachet water were the most common sources of drinking water though these sources may be expensive or not sustainable. Notwithstanding, the proportion of the project community households with adequate access to potable water was better than the average

reported for South-South Nigeria in the 2008 National Demographic and Health Survey (NDHS 2008).

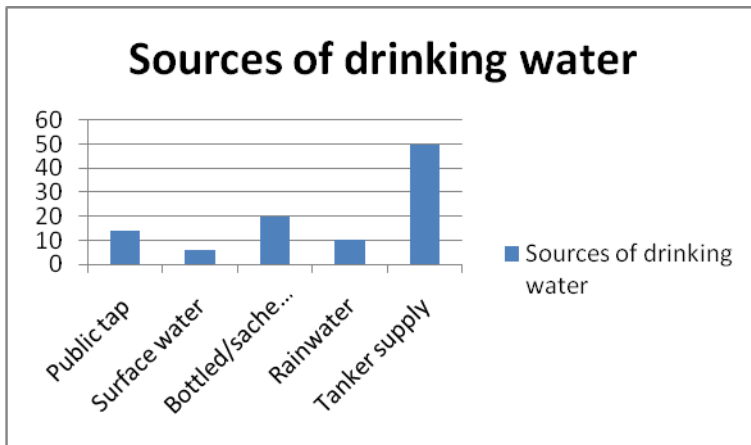


Fig. 4.11.1: Sources of drinking water

Furthermore, only about 15% of households spent more than 30 minutes to complete a round trip to their preferred water source. This proportion was also better than the average rate of 28.5% reported in the 2008 National Demographic and Health Survey for rural areas in Nigeria and compares well with the average proportion reported for urban areas (Fig 4.11.2).

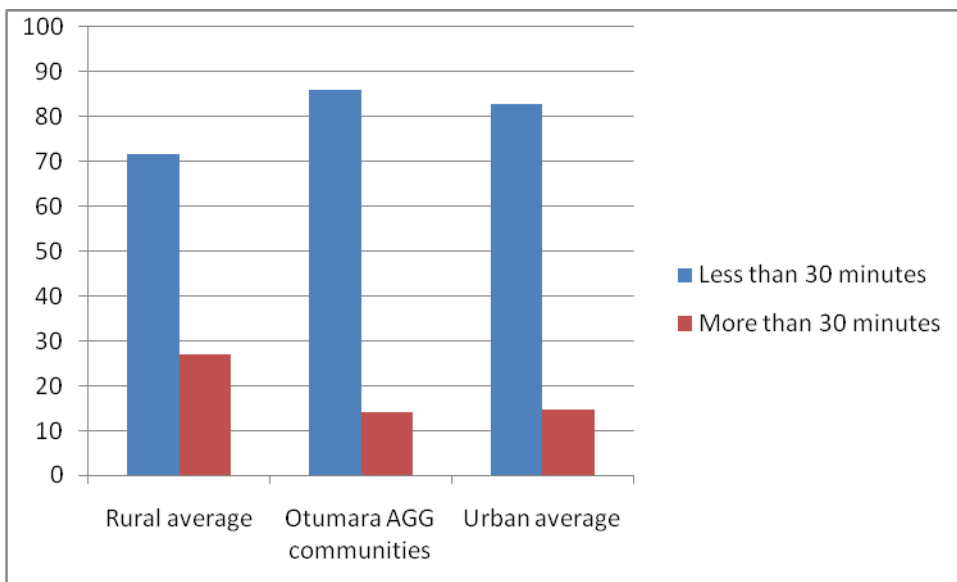


Fig. 4.11.2: Time spent to fetch water in the Otumara AGS communities

Government, NNPC, Chevron and SPDC had provided several water boreholes in the project communities but most were non-functional for a variety of reasons. The borehole facilities at Ajudaibu were abandoned because the water from them was said to be salty while facilities at Ogidigben, Ugborodo and other communities were damaged during the communal crisis and were yet to be repaired. This situation perhaps accounted for the dependence on expensive or less sustainable options like tanker supply and sachet water or unsafe and unprotected sources such as unprotected artificial surface ponds (Plates 4.11.1 and 4.11.2).

Apart from threat to health due to high risk of contamination of unprotected surface water sources, artificial surface ponds also provide favourable breeding grounds for vectors of diseases (eg. mosquitoes) that transmit Malaria, Filariasis and Schistosomiasis. Furthermore, as at the time of this EIA baseline study, a bag of sachet water (about 500 mls) sold for 20 naira. Improvement of the borehole facilities in Ajudaibu to obtain fresh water and repair of those in other communities will be more sustainable and also free some household finances for other household needs such as food procurement. Filling of surface ponds will also reduce illness due to Malaria and other water related diseases and ultimately contribute to improved health status of the households, especially that of children.



Plate 4.11.1: Water sources in the host communities

From left: Non-functional NNPC built water facility in Ogidigben, and an impounded water source in Ajudaibu



Plate 4.11.2: Water sources in the host communities

From left: Surface tanks in Ajudaibu community and Surface tanks used to collect rain water in Otumara.

Public water facilities have a tendency to break down frequently because plans are hardly in place for their maintenance. Addressing these problems in the project communities would basically require the establishment of a proper management structure for the facilities since the facilities were mostly already in place (Ordinioha and Adeosun 2008). Empowering members of the communities and the provision of technical support would go a long way to achieve this. The Village Level Operation management of Maintenance (VLOM) advocated at the start of the International Drinking Water and Sanitation Decade for the maintenance of water facilities is specially recommended to ensure the sustainability of the water facilities in these communities (WEEL 1998).

The Quality of Ground Water in the Communities

Results of laboratory analysis of ground water samples collected during field studies showed high salinity, and high total and faecal coliform counts. The high salinity is a reflection of salt water intrusion which is an established phenomenon in the Niger Delta coastal communities. The Total Coliforms count was much higher than the limit specified in National Guidelines (for potable water value of 0.0 MPN/100ml). The Total Coliform count of the ground water sample ranged from 2.2 to 20 MPN/100ml, while the surface water sample contained even higher levels of between 11 MPN/100ml and 40 MPN/100ml. These findings are not surprising considering the widespread use of the over-hung (jetty-type) toilet in the communities (Ordinoha 2011). The use of water contaminated with Coliforms is capable of causing diarrhoea, but can be made potable by the addition of chlorine tablets, especially those that also have coagulants and flocculants, like the “water guard” marketed by the Society for Family Health (Clasen *et al.* 2005).

Apart from high salinity and high coliform count, the ground water samples did not contain any detectable concentrations of Benzene, Toluene and Xylene components of the Total Hydrocarbon Content that are said to be potentially carcinogenic (ATSDR, 1999). None of the samples contained detectable concentrations of Cadmium, Lead, Manganese and Vanadium that have been shown to have some effects on human health (WHO/FAO/IAEA, 1996).

It was also noticed during the field study that members of the communities often used discarded drums of drilling chemicals as water storage containers. Thankfully, none of the drilling chemicals were detected in the water samples. The health implications of the use of the drums are however not known to members of the communities. There is therefore a need for proper health education, especially as the oil companies operating in the communities can easily be blamed for any health effects that arise from the use of the drums (Plate 4.11.3).



Plate 4.11.3: Discarded drums of drilling chemicals used to collect rain water in Ajudaibu community.

Access to Sanitary Faecal Disposal Facility

Sanitary disposal of faeces is another important determinant of health. Sanitary disposal of faeces reduces the risk of faeco-orally transmitted infections like cholera and other diarrhoeal diseases, typhoid, amoebiasis and intestinal helminthiasis. Access to sanitary faecal disposal/sanitation facility is another Millennium Development Goal. During field study, a

faecal disposal facility/latrine was considered to be sanitary if it was either a toilet or a latrine with a septic tank that effectively prevents contamination of surface or underground water with fresh human faeces. Overhung toilets or flush toilets that channelled effluents directly into the river were considered insanitary. A household had access to sanitary faecal disposal facility if it had a private facility or shares one with not more than five other households in a building or compound (Billig *et al.*, 1999). Most latrines in the project communities were the jetty or overhung toilets that discharge faeces directly to surface water and therefore insanitary. Few sanitary toilets were however seen in the bigger communities (Plate 4.11.4).



Plate 4.11.4: The jetty-type toilet is the commonest toilet in the host communities

Housing and vector/pest control

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



Plate 4.11.5: Raised house in a host community



Plate 4.11.6: One of the houses built in Ogidigben by the Itsekiri Regional Development Council

Air Quality

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

The concentrations of Suspended Particulate Matter (SPM) in the ambient air of the study communities varied from $0.62\mu\text{g}/\text{m}^3$ to $2.66\mu\text{g}/\text{m}^3$. These concentrations are significantly lower than the Nigerian Federal Ministry of Environment limit of $250\mu\text{g}/\text{m}^3$, and even the WHO's annual limit of $20\mu\text{g}/\text{m}^3$ that is said to be the threshold for significant adverse health effects (WHO, 2006). This is remarkable, considering that SPM is not only produced by gas flaring, but also by the combustion of bio-mass fuel, such as firewood that is commonly used in the

communities. Otumara AGS project should therefore contribute to improvement of air quality in the project communities.



Plate 4.11.7: Firewood is the commonest source of fuel for domestic use

Waste Management

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



Plate 4.11.8: Refuse dump site at the bank of the river at Otumara

Behavioural Factors

Behavioural factors play important role in the epidemiology of both communicable and non-communicable diseases. Cigarette smoking, substance (drugs) and alcohol use are well-established risk factors for coronary heart diseases, cancers and several psychosocial health-related issues like prostitution, armed robbery, domestic and gender-related violence. Risky sexual behaviour is associated with transmission of sexually transmitted infections including HIV. The influx of younger males and females into the project communities to search for employment would no doubt influence behavioural practices in the project communities. For this reason, key behavioural practices were assessed during the field study.

Alcohol and Tobacco use

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

Smoking is common in the communities among young men; about 50% of the young males in the communities were said to smoke cigarettes but an average smoker takes at most three sticks of cigarette a day. Women rarely smoke cigarette in most of the communities but female smokers could be found in some of the communities close to the flow station for example Otumara.

Sexual Behaviour

The sexual behaviour of members of the project communities posed significant risk for the transmission of sexually transmitted infections including HIV/AIDS. Polygamy was common among the married adult males while single girls reported that they had multiple sexual partners. Culturally in the communities, fidelity in marriage is prescribed for women while men could engage in extra-marital affairs. Some of the communities, like Otumara, had a history of accommodating commercial sex workers.

While more detailed information on the sexual behaviour of members of the communities could not be obtained because of the sensitive nature of the topic, discussants were nevertheless unanimous on the fact that sexual behaviour is no different from that of the other communities of the South-South region of Nigeria. According to 2003 Nigerian National HIV/AIDS and Reproductive Health Survey (FMOH, 2004);

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

Knowledge of HIV/AIDS

Human Immunodeficiency Virus (HIV) in adult Nigerians is mainly transmitted through the heterosexual route and this explains why the “ABC” method forms the basis for HIV control in Nigeria. The “ABC” method is an acronym that stands for sexual abstinence, being faithful in monogamous relationship between HIV-negative partners, and condom use for people not practicing abstinence. Focus group discussants had heard of HIV/AIDS and demonstrated good knowledge of the “ABC” methods of HIV prevention. They attributed their knowledge to the health enlightenment campaign conducted by the health workers and NGOs with the generous support of SPDC. Because of the possibility that the project may bring about in-migration of other youths who may have poorer knowledge of HIV transmission, it is recommended that the campaign be intensified. Also, oil and gas projects have been reported to increase the transmission of HIV in the Niger Delta (Nwauche and Akani 2006).

Household Food Security and Feeding

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

The prevalence of malnutrition among the under-five children is one of the indicators for Millennium Development Goal One. The nutritional status of under-fives in the project communities was assessed during the field survey using anthropometry. Two hundred and thirty-nine under-five children were assessed; of these, 46 (19.25%) were found to be underweight. Fig 4.11.3 compares the prevalence of malnutrition in the project communities with the national and South-south geopolitical zone averages. Although the prevalence was lower than the national averages, it was nevertheless higher than that of the South-South zone. It should however be borne in mind that malnutrition in children is not only a reflection of the diet and socio-economic status of the household but is also influenced by frequency of infections and other environmental conditions (Ruel and Menon 2003).

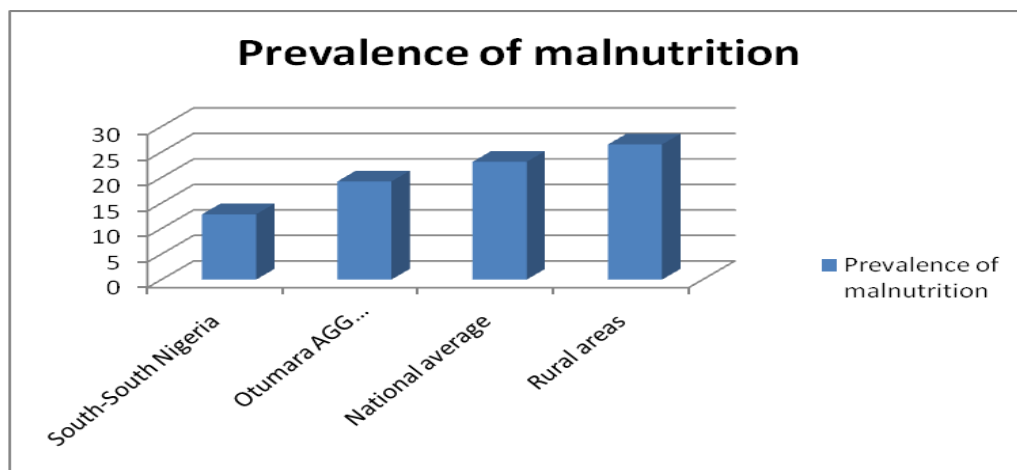


Fig. 4.11.3: A comparison of the prevalence of childhood malnutrition

Morbidity Pattern

Focus group discussants agreed that the commonest causes of ill health in the communities were malaria, diarrhoeal diseases, typhoid fever, upper respiratory tract infections and skin diseases. These are believed to be similar to common causes of morbidity in other similar communities in Delta State and in the rest of the Niger Delta region. The diseases listed are also consistent with what is reported by national survey (NDHS 2008). Discussants also believed that the incidence of non-communicable diseases like hypertension, diabetes mellitus are beginning to rise in the project communities though none of the discussants knew someone who died of these conditions. Interestingly, the rise in non-communicable diseases incidence was associated with oil and gas exploration.

Mortality Pattern

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

On the average, about 62 child deaths were reported to occur in the communities every year by Focus Group Discussants. The common causes of these deaths were: malaria and its complications, especially anaemia and febrile convulsion, gastro-enteritis (diarrhoea and vomiting, dysentery), cholera, acute lower respiratory tract infection; and vaccine preventable diseases, especially measles. These causes are also common in most other communities in South-South Nigeria (NDHS, 2008) and are associated with poor environmental conditions, poor health seeking behaviour and poor standard of health care delivery in the communities. Inter-personal violence was noted to be an important cause of death of youths in the area, especially during the crisis period of the late 1990s and the early years of the 21st century.

The Health System:

Primary Health Centres

Most of the host communities, including the smaller communities, had a health facility located within the prescribed 5 kilometre distance or 30-60 minutes travel time. The Primary Health Care facilities were sited in Deghele and Ogborodo. In addition, most of the facilities had received assistance from SPDC through the supply of medical equipment, consumables and training of staff. Notwithstanding the availability of the physical facilities, utilisation of facilities has been less than optimal because of dearth of health staff. The Focus Group discussants reported that health workers left the communities at the wake of the communal crisis of the late 1990s and early 2000s. During the field studies, renovated and yet-to-be commissioned health facilities were seen in Ajudiabo (Plate 4.11.9).



Plate 4.11.9: PHC Ajudaibo

Secondary Health Care Facilities:

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



Plate 4.11.10: Cottage hospital in Ogidigben being renovated

Medical Emergency Evacuation System:

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

4.12 Consultation and Stakeholder Engagement

In the EIA process, consultation is accorded high priority so as to capture and address issues and concerns of the stakeholders. Consultation with the identified stakeholders for the Otumara Field Associated Gas (AG) Solution Project is designed to be a continuous process throughout

the development and operation of the facilities. The principal objective is to acquire and disseminate information, identify and address legislative, community, and environmental concerns, proffer appropriate mitigation options for all the negative impacts, and enhance the positive impacts. Consultation with the stakeholders has been on since 1969 when the field was discovered. The present renewed consultation exercise has become necessary in view of the current AG Solution project.

The scoping workshop held on Tuesday 25th October 2005 at the conference hall of Hotel Excel, Effurun served as the first contact between SPDC and the various stakeholders and communities involved with the project.

4.12.1 Objectives

The EIA Act requires EIA reports on all major additional activities to ongoing projects or existing projects. In line with the new SPDC EIA Process Manual, consultations form part of all EIA reports and hence the present consultation initiative which is intended to carry along all the stakeholders in this project. The consultation process for the EIA is undertaken at an early stage to help develop a scope of issues to be addressed and to identify the significant issues relating to the project activities. The main objectives for carrying out consultation for the current Otumara Field AG Solution Project include:

- Sustaining consultation with stakeholders via people's parliament with explanation on key issues associated with the project and their effects on the people.
- Maintaining effective communication between SPDC and the host communities.
- Assuring full commitment to implement mutually accepted sustainable community development Projects.
- Facilitating communication and understanding between the various stakeholders and SPDC (the project proponent).
- Gaining support and buy-in from all relevant stakeholders.
- Comply with mandatory statutory requirements.
- Identifying issues relevant to the project which are likely to cause impact.
- Avoiding conflict with the primary stakeholders by addressing issues promptly.
- Ensuring that any apprehension and disenchantment about the project with respect to environmental impacts are given the required attention by sensitizing, and mobilizing the host communities to express their concerns vis-a-vis the potential impacts of the project.
- Providing a link between the communities and SPDC in order to obtain early notification of any changes in the environment as a result of the project.
- Being aware of stakeholders' views of the project with respect to the present environmental conditions in the area and any changes thereof in the future.
- Considering effective participation of the host communities in maintaining and sustaining the beneficial impact of the project.
- Maintaining continuous interaction with the host communities to obtain early warning information on the physical, chemical, biological, health, and social components of the environment to tackle detrimental consequences during the construction and operational phases of the project.

4.12.2 Identification and involvement of key stakeholders

Experience has shown that certain potentially contentious issues get to the public domain only when appropriate consultation process is maintained from the conceptual stage of any project. Since the discovery of the field and up till this moment, SPDC has continued to maintain a steady consultation process with all the relevant parties, to ensure that all the issues of concern are rationalised and sorted out prior to construction and operation of the proposed project. This philosophy has been upheld in the present case of the Otumara AG Solution Project.

The Primary Stakeholders

These are the indigenous people from the three major host communities (Ugborodo/Aruton, Deghele and Ugbeogugun) in Warri South West Local Government Area of Delta State. Also invited were NGO's and CBO's.

The Regulators

The identified regulators are:

- Federal Ministry of Environment, Abuja (FMEnv)
- Department of Petroleum Resources (DPR)
- Delta State Ministry of Environment (DSMENV)

The above regulators were notified through letters of SPDC's intention to carry out the Otumara Field AG solution Project, and also their invitation to participate in the HSE Workshop exercise of 13th August 2012.

4.12.3 EIA HSE Workshop

An HSE Workshop was held on 13th August, 2012, at the MOA Restaurant, SPDC Warri, Delta State. The purpose of the workshop was to identify issues that were perceived to be relevant to the fieldwork exercise. The major highlights during the Plenary Session were the Logistics and Security for the field work.

An inventory of identified issues was reviewed with an EIA team from SPDC, EIA Consultants, and DPR/FMEnv regulators present.

4.12.4 Issues and Concerns

In general, interaction with the community was positive and there was widespread appreciation of the consultation process undertaken. The host communities were delighted about the proposed project. The requests made by the various communities are summarized as follows:

- Creation of job opportunities for the host communities during the project execution phase.
- Provision of potable water, electricity, cottage hospitals and river transportation.
- Involvement of the communities in the EIA study
- Implementation of appropriate mitigation measures

In response SPDC advised the communities to include areas of concerns relating to the provision of infrastructure in their Participatory Rural Appraisal Programmes for greater attention by SPDC. In addition, SPDC reiterated that:

- All complaints/issues raised outside the context of the project shall be sent to appropriate authorities
- Terms of reference (TOR)/scope of work from the workshop will form the basis of the EIA study
- Consultation will be continuous and all mitigation measures shall be implemented.

Freedom to Operate (FTO) document was issued by Ugborodo, Deghele and Ugboegungun Communities respectively, for a duration of one year.

4.12.5 Future Consultations

SPDC, contractors and subcontractors would continue to consult with all relevant parties (host communities, Warri South West Local Government Area, Delta State Government, the Federal Ministry of Environment, DPR) and all parties concerned with or are likely to be affected by the project, at all stages of the project development.



Plate 4.12.1: Members of Otumara Community (Ugborodo, Ugboegungun and Deghele).



Plate 4.12.2: The elderly and women leaders in Ugboegungun Community



Plate 4.12.3: Engagement session in the home of the Olaraja of Ogidigben community



Plate 4.12.4: Engagement session with some elders and members of the youth taskforce at Madangho Community

CHAPTER FIVE

ASSOCIATED AND POTENTIAL ENVIRONMENTAL IMPACTS

5.1 Assessment Methodology/ Analysis Tools

5.1.1 Introduction

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

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

The following considerations were adopted in this impact assessment:

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

Uncertainties

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

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

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

5.1.2 Basis for Screening

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

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

The criteria applied to the screening of various activities are:

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

5.1.3 Environmental Screening Process

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

5.2 Scoping

Objective of Scoping

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

Table 5.1: Identified Phases of Project Development and their Activities

| S/N | Project Phases | Project Sub- Phases | Activities |
|-----|------------------------------------------|--------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | Pre-Mobilization and Mobilization | Pre-Construction - Site Investigation/Preparation, Transportation of Modules, Personnel and Equipment | Land take, Transportation of equipment and personnel, RoW clearance, De-stumping, Tree Felling, Sand filling, Water traffic Towing of large Barges using Tugs, Personnel Carriers |
| 2 | Construction | Dredging and Piling | Widening of river/creek and deepening/sweeping of river/seabed, Capital dredging, Spoil disposal. |
| | | Fabrication of equipment/modules and other ancillary equipment | Cutting, welding, painting of equipment |
| | | Construction of Field Logistics Base (FLB) | Excavation/Sandfilling, Cement Slurry, Painting, Domestic/Industrial Waste disposal |
| | | Construction/installation of power supply system to project communities | Excavation, sandfilling, piling, installation of the power modules |
| | | Pipeline/Facilities Construction | Trenching, Piling, Pipe stringing and Welding, Coating and Wrapping, Hydrostatic Testing, River crossing, Cathodic protection, back filling and Spoil disposal, Non-Destructive testing (NDT). |
| | | Fibre Optics Cable Laying | Clearing the seabed of debris using de-trencher grapnel, High Pressure Water Jetting Burial of Cable, back filling of cable trenches |
| | | Gas Conditioning Facilities Installation | Piling, Welding, Blast cleaning, Lifting, Cutting, Cleaning, Painting, Drainage and Water Traffic, waste disposal. |
| 3 | Operation/ Commissioning and maintenance | System Commissioning, Operation & Maintenance | Collection, Monitoring and Disposal of Wastes & Effluent discharges, Corrosion control, Monitoring of emissions. Equipment Testing, Start-ups and Introduction of Hydrocarbons, Sewage Disposal. |
| 4 | Decommissioning and Abandonment | Decommissioning and Abandonment | Domestic and Industrial waste management. Cutting, Lifting, Welding, Draining, Cleaning, Water Traffic. |

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

5.3 Impacts Identification

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

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

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

The ISO14001 requires identification, evaluation and registration of environmental aspects associated with SPDC's activities. SPDC's HSE MS is the tool for achieving ISO 14001 requirement, and this EIA report is a component of the HSE-MS.

We identified impacts associated with activities of the project through many sources of documentation including:

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

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

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

| S/N | Components of Environment | Impact Indicators |
|-----|---------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | Climate | Humidity, Temperature, Rainfall, Wind. |
| 2 | Air Quality | Particulate, NO _x , SO _x , CO ₂ , CO, VOCs, H ₂ S, CH ₄ Heavy metals (Fe, Cd, Cr, Pb, Ni, V, Zn), BTEX |
| 3 | Water Quality | Colour, alkalinity, TDS, TSS, Turbidity, EC, THC, pH, DO, BOD ₅ , COD, Oil & Grease, PAH, TPH, BTEX, Anions/Cations, NH ₄ ⁺ , NO ₃ ⁻ , NO ₂ ⁻ , PO ₄ ³⁻ , SO ₄ ²⁻ , SiO ₂ , Na ⁺ , K ⁺ , Ca ²⁺ , Mn ²⁺ , Mg ²⁺ . Heavy metals (Fe, Cd, Cr, Ni, V, Pb, Zn, Hg). |
| 4 | Groundwater | Solids, pH, Na, Cl, Cond, THC, TPH, Trace metals. |
| 5 | Soil/Land Use | Contamination with oil, Loss of farmland. |
| 6 | Hydrobiology | Species composition, distribution, diversity and abundance and seasonality of Phytoplankton, Zooplankton, Benthos, Aquatic Macrophytes, Macrophyte-associated macrofauna |
| 7 | Fisheries | Productivity, Diversity & Abundance, |
| 8 | Noise & Vibration | Ambient noise level dB(A) |
| 9 | Socio-economic | Population, Social Structure, Income, Settlement pattern, Employment, Education |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| S/N | Components of Environment | Impact Indicators |
|-----|---------------------------|---------------------------------------------------------------------|
| | Status | and Infrastructure. |
| 10 | Health Status | Incidence of diseases, change in health status, Safety and Security |

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

| Development Phase | Project Activity | Potential/Associated Impacts |
|-----------------------------------------------------------------|--------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Site Preparation | RoW Clearance | <ul style="list-style-type: none"> • Surface erosion from removal of tree canopies, • Loss of economic trees and ecologically important vegetation (mangroves and rain forests), • Injuries and accidents from not following approved work procedures and non-used of Personal Protective Equipment PPE • Loss of habitats for wildlife. • Compensation to the communities for land take • Employment opportunities |
| | Waste Disposal | <ul style="list-style-type: none"> • Suspended solids in water |
| Dredging/Sweeping | River Crossing | <ul style="list-style-type: none"> • Shoreline erosion, • Disturbance of riverbed topography • Increased turbidity and suspended solids, • Dis-aggregation of benthic habitats and loss of benthic organisms. • Loss of juvenile fishes due to gill damage from silt particles. • Dredging improves circulation of water currents and transport of nutrients for marine life food chain. • Injuries and accidents from not following approved work procedures and non-used of Personal Protective Equipment PPE • Employment opportunities • Local contracting opportunities |
| | Creek widening | <ul style="list-style-type: none"> • Loss of buffer effects of shoreline vegetation. |
| | Spoil disposal | <ul style="list-style-type: none"> • Smother epifauna and impair surface drainage. |
| | Water Traffic | <ul style="list-style-type: none"> • Fishing/Water traffic disruption • Injuries and accidents from not following approved work procedures and non-used of Personal Protective Equipment PPE |
| | | |
| Pipeline/Facilities Construction, and Laying Fibre Optics Cable | Trenching/Backfilling | <ul style="list-style-type: none"> • In tidal swamps, this will increase surface water sediment loading and suspended solids, • Irreversible soil compaction and may alter the topography of the RoW. • Injuries and accidents from not following approved work procedures and non-used of Personal Protective Equipment PPE |
| | Welding/Coating/Wrapping | <ul style="list-style-type: none"> • Improper disposal of lay barge deck drainage will contaminate surface water and sediment. • Employment opportunities |
| | Hydrostatic Testing | <ul style="list-style-type: none"> • Discharge of untreated test water into the receiving environment. • Injuries and accidents from not following approved work procedures and non-used of Personal Protective Equipment PPE |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| Development Phase | Project Activity | Potential/Associated Impacts |
|------------------------------------|------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | River Crossing | <ul style="list-style-type: none"> Disaggregation of benthic habitats and loss of benthic organisms. Disturbance of seabed topography Shoreline erosion Disruption of fishing activities Injuries and accidents from not following approved work procedures and non-used of Personal Protective Equipment PPE |
| | Waste/Spoil Disposal | <ul style="list-style-type: none"> Improper disposal of backfill residue will alter the morphology of the area and impede drainage. |
| Transportation of Module/Equipment | Water traffic | <ul style="list-style-type: none"> The size and number of barges conveying equipment, materials and personnel, and the associated waves will endanger small canoes/boats and limit fishing activities. |
| CPF Installation | Piling/Welding | <ul style="list-style-type: none"> Piling and welding will cause occupational impacts from noise and release of toxic fumes. Employment opportunities Local contracting opportunities |
| | Waste Disposal | <ul style="list-style-type: none"> Substantial quantities of packing materials will be generated on site and need to be managed properly to avoid littering the project area. Contamination of water with paints and corrosion inhibitors. Leaks and spills of diesel fuel and lubricants into water, Potential leakage and spills of glycol during installation. |
| System Operation | Emissions to atmosphere | <ul style="list-style-type: none"> Discharge of effluents from flowstations/CPF into water. Leaks and accidental spills of glycol during operation, as well as emission of glycol vapour with gas stream as fugitives. Emergency gas flare will cause explosion which will startle operational staff and wildlife and leave them in perpetual anticipation of future occurrence. Lead to air pollution. Gas emissions from pipelines damage due to sabotage. Noise from gas turbine. Employment opportunities Local contracting opportunities |
| | Effluent Discharges | <ul style="list-style-type: none"> Discharge of untreated effluents from flowstations/CPF into water. Leaks and spills of TEG during storage, handling and decanting. Domestic and sewage disposal from the logistic centre. |
| | Waste Disposal | <ul style="list-style-type: none"> Domestic and industrial solids from the logistic centre. |
| Abandonment | Mothballing of Saghara Flowstation | <ul style="list-style-type: none"> Soil/Water pollution from removal of oil pumps, Surge vessel and Separators Employment opportunities Local contracting opportunities |
| | Cutting/Lifting | <ul style="list-style-type: none"> Oxy-acetylene explosion, falling objects. |
| | Waste Disposal | <ul style="list-style-type: none"> Poor aesthetic features from abandoned structures on site. |
| | Restoration | <ul style="list-style-type: none"> Alteration of vegetation pattern and disturbance of aesthetic beauty of the original environment. Employment opportunities Local contracting opportunities |

Table 5.3: SPDC Risk Matrix

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

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

Criteria and Rating for Identifying Significant Environmental Impacts of the proposed Otumara Field AGS Node project are:

1. Legal / Regulatory Requirements (L) – is there a legal/regulatory requirements or a permit required?
 0 = There is no legal/regulatory requirement
 3 = There is legal/regulatory requirement
 5 = There is a permit required
2. Risk (R) - What is risk/hazard rating based on RAM?
 1 = Low
 3 = Medium/intermediate risk
 5 = High risk
3. Environmental impact Frequency (F) – What is frequency rating of impact based on RAM?
 1 = Low frequency
 3 = Medium intermediate frequency
 5 = High frequency
4. Importance of Affected Environmental Component and Impact (I) – What is rating of

importance based on consensus of opinions?

1 = Low importance

3 = Medium/intermediate importance

5 = High importance

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

1 = Low perception and interest

3 = medium/intermediate perception and interest

5 = High perception and interest

5.4 Impact Quantification And Determination Of Significance

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

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

High Impact

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

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

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

Medium Impact

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

Table 5.5: Significant Impacts of the Proposed Project

| Project Activity | Description of Impact | Impact Qualification | | | | | | | | Impact Quantification | | | | | | F+I | Impact Rating |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|----------|--------|----------|------------|-----------|------------|--------------|-----------------------|---|---|---|----|-------|-----|---------------|
| | | Positive | Negative | Direct | Indirect | Short term | Long term | Reversible | Irreversible | L | R | F | I | P | Total | | |
| All Phases | Climate Extremes – Heavy rainfall and Lightning strikes; May increase safety hazards of the work. Delay in project schedule may increase time of delivery and cost; | | x | x | | x | | x | | 0 | 5 | 3 | 3 | 5 | 16 | 6 | H |
| | Fatality, damage to assets due bad weather | | x | x | | x | | x | | 5 | 1 | 1 | 5 | 5 | 17 | 6 | H |
| | Deprivation of personal liberty, injury, fatality due to Kidnapping | | x | x | | x | | x | | 3 | 3 | 5 | 3 | 5 | 19 | 8 | H |
| Pre-mobilization and Mobilization Phase <ul style="list-style-type: none"> • Land Acquisition • Land survey • RoW Clearance, Tree felling/De-stumping, Civil Works, and Facilities Construction site • Waste Disposal • Dredging/Sweeping/Piling • Piling • Dredging Waste Disposal | Loss of vegetation through cutting of line traces | | x | x | | x | | x | | 3 | 1 | 1 | 1 | 1 | 7 | 2 | L |
| | Increased erosion potential due to removal of vegetation canopies and road paving | | x | x | | x | | x | | 5 | 3 | 3 | 3 | 1 | 15 | 6 | H |
| | Loss of economic trees and ecologically important vegetation (mangroves and rain forests), | | x | x | | x | | x | | 5 | 3 | 1 | 3 | 5 | 17 | 4 | H |
| | Loss of habitats for wildlife. | | x | x | | x | | x | | 5 | 1 | 3 | 1 | 3 | 13 | 4 | M |
| | Loss of farmland, fishponds, gin distilleries and shines may result along the pipeline routes. | | x | x | | x | | x | | 5 | 3 | 3 | 3 | 5 | 19 | | H |
| | Income to local workers that may be employed for the bush clearing activities | x | | x | | x | | x | | 0 | 3 | 1 | 5 | 5 | 14 | | P |
| | Improved quality of life may result from increased project spending which will stimulate economic activity in the area. | x | | x | | x | | x | | 0 | 3 | 1 | 5 | 5 | 14 | | P |
| | More infrastructures may be built or developed in the communities as part of the projects' CD initiatives. | x | | x | | | x | | x | 0 | 3 | 1 | 5 | 5 | 14 | | p |
| | Water related disease may increase due to poor sanitation practices when more pressure is put on already poor state of housing. | | x | x | | x | | x | | 3 | 5 | 5 | 3 | 5 | 21 | 8 | H |
| Increase in cases of sexually transmitted disease and other disease strains may result through migrant workers. | | x | x | | x | | x | | 0 | 5 | 5 | 3 | 5 | 18 | 8 | H | |
| Accidents to workers will increase especially for local labour not sufficiently skilled for the | | x | x | | x | | x | | 0 | 3 | 3 | 5 | 5 | 16 | 8 | H | |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| Project Activity | Description of Impact | Impact Qualification | | | | | | | | Impact Quantification | | | | | | F+I | Impact Rating | |
|------------------|------------------------------------------------------------------------------------------------------------------------------------|----------------------|----------|--------|----------|------------|-----------|------------|--------------|-----------------------|---|---|---|---|-------|-----|---------------|--|
| | | Positive | Negative | Direct | Indirect | Short term | Long term | Reversible | Irreversible | L | R | F | I | P | Total | | | |
| | type of work. | | | | | | | | | | | | | | | | | |
| | Increased in suspended solids in water | | x | x | | x | | x | | 3 | 5 | 3 | 5 | 3 | 19 | 8 | H | |
| | Discharge of faecal waste into the water will contaminate drinking water sources and increase water related disease (cholera etc). | | x | x | | x | | x | | 5 | 5 | 3 | 5 | 3 | 21 | 8 | H | |
| | Shoreline erosion, | | x | x | | x | | x | | 3 | 3 | 5 | 1 | 3 | 15 | 6 | H | |
| | Disturbance of riverbed topography and re-suspension of fine sediments and bottom materials | | x | x | | x | | x | | 5 | 1 | 1 | 1 | 1 | 9 | 2 | M | |
| | Increased turbidity and suspended solids, | | x | x | | x | | x | | 3 | 3 | 3 | 3 | 3 | 15 | 6 | H | |
| | Disaggregation of benthic habitats and loss of benthic organisms. | | x | x | | x | | x | | 3 | 1 | 3 | 3 | 1 | 11 | 6 | M | |
| | Displacement of water by increased frequency of badge traffic may result in flooding of low lying communities. | | x | x | | x | | x | | 3 | 1 | 1 | 3 | 3 | 11 | 4 | M | |
| | Loss of juvenile fishes due to gill damage from silt particles. | | x | x | | x | | x | | 3 | 3 | 1 | 5 | 5 | 17 | 6 | H | |
| | Dredging improves circulation of water currents and transport of nutrients for marine life food chain. | x | | x | | x | | x | | 3 | 1 | 1 | 3 | 1 | 9 | 4 | M | |
| | Loss of buffer effects of shoreline vegetation may result from creek widening | | x | x | | x | | x | | 3 | 3 | 3 | 5 | 3 | 17 | 8 | H | |
| | Temporary disruption of local fishing/harvesting activities. Fish spawning habitat may also be destroyed. | | x | x | | x | | x | | 3 | 3 | 3 | 3 | 5 | 17 | 6 | H | |
| | Acidification of the soil and surface water as a result of deposition of dredge spoils on the banks of the river | | x | x | | | x | x | | 3 | 3 | 3 | 3 | 5 | 17 | 6 | H | |
| | Salt water intrusion (surface and ground water)as a result of dredging activities | | x | x | | | x | x | | 3 | 3 | 3 | 3 | 5 | 17 | 6 | H | |
| | Water traffic disruption with possible increase in marine accidents | | x | x | | x | | x | | 3 | 3 | 3 | 3 | 5 | 17 | 6 | H | |
| | Impairment of hearing due to noise and vibrations | | x | x | | x | | x | | 3 | 1 | 1 | 3 | 3 | 11 | 4 | M | |
| | Spoil disposal will smother epifauna and impair surface drainage especially in wetland areas | | x | x | | | x | x | | 3 | 3 | 3 | 5 | 1 | 15 | 8 | H | |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| Project Activity | Description of Impact | Impact Qualification | | | | | | | | Impact Quantification | | | | | | F+I | Impact Rating |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|----------------------|----------|--------|----------|------------|-----------|------------|--------------|-----------------------|---|---|---|---|-------|-----|---------------|
| | | Positive | Negative | Direct | Indirect | Short term | Long term | Reversible | Irreversible | L | R | F | I | P | Total | | |
| | Pollution of drinking water sources may occur if domestic waste is discharged directly into the river. | | x | x | | x | | x | | 3 | 3 | 1 | 3 | 5 | 15 | 4 | H |
| Construction Phase | Emissions from internal combustion engines | | x | x | | | x | x | | 3 | 1 | 1 | 3 | 1 | 9 | 4 | M |
| <ul style="list-style-type: none"> • Pipeline/ Bulkline Construction and Laying Optic Fibre Cable • Trenching/ Backfilling • Welding / NDT/ Coating/Wrapping • Hydrostatic Testing • River Crossing • Waste/Spoil Disposal • Communities electrification • Transportation of Module/ Equipment • Water transportation • CPF Installation and FLB Construction • Welding • Installation, tie-in and pre-commissioning of facilities. • Unloading and installation of CPF/ Modules | In tidal swamps, this will increase surface water sediment loading and suspended solids. | | x | x | | x | | x | | 5 | 3 | 5 | 5 | 3 | 21 | 8 | H |
| | Irreversible soil compaction which may alter the topography of the RoW. | | x | x | | | x | | x | 5 | 1 | 1 | 1 | 1 | 9 | 8 | M |
| | Salt water intrusion into ground water, through ELPS (hydraulic seepage around the circumference of the pipe) | | x | x | | | x | | x | 3 | 3 | 1 | 3 | 5 | 15 | 8 | H |
| | Exposure to radioactivity and release of chemicals | | x | x | | | x | | x | 3 | 3 | 3 | 3 | 5 | 17 | 6 | H |
| | Impairment of vision | | x | x | | | x | | x | 3 | 1 | 3 | 3 | 3 | 13 | 6 | M |
| | Improper disposal of lay barge deck drainage will contaminate surface water and sediment. | | x | x | | | x | | x | 5 | 1 | 1 | 1 | 1 | 9 | 2 | M |
| | Discharge of untreated test water into the receiving environment. | | x | x | | | x | | x | 5 | 1 | 1 | 1 | 1 | 9 | 2 | M |
| | Disaggregation of benthic habitats and loss of benthic organisms. | | x | x | | | x | | x | 5 | 1 | 1 | 3 | 1 | 11 | 4 | M |
| | Disturbance of riverbed topography. | | x | x | | | x | | x | 3 | 3 | 1 | 1 | 1 | 9 | 2 | M |
| | Shoreline erosion | | x | x | | | | x | x | 3 | 3 | 3 | 3 | 3 | 15 | 6 | H |
| | Improper disposal of backfill residue will alter the morphology of the area and impede drainage. | | x | x | | | x | | x | 5 | 1 | 1 | 1 | 1 | 9 | 2 | M |
| | Increased income to local workers | | x | | x | | x | | x | 0 | 3 | 1 | 5 | 5 | 14 | 6 | P |
| | Improved quality of life may result from increased project spend which will stimulate economic activity in the area. | | x | | x | | x | | x | 0 | 3 | 1 | 5 | 5 | 14 | 6 | P |
| | More infrastructures may be built or developed in the communities as part of the projects' CD initiatives. | | x | | x | | x | | x | 0 | 3 | 1 | 5 | 5 | 14 | 6 | P |
| | Water related disease might increase due to poorer sanitation practices when more pressure is put on already poor state of housing. | | | x | x | | x | | x | 3 | 5 | 5 | 3 | 5 | 21 | 8 | H |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| Project Activity | Description of Impact | Impact Qualification | | | | | | | | Impact Quantification | | | | | | F+I | Impact Rating |
|------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|----------|--------|----------|------------|-----------|------------|--------------|-----------------------|---|---|---|---|-------|-----|---------------|
| | | Positive | Negative | Direct | Indirect | Short term | Long term | Reversible | Irreversible | L | R | F | I | P | Total | | |
| | Increase in cases of sexually transmitted disease (HIV AIDS) and other disease strains may result through migrant workers. | | x | x | | x | | x | | 0 | 5 | 5 | 3 | 5 | 18 | 8 | H |
| | Improve socio-economic activities | x | | x | | x | | x | | 0 | 1 | 1 | 1 | 5 | 8 | 2 | P |
| | The size and number of barges conveying equipment, materials & personnel and the associated waves may endanger small canoes/boats and curtail fishing activities. | | x | x | | x | | x | | 0 | 5 | 3 | 3 | 5 | 16 | 6 | H |
| | Welding activities will release toxic fumes. | | x | x | | x | | x | | 3 | 3 | 3 | 1 | 3 | 13 | 4 | M |
| | Contamination of water with paints and corrosion inhibitors. | | x | x | | x | | x | | 3 | 3 | 1 | 3 | 1 | 11 | 4 | M |
| | Leaks and spills of diesel fuel and lubricants into water. | | x | x | | x | | x | | 3 | 3 | 1 | 1 | 3 | 11 | 2 | M |
| | Potential leakage and spills of glycol during installation. | | x | x | | x | | x | | 3 | 3 | 3 | 3 | 3 | 15 | 6 | H |
| | Increased potential for injuries to personnel and damage to assets during heavy lift and positioning activities. | | x | x | | x | | x | | 3 | 3 | 1 | 5 | 5 | 17 | 6 | H |
| Commissioning and Operation Phase • Commissioning and System Operation/ Maintenance • Pigging | Effluent Discharges | | x | x | | x | | x | | 3 | 1 | 5 | 3 | 5 | 17 | 8 | H |
| | Discharge of untreated effluents from flowstations /CPF into water. | | x | x | | x | | x | | 5 | 1 | 1 | 3 | 3 | 13 | 4 | M |
| | Leaks and spills of TEG during storage, handling and decanting. | | x | x | | x | | x | | 3 | 3 | 1 | 5 | 3 | 15 | 6 | H |
| | Domestic wastewater and sewage disposal from the logistic centre. | | x | x | | x | | x | | 3 | 3 | 1 | 5 | 3 | 15 | 6 | H |
| | Domestic and industrial solids from the logistic centre. | | x | x | | x | | x | | 5 | 1 | 3 | 3 | 3 | 15 | 6 | H |
| DECOMMISSIONING AND ABANDONMENT • Cutting/Lifting • Waste Disposal • Restoration | Accidents from demolition activities - explosions, falling objects etc, especially when unskilled personnel are employed for the works. | | x | x | | x | | x | | 3 | 1 | 1 | 5 | 5 | 15 | 6 | H |
| | Poor aesthetic features from abandoned structures on site. | | x | x | | x | | x | | 3 | 1 | 1 | 3 | 3 | 11 | 4 | M |
| | Alteration of vegetation pattern and disturbance of aesthetic beauty of the original environment. | | x | x | | x | | x | | 3 | 1 | 1 | 3 | 3 | 11 | 4 | M |

5.4.1 Discussion of Ranking in Table 5.6

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

Air Quality

Measured air quality parameters show that some emissions from existing facilities are significant, mainly from gas flaring. The aim of this project is to reduce gas flaring to at most 10% of production, thus further reducing emissions below existing levels, with resultant improved air quality. This is positive impact (+17).

Water Quality

Bush clearing and dredging have been identified from past studies, Macgill, 1996 (Plates 5.1 and 5.2) as sources of negative impact on creeks in the construction area. The impacts are severe for TSS, TDS and toxicity for (rainy season and dredging in tidal waters) and moderate for (dry season dredging). In both dry and rainy season dredging, the impacts are high in spatial extent. Pipe laying excavated spoils and back-filling in tidal swamps will create turbidity with high spatial extent, especially during the rainy season but these impacts will be of short duration. Cable laying, trenching and river crossing activities will have moderate impacts on macrobenthic organisms. The overall negative impact of these activities is significant (-21).



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

Hydrogeology

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

Soil and Landuse

The project terrain is flat, low lying and flooded during the rainy season. Soil erosion is expected to be a medium impact resulting from bush clearing, excavation, spoils disposal and trenching. This score (-9) is borne out of experience of past projects of similar nature. The surface area to be exposed is a small fraction of the total land area in the project field.



Plate 5.2: Grab dredger in action in Opukushi field.

Observe impact on water: Turbidity, Suspended solids (Macgill, 1996).

Ecology

Loss of flora and habitats for fauna due to bush clearing is the expected impact on ecology. Recent Satellite base map and reconnaissance visits reveal that the area to be affected by gas pipelines is largely occupied by 80% mangroves and 20% rain forest. The land area to be cleared is very small (2.1%), compared to the total land within the area of influence of the project. Although the impact on land take is not significant, the loss of buffer effects of shoreline vegetation through widening of the creeks is significant (-17), as well as smothering of epifauna and impairment of drainage from depositing of dredge spoils on river banks (-15). Cable laying (-11) and riverbed clearance (-7) have medium and low significant impact on ecology respectively. Although the impact on actual land take is not significant, the loss of buffer effects of shoreline vegetation through widening of the creeks is significant (-17), as well as smothering of epifauna and impairment of drainage from depositing of dredge spoils on river banks (-15).

Fisheries

Fishing is one of the major occupations in the area. Dredging seriously pollutes the water with high toxicity and turbidity, which will kill juvenile fishes (-17) and force adult ones out of the environment for weeks after dredging. Both sweeping and capital dredging will take place. The fact that the mouth of Escravos River will be dredged increases the possibility of significant impact. Movement of many watercraft (dredger, cable Laybarge, equipment movement barges and personnel carriers) will curtail fishing activities. The impact is significant (-17).

Noise

Construction noise will have insignificant impact on distant communities (nearest community to Otumara flowstation is well over 2 km away). Piling however is expected to have moderate occupational impact on the construction crew (-11). Shockwaves (compression stress waves) induced on the pile by the hammer, will send omni-directional vibrations from the tube pile. At the onset of the pile driving, these vibrations could disorient fishes in the close proximity before they are able to get away to safer waters. These vibrations could also have negative impacts on the hatching of fish eggs, although the manner it affects them is not yet clearly understood. Potential noise impact on wild life is medium and of short duration (-11).

Socioeconomics

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

Health

With about 400 construction workers, half of them locals, human waste disposal and other toxic wastes could get into water and give rise to water related disease (-21). Other potential negative impacts judged to be significant are scored as: sexually transmitted disease (-18), accident to workers (-16). Explosions could result from maloperation of oxy-acetylene cutting equipment as well from residual hydrocarbons in the process equipment, during abandonment activities (cutting of steel members, etc.), as well as falling objects during lifting operations. These could lead to serious accident, hence total score (-15).

The unexpectedness of full gas flaring and the potential bang that accompanies it will have negative psychological effects on both workers and nearby communities (-19).

Potential injuries to personnel and damage to assets during installation of the CPF (-17) is also significant.

Wildlife and Forestry

The probable impact of bush clearing, noise, heat and light on wild life is of medium significance and of short duration (-11). The potential impact on forestry is also of medium significance (-9).

5.5 Impact Prediction and Analysis

Introduction

The activities scheduled for execution are as detailed in Sections 3.4.1. We restate here for ease of reference, those activities likely to have impacts:

(A) Flowstation and Gas Plant Activities

1. Otumara Central Processing Facility (CPF) of 20 mmscf/d nominal capacity
 - Gas processing Module- Nominal 30 mmscf/day
 - Gas Compression - Nominal 20 mmscf/day

- Power generation/utility modules- Circa 5.5 MW ISO
 - Flare systems relief
 - Blow down systems.
2. Otumara Flowstation Brown Field works
 - Modifications and tie-ins to integrate the new facilities.
 - Site preparation and civil works including all dredging, piling and shoring works.
 3. Design, construction and commissioning of a 44-bed FLB
 4. Decommission, preserve and mothball Saghara flow station, and convert to a free-flow manifold

(B) Pipeline Activities

- i. Corrosion Inhibition Lines - 2" x 5km (From Otumara CPF to Saghara Manifold)
- ii. Test Line - 4" x 5km (from Saghara Manifold to Otumara F/S)
- iii. Bulk line - 6" x 5km (from Saghara Manifold to Otumara F/S)
- iv. Gas Export line - 12" x 12km (from Otumara CPF to ELPS manifold at Escravos Beach)
- v. Flowlines – 15km (Re-routing of 7nos Otumara wells from Saghara F/S to Otumara F/S).
- vi. Manifolds and Pigging facilities (launcher and receiver)
- vii. Cathodic protection system
- viii. 21km Fibre Optic cable for data transmission

Site preparation precedes all the above activities and their impacts will be discussed under the environmental components to be affected.

5.5.1 Emissions to Air

(i) Analysis Years

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

(ii) Primary Pollutant Sources

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

(iii) Secondary or Exogenous Sources

Escravos Beach and Saghara Flowstations are South of Otumara Fields and within 6 km distance. Given the predominant South-Westerly wind direction in the area, Escravos Beach and Saghara Flowstations could be exogenous sources of pollutants.

(iv) Pollutant Receptors

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

Impact Scenarios

The following impact scenarios are considered:

Emission Scenarios

(i) No Project Scenario

A no-project scenario implies continued gas flaring. Fig. 5.1 shows the gas flare record for Otumara and Saghara Flowstations from 2007 to 2013, (the data for 2013 represents one month flare- January). With planned decommissioning of Saghara Flowstation, gases currently flared there will be added to those flared in Otumara. Nitrogen dioxide (NO₂) and SO₂ are presently above regulatory limits albeit for short averaging times. A no-project scenario will mean continued violation of regulatory guidelines.

(ii) Emission from Existing sources

The existing pollutant sources are as indicated in section 5.5.1(ii). The existing air quality within the Otumara and Saghara fields is reported in Section 4.2 of this report, and found to be within the statutory guidelines of DPR/FMEnv for most parameters except NO₂ and SO₂ which exceeded the limits. The emissions from the proposed activities are viewed as distributed sources within the control volume and are assessed for the various stages of the development.

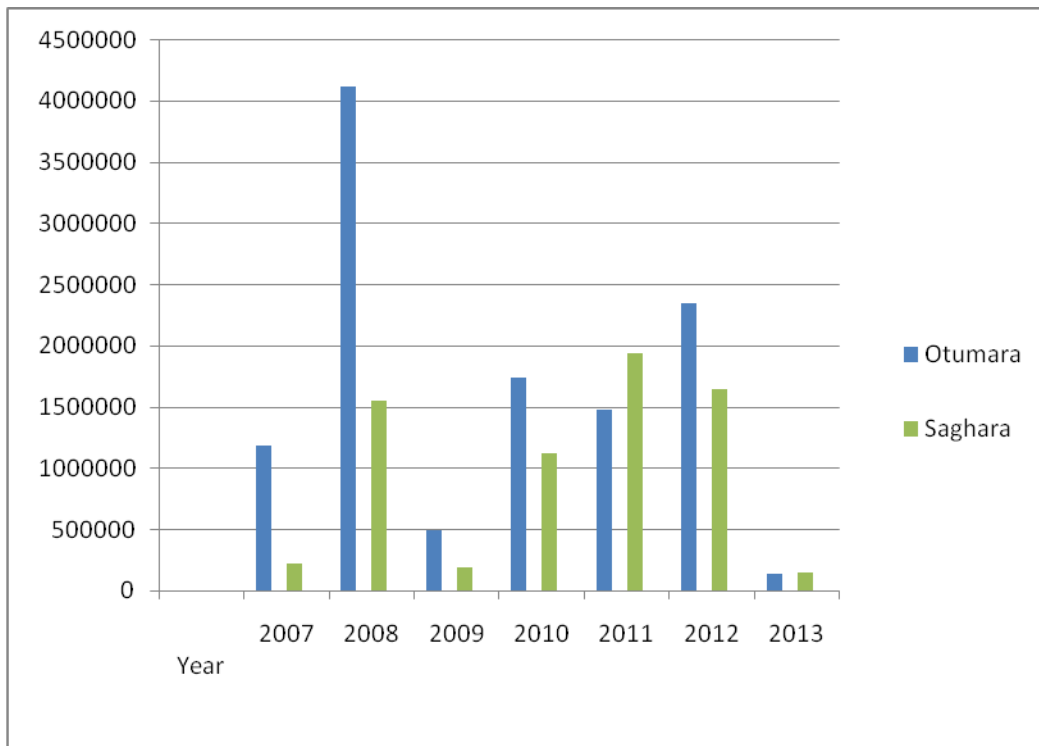


Fig. 5.1: Otumara and Saghara Gas Flare Records (scf/d)

(iii) Site Preparation and Construction

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

The principal air quality impacts during construction in the dry season are:

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

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

Table 5.6: Operational Gas Flares And Typical Gaseous Emission Sources And Quantities

| SOURCE | QUANTITY | QUANTITY | REMARKS |
|---------------------------------------------------|---------------------|-------------------------------------|-----------------------------|
| | 2012 (Existing) | 2017 (Forecast Operational case) | |
| Otumara* | 2,342,011 mmscfd | 1,566,648.2** | Daily average |
| Saghara* | 1,639,412 mmscfd | - | Daily average |
| Exhaust gas from gas engine power generator | 0.2 mmscfd | | |
| Exhaust gas from diesel engine power generator | 0.22 mmscfd | | Unit normally on standby |
| Exhaust gas from gas engine oil pump driver | 0.59 mmscfd (each) | | |
| Instrument Gas | Minimal | | Instrument Gas Vent |

Note:

1. Data for Diesel/Gas Engines supplied by Caterpillar.
2. Gas production data taken from production and gas forecast records.
3. * Data from SPDC
4. ** Based on design criterion of maximum process gas flaring of 10% of production (Forecast for 2017 = 15,666,482 mmscf/d).

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

Table 5.7: Typical Exhaust Gas Compositions

| Exhaust Component (kg/hr) | Gas | Engine Type | | |
|---------------------------------|-----|----------------------|---------------------|----------------------------|
| | | Gas Engine Generator | Diesel Generator | Engine Gas Engine pumps |
| CO ₂ | | 42.86 | 40.55 | 10.6 |
| CO | | 0.06 | 0.28 | 0.13 |
| NO _x | | 1.38 | 1.05 | 5.02 |
| Hydrocarbon | | 0.02 | 0.09 | 0.07 |
| SO ₂ | | - | 0.05 | - |

(iv) Operational

It is anticipated that the most significant air quality impacts will arise during the operational phase of the development. Operations at the flowstations will result in emission of a number of gaseous pollutants including methane, volatile organic compounds, sulphur and nitrogen dioxides. Fugitive emissions of methane and VOC's will occur due to leakages from the process plant and instrumentation, valve actuators and small pumps which are powered by high pressure gas.

The principal gaseous emissions will occur due to combustion of gas by power generators and for powering of compressors. Minor emissions of intermittent nature will occur from the use of standby diesel power generator and process gas flares. Particulate emissions may also occur due to the smoke from flaring under abnormal operating conditions (process offsets) or start-up of diesel engines.

Figure 5.3 shows the existing gas production level and the lift gas for Otumara Flowstation between 1993 and 2013 (January only for 2013), while Figure 5.4 shows the Oil and Water production over the same period. It shows that significant use of Lift Gas really came on-stream from 2009. Actual gas production in 2012 in Otumara Flowstation amounted to 2,846,028.62 mmscf/d, of which 2,440,972.26 mmscf/d was flared. Similarly, 1,639,412 mmscf/d was flared in Saghara Flowstation leading to a combined gas flare of 4, 981,408.5 mmscf/d or 140,973.86 mmcm/d. Using the current Best Practice for Green House Gas (GHG) Emissions Estimation, this translates to the generation of 270,105,916 tonnes/d of CO₂, 5216 tonnes/d of CH₄ and 4934 tonnes/d of N₂O from gas flares in Otumara and Saghara Flowstation. By 2017, there will be no gas flare in Saghara, as the Flowstation would have been mothballed. The Forecast gas production in Otumara by 2017 is 15,666,482 mmscf/d.

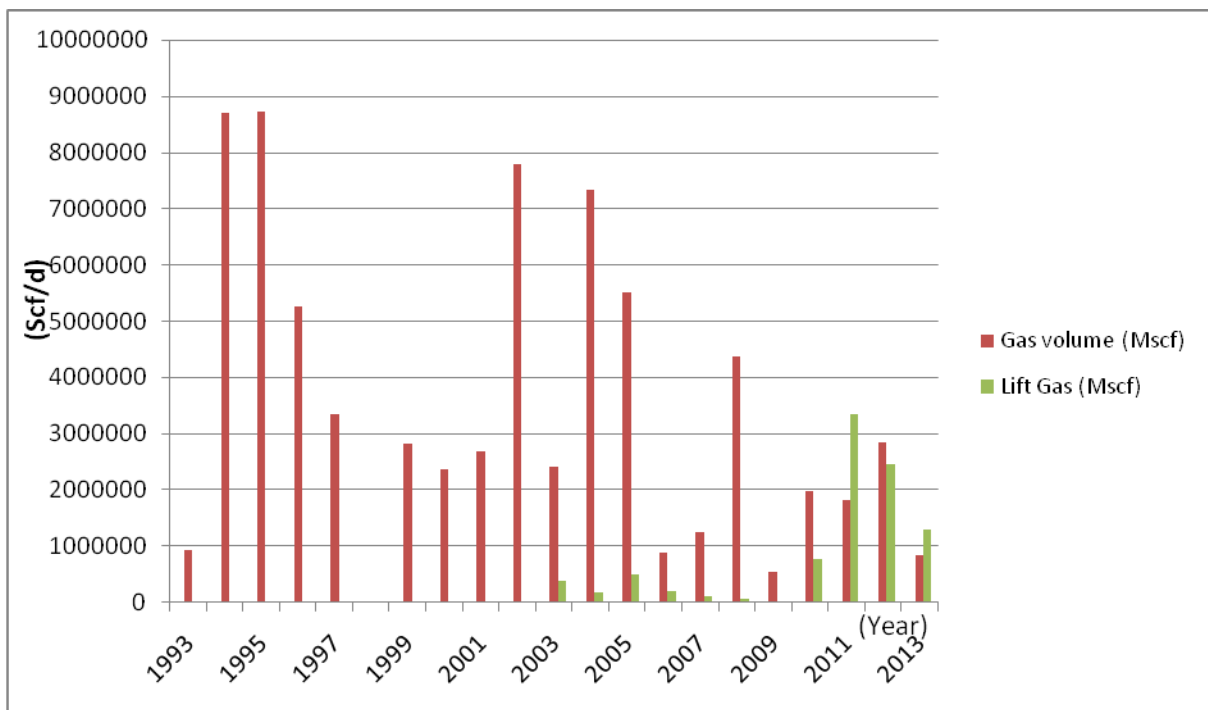


Fig. 5.3: Otumara Flowstation Gas Production and Lift Gas Consumption (1993-2013)

The basis for design provides for maximum gas flare of 10% of gas production. This translates to 1,566,868.2 mmscf/d (Table 5.6 above). Table 5.8 below shows the GHG emission scenario in 2012 and 2017. It shows that the proposed project will lead to very significant reduction in flared gas, and consequently GHG emissions.

Table 5.8: Green House Gas Emission Scenario in 2012 and 2017

| GHG | Tonnes/day | |
|------------------|-------------|------------|
| | 2012 | 2017 |
| CO ₂ | 270,105,916 | 84,959,980 |
| CH ₄ | 5216 | 1640.60 |
| N ₂ O | 4934 | 1551.98 |

5.5.2 Impacts on Soil/Land Use and Groundwater

5.5.2.1 Soil/Landuse

Site Preparation

(a) Bush Clearing and Destumping

Most of the impact of the project on soil and landuse are anticipated during site preparation and construction phases. Specifically, RoW clearance and de-stumping, and spoil disposal are the likely sources of medium impacts. We examine the impacts under the various activities.

In respect of land-take, only 11.0 Ha for the FLB and 3.0 Ha new acquisition for injection of the harvested AG into the ELPS, i.e., a total of 14.0 Ha, will be acquired. No new land acquisition is anticipated. The CPF which will require only about 0.4 Ha, will be constructed within the existing Flowstation boundary. Most of the other pipelines will be laid along existing RoW. It is the practice to de-stump the RoW of 15 m. This may be acceptable on land where one can re-grass the RoW to prevent soil erosion but not in the swamp where reinstatement has proved unsuccessful. In swamp environment, only the width of the excavator need be de-stumped. Thus, the project will have no significant impact on land-take. The impact of this phase of the project on soil is that of compaction and erosion of the de-stumped area with consequent influx of suspended solids into the creek, exacerbated by the tidal nature of the area, leading to increased turbidity of the creek. Soil compaction will also alter the drainage pattern of the area. There is the need to manage the tree trunks and large quantities of vegetable matter that will arise from this activity.

The installation of Booster compressors at Otumara and upgrade of the existing flowstation, will not require acquisition of new land. Both activities will take place within the existing flowstation grounds, hence no significant impact on soil and land use will be experienced through this aspect of the project.

(b) Construction Activities

Pipelines

The stripping of topsoil, trenching and backfilling and reinstatement operation, coupled with the contact pressure of equipment within the working width, have potential impact on soil structure and drainage (assuming standard construction method). Three main processes cause the impacts: compaction, disaggregation and rearrangement, and loss of water.

Compaction occurs in soils where the bearing strength of the soil, or a horizon within the soil, is exceeded by the weight of the plant machinery moving over it. The resulting changes in permeability could significantly affect the drainage characteristics of a soil and water logging could occur. This, in turn, could have secondary impacts upon vegetation species composition and hence, a tertiary impact on landscape quality. The soils most susceptible to

this damage are those of high porosity, low-bearing strength and high water content, typical of the soils of the proposed project areas. The textural profile of the soils in the project areas shows the soil to be sandy to loamy sand at both top and bottom levels. Generally, under the wettest condition, most soils are susceptible to structural damage from compaction and measures to avoid this problem will be outlined under mitigation. Soil compaction is an irreversible impact and is thus better avoided.

Disaggregation and rearrangement is likely to occur wherever topsoil is stripped, stored and replaced, most notably in the trench. This process destroys the natural physical and chemical stratification of the soil. As the soil of the project area is low in Phosphate, the subsoil content being lower than the topsoil, mixing of the topsoil with subsoil during the stripping process would result in considerable dilution of Phosphate and this deficiency would result in poor reinstatement.

Otumara-Escravos Beach Cable Route

It is expected that the Optic Fibre cable will run along the existing RoW to Saghara.

(c) Dredging

The modules and other heavy components will pass through Escravos River and via Otumara Creek to Otumara Flowstation. There will be Capital Dredging into Otumara Field, as well as widening and deepening the narrow/shallow Creeks (Otumara) to accommodate the large vessels that will bring-in the modules. The impacts of dredging on Soil and Landuse are identified as:

- (a) land take and,
- (b) Spoil disposal.

Land take

A 30 m wide barge will need a creek of 60-100 m minimum width for negligible impact on shoreline erosion. Bathymetric survey of Otumara/Saghara creek to identify portions requiring widening and deepening has been done.

The standard width of pipeline RoW is 15 m but at a major river crossing, the RoW is extended to 30 m. Piling for the CPF foundation will be done on swamp and water.

Spoil Disposal

Spoils are routinely dumped on both sides of the creek. This practice unwittingly alters the land use classification of the area as seen by the Satellite. It provides cultivable land (when dry) and encourages squatter camps. Thus, the impact of dredging on soil and landuse is both positive and negative. The positive aspect is the creation of dry, fertile soil (dredge spoil) for planting plantains, cassava, cocoyam, etc. The negative impacts may be summarized as follows:

- Alteration of aesthetics and drainage pattern: the dumping of dredge spoils on the banks of creeks/slots alters the aesthetics and drainage pattern and the geomorphology of the area.
- Terrestrial fauna mortality through burial: this impact is not judged significant for infauna, given the resilience and adaptive ability of such benthic organisms; however

the epifauna may not be so lucky to burrow their way out of the heap of spoil. This is a long term impact.

- Acceleration of collapse of creek/slot bank walls: Wave action from dredging and associated water traffic, and spoil deposition on banks will accelerate collapse of creek/slot bank walls, thus promoting bank walls erosion. Since the creek segments to be dredged are small, the impact is localised to the dredged area, and of medium significance on the morphology and hydrology of the area.
- Acidification from dredge spoil: This could arise by the oxidation of pyrite leading to water contamination and loss of aquatic lives
- Changes in the hydrology: This could lead to emergence of fresh water species in mangrove areas

5.5.2.2 Impacts on Groundwater

Site Preparation

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

The water table in the project area is increased by dredging, thereby increasing the chances of aquifer contamination. The charge and recharge characteristics of the first aquifer in the project area is promoted by dredging. The water table in Otumara ranged from 1.2 m to 1,9 m while that in Saghara ranged from 1.0 m to 1.2 m. The depth (above ground surface) to aquifer is about 15 m in Otumara and 12m in Saghara. From past experience of pipeline profiles, no pipeline lies more than 3 m below the ground level. It is recognised however that there is wide variability in aquifer cover in Northern Swamp area. Borehole lithologs indicate that the aquifer will not be contaminated by pipeline construction in these fields.

Operation and Maintenance

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

Impacts of Pipeline Sabotage

The probable impact of corrosion leakage of underground gas pipe is given above. In the unlikely event of gas pipeline sabotage, wherein it will be assumed that the pipe is accessed after excavation to a depth of at least 1.0 m and sawed or drilled, the scenario is akin to that

of a fluid bursting through an orifice (if drilled) under infinite pressure, to atmospheric conditions, or through a slit (if sawed). It is expedient to consider the orifice scenario. A gas explosion will result in a hyperbolic gas plume with increased temperature and pressure leading to catastrophic consequences for the perpetrators of the act and other life in the neighbourhood. The plume of the hyperboloid and the extent of its propagation can be determined using a mathematical model based on Computational Gasdynamics, but this is outside the scope of this EIA.

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

Toxicity of Gas

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

5.5.3 Effects on Ecosystem

General

The mangrove swamp forest is an area of highest ecological sensitivity, ranking 10 in a scale of 1 - 10 in increasing order of sensitivity (Gundlach & Hayes, 1978). Similarly, the primary forest is an ecological conservation area. Section 21 of the Petroleum Decree No. 51, 1969, protects both mangrove and primary forests. This Section 5.5.3 will be discussed under two headings: Observed Existing Impacts and Associated Potential Impacts of the Proposed Otumara Node AGS Project.

5.5.3.1 Observed Impacts of Existing Activities and Facilities on the Host Environment

From the field survey, it is obvious that the existing facilities and activities have had some impacts on the original environment in this sensitive wetland ecosystem. The important themes are:

A. Dredging and disposal of dredge spoils. The existing facilities in the Otumara area include basically over 32 well head (functioning or not) locations, pipe lines, and the numerous slots dredged for easy access to these facilities. Measurements from the satellite images and ground observations reveal that these channels are 100 to 180 feet wide. The over 20.6 km of dredge slot in the entire field, mathematically, covers between 6 – 700,000 sq meters (= 60-70 Hectares) of sensitive wetland vegetation. The spoils from the dredge are dumped along the edges of the slot with definite consequences for this delicate ecosystem as shown in the Plate 5.3 below.



Plate 5.3: Showing an *Acrostichum* community cut off from the adjoining Swamp – *Acrostichum* Marsh transition zone by dredge spoil associated Plantation farm at VG 15.

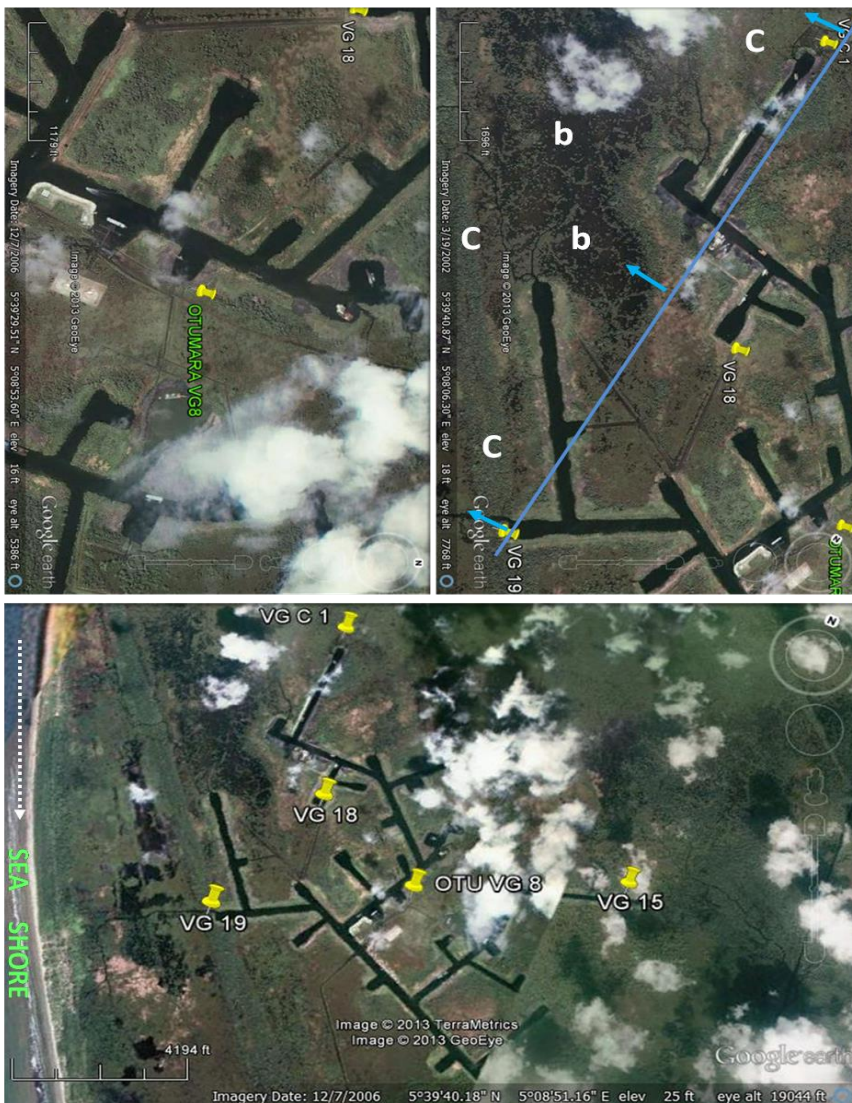


Plate 5.4: Top Left: Slot mesh on HIGH SALT MARSH; Top Right: Slot mesh on LOW SALT MARSH, C= dense *Acrostichum-Avicennia* belt, b = sparsely vegetated low marsh; Bottom: the nearness of the well heads and slot mesh to the coast line.

Whitish brown margins of slots reveal dredge spoil; golden arrows point to some pipeline tracks/ right of ways.

From ground survey, each of the plantain farms is about of 50 feet (15.24 meters) wide and runs along the length of the slot on both sides. This implies that a total of 0.01524 x 20.6 (sq km) area is available on each side of the total slot length. This translates to 627, 888 sq m (62.8 ha) putting both margins of all the slots into consideration. It is observed that about 30-40% of this area (about 25.12ha) is farmed leaving greater potentials for more plantations.



Plate 5.5: Shows a cleared area (about 100 ft wide) adjoining the dredge plantation at VG 15. This is probably part of pipeline laying activities.

More environmental disturbance in the near future is also expected because this platform has made it easier for the indigenes to ravage the patches of transitional swamp vegetation for timber (esp. *Abura*. *Fleroya ledermanni*. Syn *Hallea ciliata*), as well as slash and burn activities for expansion of plantation holdings as seen in Plate 5.5 above.

At the domestic level, Plantain, Coconut, Pawpaw, African breadfruit, and a few other species are seen within the surroundings of houses. Other plantation crops include very few and small estates of Oil palm and *Cassia alata*.

Summary/Quantification of Impact:

1. Estimated total length of dredged area is 20.6 km x 0.039624 km (130 ft) = 0.816 sq km or 816, 000 sq m.
2. Estimated area covered by dredge spoil = 20.6 km x 0.01524 km (50 ft) = 627,888 sq m.

Thus total area impacted by dredging from 1 and 2 above, either for a new slot, or widening of existing creeks (without considering the size of each well head location dredged) as at 19/03/2002 = 816,000 + 627,888 sq km = 1,443,888 sq m (1.443888 sq km). This translates to approx. 144 ha of mostly salt marsh.

3. About 25 hectares of non native vegetation (plantain and associated weeds) has been introduced into the ecosystem.

On a larger scale, the impact measured above, influences the about 22 sq km area transversed by the Otumara field mesh work. The overall implication can therefore be far reaching. It is not unexpected that the dredging of channels and creeks, and the consequent dredge dump mounds would reduce the tidal outreach across the salt marsh and alter the integrity of the ecosystem in some areas. Presently, intertidal range is high and exposes the true capacity of the water channels at low tides; as the water courses become extremely narrow.

B. Siltation of Creeks and Sediment Accretion of Coastlines

Changes in the upstream fluvial environment can reduce the rate of water discharge, and increase the rate of sediment discharge, from river to the coastal environment (Milliman and Ren, 1995).

Dredging which also demands continuous dredging – to check over wash of dredge spoils, and maintain desired depths – have the capacity to alter the natural drainage system: impacting flow dynamics, and donating loads of loose sediments which through longshore drifts translates to coastline sediment accretion. This model is most significant in determining coastline sediment accretion and its rate, as fluvial supply makes up 95% of sediment discharge into the ocean (Walling, 2006).

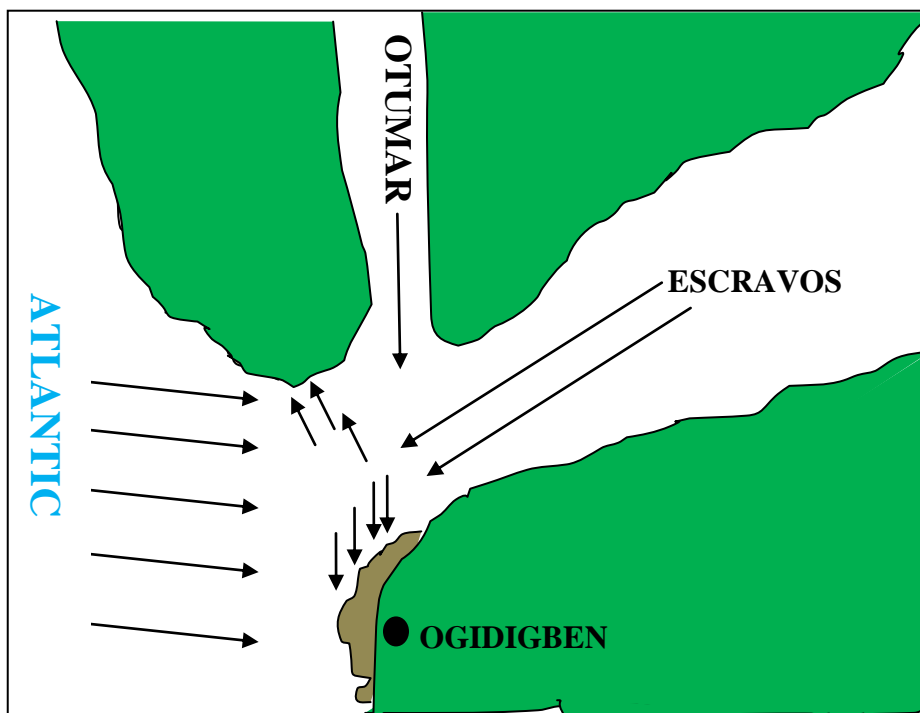


Fig 5.4 Model showing the deposition of sediments at the mouth of the Escravos river.

It has been established that sediment accretion is the major challenge of coastline around the mouth of the Escravos River. The annual rate of sediment accretion on the Niger delta shoreline from the Benin River to the mouth of River Escravos is estimated at 0.521 sq km with the Escravos river mouth as one of the four flash points (Adegoke et. al, 2010). With the southwards flow of water, Its therefore not accidental that the Escravos river mouth and the Ogidigben axis are flash points of sediment accretion which is a product of the combined flow from the Otumara axis and from the upstream of Escravos river into the estuary Fig.5.4.

C. Introduction of Invasive Species and alteration of ecological balance

It was observed that there is a gradual introduction of *Rhizophora racemosa* from the Saghara axis or the TIBO 001 well area into the Otumara area, as shown by the presence of young pioneer *Rhizophora spp* trees (2 – 4m high) scattered along the edge of the dredge slots in Otumara. More worrisome and dangerous is the introduction of the invasive nuisance palm (*Nypa fruticans*) into the area. The Nypa palm is a notorious invasive species that is particularly useless hence the name Nuisance palm. Its capacity to smother existing vegetation, including mangrove, is great.



Plate 5.6: Showing the invasive Nuisance Palm at several locations in Otumara.

This invasion is clearly at the initiation phase as Nypa was spotted along the slot (028/023) which links the Otumara field with the main river that empties into Escravos River. The palms disappear at the saghara end of the slot but are seen dotting the river as it leads to TIBO 001 slot area. It possibly came from that area and was ferried up into the wells 028/023 slot and further inside the Otumara flow station influence area. However, it points to the need to ensure that equipment are properly inspected and cleaned up before use in the area.

5.5.3.2 Associated Potential Impacts of the proposed Otumara Node AGS Project

Site Preparation

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

- bush clearing and de-stumping,
- dredging and seabed clearing;
- river crossing;
- water traffic.

These aspects will be briefly described below. The potential impacts of site preparation (Bush clearing, de-stumping and dredging) are summarised as follows:

(a) Bush Clearing and Destumping

It is proposed that gas pipelines from Otumara to Escravos Beach will follow existing ROWs, except for 3Ha additional land for injection of the harvested gas into the ELPS. Thus, there is negligible impact of pipeline site preparation.

(b) Dredging/Clearing of Riverbed

Sea bed sweeping rather than capital dredging will be the dominant activity in site preparation. Capital dredging will not be undertaken at the banks of Escravos River and any other rivers wider than 50 m. For access to Otumara flowstation with the CPF module barge, through Nana Creek significant widening will be undertaken to ensure at least 70 m width. In the following observations based on past experience, the word ‘dredging’ has been used interchangeably with the word ‘sweeping’ to mean removal of bottom or sides of a creek to improve its navigability.

- Results of previous studies (Macgill, 1994) showed that dredging reduced the abundance of plankton in the waters of the project area, with concomitant effect on fish abundance.
- Increase in nutrient levels (nitrates and phosphates) from dredge spoils would normally cause phytoplankton bloom, but the observed significant decrease in its abundance during dredging in Otumara field was symptomatic of a stressed environment due to release of high concentrations of heavy metals from dredge spoils (Macgill, 1994).
- Past studies (Macgill, 1994, 1996) showed that dredging caused substantial decrease in the abundance of fauna associated with bank roots, macrophytes and benthic organisms. However, Slotta, *et al* (1974), reported that in a study of impact of dredging on aquatic environment, readjustment of benthic infauna to former abundance levels occurred within two weeks of dredging. Thus, although the impact is significant in magnitude and extent, it is short in duration.
- It is known that significant increase in turbidity and level of suspended solids are by-products of dredging, however, Slotta, *et al* (1974), have shown that increases in turbidity and suspended solids associated with dredging do not represent significant impacts if activity is localised. In the present case, dredging will be confined to narrow portions of creeks and silted areas less than 4 m deep. Dredging is thus localized in this project. Thus, the impact is judged of medium significance in magnitude and spatial

distribution and of short duration.

- Given that fishes are sight feeders, fish catches will be reduced due to high turbidity associated with dredging, and juvenile fishes will be adversely affected by gill damage from sediment particles; this will lead to the death of these juvenile species with attendant long term effect of fish availability in the area. The adult species, which require clear vision for sourcing their food, would migrate to clearer waters outside the project environment thereby creating temporary fish scarcity within the project environment. In general, the economic position of the local communities will be weakened by the adverse impact of fish scarcity. Given the localized nature of the dredging in this project, the anticipated impact is judged of medium significance in magnitude and spatial extent and of short duration.
- Clearing of seabed with grapnel may not be noticed even by the keenest observer, nor even by the most inhabitants of the sediment. The movement of the site clearing barge is slow (1000 m/hr), and the fingers of the grapnel are unobtrusive. This impact is low in magnitude (given the small width of the grapnel) and of short duration.

Construction/ Installation

Construction activities likely to impact negatively on the receiving environment to varying degrees include:

- ditching;
- backfilling;
- piling;
- submarine cable laying;
- river crossing;
- water traffic.

These aspects will be briefly described below.

Ditching and Backfilling

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

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

Piling

The piling activities likely in this project are at the site of the proposed logistic centre at Otumara flowstation where the CPF will be installed. Large quantities of steel piles will be driven into the ground using pile hammers. Pile driving produces the loudest high frequency noise in the construction industry (96-106 dBA at 10 m). Shock waves propagating down the pile cause omni-directional transverse vibrations (inaudible shock waves), which propagate through water and land, assailing soil and macrobenthic fauna as well as fishes. At the onset of

piling, fishes in the impact zone (area of close proximity of the pile) could be disoriented and some may die, while others will migrate away from the area of impact until vibration subsides. Benthic macrofauna are the most susceptible to the impact from intense vibration from piling, especially the sessile ones. Pile driving can trigger land subsidence in unfavourable soil conditions. Given the terrain of the project area, subsidence from pile driving has negligible probability. Studies of impacts of Sonic Boom on wild life confirmed that intense shock waves from supersonic flights affected hatching of eggs of birds (ICAO, 1973). The impact of this activity is however localized, low in magnitude and of short duration, hence not significant.

River crossing and Water traffic

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

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

Optical Fibre Cable Laying

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

Operation and Maintenance

Pipelines

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

Pipeline maintenance would involve occasional pigging operations with the aim of:

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

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

Power Generation and Gas Conditioning Facilities

Past experience has shown that whenever production facilities are installed on piled platform over creeks, both plankton and benthic fauna population are always low in abundance in the vicinity of the facilities (Macgill, 1994, 1996, 2000). Saver pit overflows during heavy rains, leaks and spills and effluent discharges have mostly been implicated in the observed conditions. Given the size of the CPF and its components, control of leaks, spills and treatment of effluent discharges to approved quality, are the major tasks confronting the operators of these facilities.

Tri-Ethylene Glycol (TEG) is the gas dehydrating agent selected for this project after evaluation with two other dehydrants. There is environmental risk associated with the use of this liquid. It can leak/spill during storage, handling and operation. It has to be regenerated in a kind of boiler and re-circulated. Special care is therefore required in handling this liquid in both its operational forms – liquid and gaseous (it could enter the atmosphere with gas as fugitive emissions).

Effluent discharges are expected from routine maintenance/ cleaning of separators, knockout vessel and dehydration plant. The effluents from separators and knockout vessel will consist largely of oil sludge and brine. The effluent from the dehydration plant will include weak carbonic acid among others, and possible oil sludge, since provision is made in the design for by-pass of the liquid knockout vessel. All these effluents will adversely affect the ecology of the receiving environment if not properly disposed.

5.5.4 Impacts on Wildlife and Forestry

5.5.4.1 Impact of the Proposed Project on Forestry and Wildlife

Site Preparation and Construction

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

The size of the area to be cleared (circa 5 Ha) is small compared to the size of the field (1,218 Ha). The impact is of long duration but low in spatial extent.

Operation

Gas flaring will go down to 10% of production level, but full flaring may occur under certain operating conditions. This unexpected full flare may have more startling effect on wild life than routine full flare to which they have adjusted. People who may for one reason or the other, find themselves near the flare pit may be hurt by unexpected flare explosion.

Experience from existing facilities show that heat and thermal radiation may affect vegetation within the sterile zone of the flare (about 200 m), but not significantly thereafter. With flare reduction to 10% of gas production, some wildlife will return to the neighbourhood of the flowstations, but may be sent out again by spontaneous flare explosion.

5.5.5 Impacts on Water

Site Preparation

Otumara and Saghara facilities are in Brown Fields where ROWs already exist and most pipeline works will take place along the ROWs. Bush clearing and de-stumping for pipeline route from Otumara to NGC Manifold in Escravos, re-routing existing Saghara Wells to Otumara Flowstation, Connecting Bulk lines and Test lines from Saghara Flowstation to Otumara Flowstation and injection of harvested gas into ELPS, are all activities that will involve trenching and backfilling. The impacts of these activities are inundation of the water bodies with suspended solids and increased turbidity (see Plates 5.1 and 5.2). These impacts will be wide spread as the debris are redistributed by tidal waves to adjoining water bodies.

Dredging

Dredging in tidal waters has the tendency to affect far greater areas of water than the immediate dredging environment. Thus, dredging will:

- increase turbidity and total dissolved and suspended solids in the water bodies including areas far removed from the immediate project area,
- increase heavy metal concentrations in the water bodies,
- degrade the quality of surface water for domestic use in local communities,
- cause release of organic and inorganic materials that can create oxygen deficiency in the water column.
- increase the piezometric ground water level in the immediate and outside the project area, thereby increasing the dangers of aquifer contamination.
- increase the water related diseases frequency due to domestic waste water and sewage being discharged into the creeks by the dredging crew.

All above are adverse impacts. There are positive impacts associated with dredging. They are:

- increased fishing opportunity by creating migratory paths for deep sea fishes into the hinterland, although some operational activities of oil companies, such as sweeping silted slots and heavy watercraft traffic, tend to negate this advantage.
- promotes increased discharge, hence increased dilution factor in the case of local contamination,
- improves circulation of water currents and transport of food chain for marine life.

Construction/Installation

Optic Fibre Cable Laying

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

Installation of the CPF and Booster Stations/Upgrades

Impacts associated with these activities include:

- droppings of paints and corrosion inhibitors for metal surfaces into water,
- leaks and spills of fuel and lubricating oils from construction equipment,

- discharge of domestic waste water and sewage into the water by construction crew,
- potential leakage and spills of glycol during installation,
- discharge of oily brine and sludge into water during replacement of crude oil export pumps.

The probabilities of occurrence of all the impacts enumerated above, are high, but the magnitude of the impacts is low, unless there occurs a major accidental spill due to human error, and the probability for this accident is low. Substantial solid wastes will be generated at the FLB. It is expected that most of the materials will be returned to SPDC Industrial Area base in Warri for appropriate disposal.

Operation and Maintenance

The main sources of impact on surface water during operation and maintenance are:

- discharge of effluents from the flowstations and the CPF,
- accidental spills of oil from the flowstations and leaks of glycol from the CPF.

In respect of regular discharges of effluents, it is important that effluent treatment facilities at the Flowstation function properly to meet statutory requirements. In respect domestic waste water and sewage discharges from the logistic base, it is expected that proper sewage treatment facility will be in place.

Assuming that about 44 persons per day use the FLB, a provision for treating at least 5,000 litres of domestic waste water and sewage per day should be made. There should be a fit-for-purpose potable water facility at the FLB, and not rely on bottle packaged water, which invariably litters the facility environment.

5.5.6 Noise and Vibration Impacts

Site Preparation and Construction

The ambient noise level in most sites within the field ranged from 46.3 dBA at uninhabited location in Otumara (AQ13) to 65.2 dBA at uninhabited location in Saghara (AQ5). The activity equivalent continuous sound pressure levels, L_{Aeq} at a distance of 10 m for various site preparation and construction activities are shown in Table 5.9.

Table 5.9: Typical Noise Levels for relevant Construction Equipment*

| Equipment Description | L_{Aeq} , dBA @ 10 m | Remarks |
|-------------------------|------------------------|-------------------------------------|
| Piling, H-section Steel | 106 | 5.5 tonne-metre energy, 65% on-time |
| Piling, sheet Steel | 96 | 6.2 t-m energy, 70% on-time |
| Excavator | 87 | 73 KW, 100% on-time |
| Trenching | 78 | 52 KW, 100% on-time |
| Trench filling | 80 | 46 KW, 60% on-time |
| Dredging | 96 | Dredger 35 m long, 100% on-time |
| Clearing River Banks | 79 | 80% on-time |
| Gas Turbine | 140 @ 1m (85 @ 1 m) | 20 MW capacity** |

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

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

Given that the Gas Turbine noise data was published over two decades ago, it is expected that the present day gas turbines will be much quieter. The specification for the proposed gas turbine at Otumara is 85 dBA at 1 m.

Otumara will be the area of highest noise level generation both during construction and operation phases. It is expected that tube steel piling will be used at Otumara while sheet piling may be undertaken at river crossings. Sheet piling will be carried out (if necessary) at Otumara flowstation to protect the shoreline from wave erosion. Given the distances of the major communities from the flowstation, ranging from 2 km to 8 km, construction and operational activities are not expected to exert significant noise impacts on them, based on existing field data (dense vegetation separating the communities from activity sites provide the necessary acoustic barrier).

Prediction of Construction Noise

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

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

The major sources of construction noise are shown in Table 5.9, and the no communities likely to be affected are within 2 km of the site, hence no negative noise impact on communities is expected.

Piling Equipment Options

There are at least three equipment options for Sheet Piling with the following characteristics:

- (a) Diesel Hammer – 5.5 tonnes (t) with no Dolly (an object placed between a pile and the head of the pile driver to prevent damage to the driver);
Soil type – silt/rock,
Noise level 106 dB at 10 m with 65% on-time;
- (b) Drop Hammer – 2.5t with wood Dolly,
Soil type – Fill,
Noise level – 81 dB,
- (c) Hydraulic Hammer – 220 t with no Dolly,
Soil type – Wet clay,
Noise level – 78 dB

Two types of hammer for Tube-Section steel piling are available, and perhaps, more:

- a. Drop Hammer, 5 t, with wood Dolly,
Soil Type – clay/flint/chalk,
Noise level – 94 dB with 50% on-time.
- b. Diesel Hammer – 6.2 t-m with no Dolly,
Soil type – clay/flint/sandstone,
Noise level – 96 dB with 70% on-time.

For sheet piling, we will consider the worst noise scenario (Diesel Hammer), and the most favourable noise scenario (Hydraulic Hammer). For the Tube-Section steel piling, there is no significant difference in the noise levels, but the drop hammer is more advantageous because of slightly lower noise level and the presence of wood Dolly which will dampen impact and minimize transverse vibrations. This project will utilize 0.75 m diameter steel pipe which has nearly the same noise range as the Tube-section but lower frequency vibration characteristics.

Low frequency vibrations have more energy and travel farther than high frequency vibrations. In the calculations of construction noise levels, it is assumed that dredging and piling crews will reside in houseboats with diesel generators, during the construction process. It is assumed that piling and dredging may not proceed simultaneously, but that flowstation operation will proceed simultaneously with either piling or dredging. We consider the worse scenario – simultaneous piling/dredging and Otumara flowstation operation:

Sheet piling with diesel hammer plus flowstation operation- Since no human settlement exists within 2 km of the Flowstation, let us take the worst case scenario of the highest noise source at the construction site - (Sheet Piling) 96 dBA at 10 m. The measured noise level at about 2 km from Otumara Flowstation (operational noise) was 46.3 dBA. The calculated noise level from Sheet Piling at 2 km distance, allowing for vegetation attenuation is 49.4 dBA. Calculated combined equivalent continuous noise level at 2 km radius $L_{Aeq} = 51.2$ dBA (Sheet Piling and Flowstation operation).

Operation

The operational noise of interest is the cumulative noise consequent upon the installation of Booster compressors at the flowstations and the gas turbine and main compressor at the CPF. Certainly, the CPF (consisting of gas turbine, main compressor and dehydrating unit), and the flowstation, will be the dominant noise source at Otumara. The proposed logistics centre will be the main receptor of operational noise. The measured (Nov 2012) noise level 450 m from Otumara Flowstation was 58.9 dBA, which translates to 91. The safety of the operational crew within the Flowstation and the CPF is covered by the Mineral Oils (Safety) Regulations of 1997.

In the Health Risk Assessment (HRA) Report (Doc. No: SF-12.01.HSE.003, 2001), a maximum noise level of 85 dBA at 1 m from the equipment had been specified for any high noise equipment. The existing conditions at all the existing flowstations are such that the crude oil pump gas engines produce the highest noise, followed by the gas powered electric generators.

Night-time Noise levels

The operational noise levels calculated above are for day-time periods. These day-time noise levels will be perceived louder at night. The calculated equivalent day-night noise levels at the proposed Logistic Centre will have to await facility layout plan. The internationally accepted indoor L_{Aeq} for residential areas for non-sleep interference, is 35-45 dBA (Hassal, *et.al*, 1988). Similarly, if we assume that the houses at the Logistic Centre will be made of 225 mm block walls, wood panel/metal doors and single glazed 6 mm glass windows in heavy frames (which is typical), a noise reduction of 20 dB can be allowed, which will reduce

the indoor noise level to an acceptable value.

Transportation Noise

Water transport is an important activity in this project. Movement of heavy equipment, such as the CPF and associated modules, pipes and piles, etc., will be undertaken using barges towed by tugs. These tugs are largely low speed machines, capable of low level noise. Personnel carriers however are sources of noise which will impact shoreline communities particularly in narrow creeks. Strict adherence to Marine Journey Management Standards and Guidelines, and effective monitoring and control of boat Captains will be imperative, given the volume of traffic anticipated.

5.5.7 Impacts on Resource Utilization

Background

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

Oil and Gas

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

The main thrust of this project is summarized in the statement "Flaring "quota" of maximum of 10% of associated gas production per annum must be achievable by 2015 with continuous improvements thereafter". Associated Gas gathering shall be in line with the newly issued flaring policy document " "Flare-Down" Policy - Current Status - 2015".

Diesel Fuel

Diesel will be used extensively as fuel largely during construction phase, and to a smaller degree for the flowstations stand-by electricity generators when the gas powered generators are not operational. It will also be used to power the numerous outboard engines that power field transport boats for personnel and goods from the logistic centre to the flowstations. At present, local contractors provide petrol powered boats to shuttle staff from Otumara to the Saghara and Escravos Beach Flowstations. Construction of Otumara FLB, and mothballing of Saghara Flowstation, will obviate the need for the shuttling and conserve diesel fuel.. Estimates of diesel fuel required for construction and operation over the facility life cycle approximate to about 12.5 million litres.

Land Take

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

Forest products

No direct use is made of forest products through operational requirements within the field. However, the presence of the flowstations and associated facilities has permitted access to greater exploitation of forest products by human settlers within the area. Forest products exploited by local people include timber for building homes, fish traps, canoes, house furniture, fuel energy for cooking, etc. Others include raffia palm for making native gin, fruits, nuts, berries etc, which are used for food and palm leaves used for their house roofing.

These may not have any significant impacts on the swamp forests at the moment but further oil and gas exploitation could lead to more demographic movement to the area thereby increasing exploitation with major impacts on the fresh water forests. Fuel wood, the principal fuel for cooking in the area, will become plentiful. Those trading in fuel wood will not search far to fetch it. This is ironical because, while on the one hand, Otumara Node AGS may destroy fish habitats and take away fishing jobs, it is creating more income for dealers on fuel wood.

Fish

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

Water

Water use and conservation is not an issue within field partly due to the high volume of seasonal rainfall within the area (annual average of 2480 mm), and because there is no infrastructure for storage and treatment of water for human consumption. The flowstation facilities rely on water imported from Warri with barges on a regular basis. The water is used on site for cooking, washing, bathing and conveniences. Drinking water for flowstation personnel is bottled and supplied during regular food runs. The local communities sometimes rely on drinking water available to the flowstation or collected in containers during rainfall.

Coastal communities rely on hand-dug wells in the oasis (small patches of freshwater forests) for potable water. The project will not have any significant negative impact on water resources in the field.

Electricity

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

5.5.8 Risk Assessment

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

Table 5.10: HAZID Assessment

| S/N | Development Phase | Activity/Event | Hazard | Effects | Remedial Action | Priority Rating |
|-----|-------------------|-------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|
| 1 | All Phases | Climate Extremes | <ul style="list-style-type: none"> • Heavy Rainfall • Lightning | <ul style="list-style-type: none"> • flooding, soil erosion, creek siltation, personnel discomfort, • impairment of construction activities, • poor visibility leading to boat accidents. • Electrocutation of people, damage to equipment | <ul style="list-style-type: none"> • Incorporate effects into detailed design, • Schedule construction during dry season • Careful marine journey management • Install lightning arrestors on construction sites/flowstations. Adequately ground steel structures. | M H |
| 2 | Site Preparation | Bush Clearing Dredging/ Sweeping Seabed Clearance/ Cable Laying | <ul style="list-style-type: none"> • Wrong use of chain saws • Lack of concentration • Diesel fuel spill during equipment fuelling • Insensitivity to third party property • Disruption of Community socio-economic life • Damage to total environment | <ul style="list-style-type: none"> • Personnel injury from chain saws • Harm to people from falling trees • Soil/Water pollution • Damage to fish ponds, shrines, distilleries and farms • Community displeasure • Damage to fishing gears, loss of fishing. • Pollutes community potable water • Disrupts commercial water traffic • Shoreline erosion • Spoil disposal degrades aesthetic quality of the environment and impedes drainage. • Damage to aquatic ecosystem <p>Damage to seabed topography</p> | <ul style="list-style-type: none"> • Exercise of care and diligence • Alertness and proactive action plan • Employ spill-proof fuelling system. • Relocate and pay compensation • Proactively sensitize the communities • Pay reasonable compensation. • Provide potable water to affected communities. • Early notice to NIWA and general public of work plan, with strategic moored guideposts. • Protect (shoreline/river bank) areas with serious erosion Problems. • Spread spoils evenly starting at least 5m from the shoreline. • Minimize requirement for dredging by using low-draft vessels. Use silt curtains to cordon off dredge site to minimize spread of total solids. • Ensure adequate reinstatement of seabed topography. • Fluidize seabed to the minimum width required. | M H H M |

5.5.9 Social & Health Impacts

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

Demographic Impacts

The various phases of Otumara AGS development will most likely attract additional people to the host communities. Some of these will be people who have come from elsewhere to seek employment or to trade. Others may be employees of the project who may take up residence in any of the host communities. Other categories of people who may move into the communities to take advantage of Otumara AGS are contractors or itinerant youth who may want to perpetrate the vexatious habit of extorting money from Otumara AGS personnel and other operatives.

New in-migrants will impact on the host communities in various ways. There will be pressure on existing facilities and social infrastructure, housing, sanitation and health services. Considering that the state of infrastructure and facilities is already very poor, the impact will be very negative. More substandard houses may be built in response. There may even be a rise in anti-social activities.

The structure of the population will be further skewed in favour of the youth as immigrants are likely to be young adults looking for ways of eking out a living.

Socio-economic Impacts

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

Beneficial Effects

Employment is one area in which expectations are very high in the communities. Otumara AGS will employ different categories of personnel, skilled and unskilled. With particular reference to the communities, employment will be provided for mainly unskilled workers because of the rather low level of skill development in relation to project requirement.

However, the project will invigorate the economies of the communities. Traders in food items and general consumer goods will witness a boom in demand as more people move into the communities. Increased demand for fish will encourage more people into fishing thus creating more employment. Boat operators will also benefit, as traffic will increase with the increase of in-migrants.

If people acquire new skills from Otumara AGS, they may create employment for themselves and even employ others. In this sense, the project may be a source of development for the communities.

By energising the local economy, creating direct and indirect employment, new sources of income will be created and old sources enhanced. Otumara AGS will therefore play a major role in poverty alleviation in the communities.

Otumara AGS will require the opening of waterways to facilitate the movement of materials and men. These waterways may not only open up the communities but will facilitate inter-

community movements and communication. This project has a Project Global Memorandum of Understanding (PGMoU) with the communities for sustainable development projects to be initiated and managed by the communities. The total value of the projects under the PGMOU is N350 million. Indeed, Otumara AGS portends to be a harbinger of modern growth in the host communities.

Harmful Effects

The mobilisation of personnel and equipment to site is required for the commencement of the various phases of the proposed project. This increased water traffic involving the movement of heavy equipment, and machinery along the major waterways in Otumara AGS will occasionally cause localised disturbances to local commuters in canoes. Waves generated from the movement could endanger the canoes both in the middle and banks of the waterways. Indeed, wave generated from the water traffic is capable of breaking fragile canoes tied along the banks in the communities. In any of the above cases, SPDC - community conflict is the likely result and demand for compensation by affected persons will be made.

The movement of heavy equipment and supply boats along the waterways, as well as the dredging of some of the waterways, could also cause temporary disturbance to commercial and fishing activities. Part of the disturbance may result in the destruction of fishing nets and traps, which are common features of the riverine areas. Accidental destruction of fishing nets could provide grounds for SPDC - community conflicts and demands for compensation by the affected individuals.

Health and Safety Impact

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

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

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

Increase in population will lead to more waste production, which will require greater attention in the form of refuse collection and disposal, sewage disposal and disease vector control. In addition, waste will be generated during some of the project activities such as site clearing,

dredging and demolition/abandonment. Improper disposal of industrial and domestic wastes into the surrounding water bodies (especially human wastes from houseboats and other facilities) may increase the incidence of water borne diseases, which are prevalent in the communities.

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

CHAPTER SIX MITIGATION OF IMPACTS

6.1 Introduction

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

6.2 Mitigation Measures

Mitigation measures are actions taken to minimize negative impacts, while also enhancing positive ones. These measures typically aim to improve the environmental sustainability of a project. Depending on the nature of the impact they apply to, they can already be applied during the design, planning or implementation stage of the project. Mitigation measures are often implemented on a continuous basis through the project's life-cycle. Specific mitigation measures are aimed at reducing negative impacts to As Low As Reasonable Practicable (ALARP) and where possible enhance positive ones.

At the preliminary Engineering Design level, some mitigation measures had been proffered, based partly on past experiences and corporate HSE policy, and partly on regulatory requirements. As part of the feasibility study for the Otumara AGS project, strategies have been put in place for the management of potential impacts identified at that level. SPDC as a company determined to carry out Exploration and Production through sound principles of sustainable development is committed to the implementation of mitigation measures that will ensure sustainability.

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

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

| Project Activity | Description of Impact | Rating Before Mitigation | | Rating After Mitigation |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|
| All Phases | Climate Extremes – Heavy rainfall and Lightning strikes; May increase safety hazards of the work. Delay in project schedule may increase time of delivery and cost; | H | SPDC shall make extensive use of yard pre-fabrication in order to minimise site construction activities. SPDC shall schedule site preparation and construction activities in the dry season (October to March) | L |
| | Fatality, damage to assets due bad weather | H | SPDC and Contractors shall make extensive use of yard pre-fabrication in order to minimise site construction activities. SPDC shall schedule site preparation and construction activities in the dry season (October to March) | M |
| | Deprivation of personal liberty, injury, fatality due to Kidnapping | H | SPDC shall strictly implement its Security Policy | L |
| Pre-mobilization and Mobilization Phase <ul style="list-style-type: none"> • Land Acquisition • Land survey • RoW Clearance, Tree felling/ De-stumping, Civil Works, and Facilities • Construction site • Waste Disposal • Dredging/ Sweeping/ Piling • Piling • Dredging Waste Disposal | Increased erosion potential due to removal of vegetation canopies and road paving | H | SPDC shall minimise bush clearing to what is required for construction activities SPDC shall avoid de-stumping as much as possible within the RoW | L |
| | Loss of economic trees and ecologically important vegetation (mangroves and rain forests), | H | SPDC shall minimise land-take as much as practicable SPDC shall pay adequate compensation for loss economic trees/plants | L |
| | Loss of habitats for wildlife. | M | SPDC shall not cut down timber-size trees greater than 60 cm girth, as they are protected by law. Site preparation land shall be limited. Low-noise equipment shall be used. Habitat loss shall be limited as much as practicable | L |
| | Loss of farmland, fishponds, gin distilleries and shines may result along the pipeline routes. | H | SPDC shall pay compensation for loss of income to those affected. SPDC shall pay adequate compensation for lost economic trees/ plants. Site preparation land shall be limited. Low-noise equipment shall be used. Habitat loss shall be limited as much as practicable | L |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| Project Activity | Description of Impact | Rating Before Mitigation | | Rating After Mitigation |
|------------------|--------------------------------------------------------------------------------------------------------------------------------|--------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|
| | Income to local workers that may be employed for the bush clearing activities | P | N/A (impact is beneficial) | |
| | Improved quality of life may result from increased project spending which will stimulate economic activity in the area. | P | N/A (impact is beneficial) | |
| | More infrastructures may be built or developed in the communities as part of the projects' CD initiatives. | P | N/A (impact is beneficial) | |
| | Communicable disease may increase due to poor sanitation practices when more pressure is put on already poor state of housing. | H | Step-up health education and sensitisation activities prior commencing construction activities and support condom donation initiatives. SPDC shall organise awareness session on communicable diseases related to water and sexual behaviour. Step-up HIV/AIDS awareness programmes. Augment the supply and issue of condoms to workers on the project and possibly extend to commercial sex workers in the vicinity if identified. | M |
| | Increase in cases of sexually transmitted disease and other disease strains may result through migrant workers. | H | Step-up health education and sensitisation activities prior commencing construction activities and support condom donation initiatives. SPDC shall organise awareness session on and sexually transmitted diseases, sexual behaviour for workers and local hands that will be employed | M |
| | Accidents to workers will increase especially for local labour not sufficiently skilled for the type of work. | H | SPDC shall ensure the provision and enforcement of the use of appropriate PPEs on site. SPDC shall provide adequate First Aid and functional medevac system on site. SPDC shall ensure that approved detailed Job Hazard Analysis (JHA) is provided by the contractor and that all the controls and barriers are adhered to. SPDC shall ensure that daily tool box meetings are held | L |
| | Increased in suspended solids in water | H | Use of silt curtain to prevent migration of plant matter, | L |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| Project Activity | Description of Impact | Rating Before Mitigation | | Rating After Mitigation |
|------------------|-----------------------------------------------------------------------------------------------------------------------------------|--------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|
| | | | debris | |
| | Discharge of fecal waste into the water will contaminate drinking water sources and increase water related disease (cholera etc). | H | Treat all waste water to DPR standards prior disposal Provision of mobile toilets for its work-force SPDC shall regularly monitor the quality of effluent to ensure that it meets regulatory standards SPDC shall adhere to its waste management procedure | M |
| | Shoreline erosion, | H | SPDC shall carry-out shore protection in areas susceptible to shoreline erosion SPDC shall use sheet piling of the area affected. | L |
| | Disturbance of riverbed topography and re-suspension of fine sediments and bottom materials | M | SPDC shall use the best available technology (suction dredging) to minimize disturbance to riverbed topography | L |
| | Increased turbidity and suspended solids, | H | SPDC shall deploy the most appropriate technology (silt curtain), to minimize loss of benthic organisms. | L |
| | Displacement of water by increased frequency of badge traffic may result in flooding of low lying communities. | M | Adherence to journey management guidelines and sensitization of boat captains | M |
| | Loss of juvenile fishes due to gill damage from silt particles. | H | Use of appropriate technology (suction dredging) and silt curtain to reduce turbidity | L |
| | Dredging improves circulation of water currents and transport of nutrients for marine life food chain. | P | Positive impact | |
| | Loss of buffer effects of shoreline vegetation may result from creek widening | H | SPDC shall Limit widening of Otumara creek or any other creek to be used for Barge movement,, to a width that will cause minimal shoreline erosion | M |
| | Temporary disruption of local fishing/harvesting activities. Fish spawning habitat may also be destroyed. | H | SPDC shall ensure strict compliance with good marine journey management practice, including sensitisation of quarter masters / boat masters on how to pass fishing and commercial boat | L |
| | Acidification of the soil and surface water as a result of deposition of dredge spoils on the banks of the river | H | SPDC shall ensure dredge spoil is deposited at least 10 metres into the buffer zone or Cap spoil with clean sand. | L |
| | Salt water intrusion (surface and ground water)as a result of dredging activities | H | SPDC shall ensure no hydraulic connection between the sea and the coastal forest by using cofferdams and sheet piling for the shoreline approach, The use of shore protection techniques to achieve rapid | L |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| Project Activity | Description of Impact | Rating Before Mitigation | | Rating After Mitigation |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|--------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|
| | | | stability of the excavated area for the shore approach area after the installation of offshore section of pipeline | |
| | Water traffic disruption with possible increase in marine accidents | H | SPDC shall ensure proper scheduling of supply boat movements so as not to interfere significantly with artisanal fishing and commercial boat activities. SPDC shall consult with the relevant Local Government and give adequate notice to the communities, of impending work and route plan, Institute good marine journey management system in-line with SPDC policy. | L |
| | Impairment of hearing due to noise and vibrations | M | SPDC shall enforce the use of appropriate PPE | L |
| | Spoil disposal will smother epifauna and impair surface drainage especially in wetland areas | H | SPDC shall dispose dredge spoils in an environmentally-friendly manner | L |
| | Pollution of drinking water sources may occur if domestic waste is discharged directly into the river. | H | SPDC shall adopt dredging technology that minimises re-suspension of sediments, such as Silt Curtains | L |
| | Third Party agitation | H | Relevant stakeholders/legacy issues shall be identified Regular consultation with stakeholders (Govt., Community, NGOs, CBOs etc.) shall be carried out to understand community perceptions, issues and concerns Effective liaison/communication channels (CIC/CROs) from the communities to the project execution team shall be established. Adequate and prompt compensation shall be made Effective Implementation of PGMoU | M |
| | | | | |
| Construction Phase • Pipeline/ Bulkline Construction and Laying • Trenching/ Backfilling • Welding/ NDT/ Coating/ Wrapping • Hydrostatic Testing | In tidal swamps, this will increase surface water sediment loading and suspended solids. | H | SPDC shall deploy the most appropriate technology, to minimize loss of benthic organisms. | L |
| | Irreversible soil compaction which may alter the topography of the RoW. | M | SPDC shall use low pressure tracked equipment for construction | L |
| | Salt water intrusion into ground water, through ELPS (hydraulic seepage around the circumference of the pipe) | H | SPDC shall ensure no hydraulic connection between the sea and the coastal forest by using cofferdams and sheet piling for the shoreline approach, The use of shore protection techniques to achieve rapid stability of the excavated area for the shore approach | L |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| Project Activity | Description of Impact | Rating Before Mitigation | | Rating After Mitigation |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|--------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|
| <ul style="list-style-type: none"> • River Crossing • Waste/Spoil Disposal • Communities electrification • Transportation of Module/ Equipment • Water transportation • CPF Installation and FLB Construction • Welding • Installation, tie-in and pre-commissioning of facilities. • Unloading and installation of CPF/ Modules | | | area after the installation of offshore section of pipeline. | |
| | Exposure to radioactivity and release of chemicals | H | SPDC shall provide radiation counter to workers for monitoring individual radiation levels. SPDC shall provide and enforce the use of protective aprons. SPDC shall ensure that the activity is carried out in accordance with standard procedures. | L |
| | Impairment of vision from arc welding | M | SPDC shall enforce the use of appropriate PPE. | L |
| | Improper disposal of lay barge deck drainage will contaminate surface water and sediment. | M | SPDC shall ensure that effluents and solid wastes are collected for off-site disposal | L |
| | Discharge of untreated test water into the receiving environment. | M | SPDC waste management specifications and guidelines (especially with regards to the discharges into the environment) shall be complied with. | L |
| | Disaggregation of benthic habitats and loss of benthic organisms. | M | SPDC shall adopt due diligence to minimize adverse impacts on benthic organisms | L |
| | Disturbance of riverbed topography. | M | SPDC shall ensure minimal disturbance to the river bed during pipeline crossing. | L |
| | Shoreline erosion | H | SPDC shall carry-out shore protection in areas susceptible to shoreline erosion | L |
| | Improper disposal of backfill residue will alter the morphology of the area and impede drainage. | M | SPDC shall ensure that no soil mounds are left after back-filling | L |
| | Increased income to local workers | P | Positive impact | |
| | Improved quality of life may result from increased project spend which will stimulate economic activity in the area. | P | Positive impact | |
| | More infrastructures may be built or developed in the communities as part of the projects' CD initiatives. | P | Positive impact | |
| | Water related disease might increase due to poorer sanitation practices when more pressure is put on already poor state of housing. | H | SPDC shall strengthen health education programs. and improve healthcare institutions | L |
| | Increase in cases of sexually transmitted disease (HIV AIDS)and other disease strains may result through migrant workers. | H | SPDC shall step-up AIDS awareness programmes. Augment the supply and issue of condoms to workers | L |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| Project Activity | Description of Impact | Rating Before Mitigation | | Rating After Mitigation |
|------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|
| | | | on the project and possibly extend to commercial sex workers in the vicinity if identified. | |
| | Improved socio-economic activities | P | Positive impact | |
| | The size and number of barges conveying equipment, materials & personnel and the associated waves may endanger small canoes/boats and curtail fishing activities. | H | SPDC shall consult with the relevant Local Government and give adequate notice to the communities, of impending work and route plan, Train marine vessel operators prior deployment. Adhere to journey management guidelines Adhere to safety procedures | L |
| | Welding activities will release toxic fumes. | M | SPDC shall enforce the use of appropriate PPEs. | L |
| | Contamination of water with paints and corrosion inhibitors. | M | SPDC shall not discharge corrosion inhibitor dosed water into the rivers or creeks without treatment. | L |
| | Leaks and spills of diesel fuel and lubricants into water. | M | SPDC shall ensure that appropriate containment (drip pans) and clean up procedures are adopted | L |
| | Potential leakage and spills of glycol during installation. | H | SPDC shall incorporate into the design and install in TEG plant, an auto transfer device for charging and topping of the glycol. Install glycol plant without the initial charge, and thereafter fill in glycol charge | L |
| | Increased potential for injuries to personnel and damage to assets during heavy lift and positioning activities. | H | SPDC shall ensure the use of well trained personnel, and the use of appropriate use of PPEs | L |
| | Third Party agitation | H | Relevant stakeholders/legacy issues shall be identified Regular consultation with stakeholders (Govt., Community, NGOs, CBOs etc.) shall be carried out to understand community perceptions, issues and concerns Effective liaison/communication channels (CIC/CROs) from the communities to the project execution team shall be established. Adequate and prompt compensation shall be made Effective Implementation of PGMoU | M |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| Project Activity | Description of Impact | Rating Before Mitigation | | Rating After Mitigation |
|------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|--------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|
| Commissioning and Operation Phase • Commissioning and System Operation/ Maintenance • Pigging | Effluent Discharges | H | SPDC shall provide effluent and waste water treatment facilities of adequate capacity and treat effluent to DPR standards prior discharge at the Otumara logistics Base. | L |
| | Discharge of untreated effluents from flowstations /CPF into water. | M | SPDC shall provide effluent and waste water treatment facilities of adequate capacity and treat effluent to DPR standards prior discharge at the Otumara logistics Base. | |
| | Leaks and spills of TEG during storage, handling and decanting. | H | SPDC shall ensure best engineering of pipeline design, construction and installation. Design to incorporate auto leak detection for pipelines. SPDC shall establish effective gas leak monitoring programme for the pipelines | L |
| | Domestic wastewater and sewage disposal from the logistic centre. | H | SPDC waste management plan shall be vigorously adhered to. SPDC shall regularly audit the waste management practices of the contractor and recover dumped wastes as much as possible | L |
| | Domestic and industrial solids from the logistic centre. | H | SPDC waste management plan shall be vigorously adhered to SPDC shall regularly audit the waste management practices of the contractor and recover dumped wastes as much as possible | L |
| | Third Party agitation | H | Relevant stakeholders/legacy issues shall be identified Regular consultation with stakeholders (Govt., Community, NGOs, CBOs etc.) shall be carried out to understand community perceptions, issues and concerns Effective liaison/communication channels (CIC/CROs) from the communities to the project execution team shall be established. Adequate and prompt compensation shall be made Effective Implementation of PGMoU | M |
| Decommissioning And Abandonment • Cutting/ Lifting | Accidents from demolition activities - explosions, falling objects etc, especially when unskilled personnel are employed for the works. | H | SPDC shall provide adequate and relevant training of all staff especially local hands SPDC shall adopt safe operating procedures consistent with good statutory and SPDC HSE requirements | L |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| Project Activity | Description of Impact | Rating Before Mitigation | | Rating After Mitigation |
|-------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|--------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|
| <ul style="list-style-type: none"> • Waste Disposal • Restoration | Poor aesthetic features from abandoned structures on site. | M | Where abandonment will lead to poor aesthetics, the structures. shall be removed | L |
| | Alteration of vegetation pattern and disturbance of aesthetic beauty of the original environment. | M | SPDC shall ensure that native species are employed in restoration activities | L |
| | Third Party agitation | H | Relevant stakeholders/legacy issues shall be identified Regular consultation with stakeholders (Govt., Community, NGOs, CBOs etc.) shall be carried out to understand community perceptions, issues and concerns Effective liaison/communication channels (CIC/CROs) from the communities to the project execution team shall be established. Adequate and prompt compensation shall be made Effective Implementation of PGMoU | M |

CHAPTER SEVEN

ENVIRONMENTAL MANAGEMENT PLAN

7.1 Introduction

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

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

This environmental management will be carried out in accordance with the provisions 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 by the Otumara AGS project management team. The project HSE-MS document, provides central guidance and co-ordination for project-wide documents - work procedures, standards, work practises etc, and to demonstrate how HEMP will be applied on the project such that HSE risks are As Low As Reasonably Practicable.

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

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

To provide assurance that the risk management and control procedures identified in this environmental impact assessment are implemented, a comprehensive EMP was developed (Table 8.1). The EMP will take cognisance of the technical implementation of the EIA findings in the design phase of project development, such that a plan of action for managing residual environmental risks can then be evolved.

7.2 SPDC's Corporate HSE Programme

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

The Environmental Management activities instigated by SPDC are intended to implement the above policy and the policy will be applied to all stages of this project from project feasibility to decommissioning. The projects' HSE-MS is fully aligned to SPDC's corporate HSE programmes.

Environmental Assessment

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

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

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

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

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

In this connection, plans should at least provide for:

- a) responsibilities and task priorities,
- b) emergency reporting system,
- c) communication network,
- d) environmental sensitivity ranking and clear response strategy,
- e) resources and supportive equipment,
- f) reporting procedures.

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

Basis for Monitoring/ Surveillance

This section must answer the following questions:

- (a) Why do we monitor? - (Monitoring Objectives);
- (b) What do we monitor? - (Impact Indicators);

(c) How do we monitor and at what frequency? - (Monitoring Programme).

The work scope that outlines the activities to be carried out is given in Section 3.2 of this report. Based on the project activities, baseline data and the identified impacts, the monitoring objectives are given below.

Monitoring Objectives

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

- to create local data bank on the impact of dredging on aquatic ecosystem, for future development of predictive models;
- to compare effluent quality and quantity with design specifications, impact predictions and with SPDC / statutory standards;
- 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,
- enrich our data bank.

Impact Indicators to be monitored

In identifying impact indicators, priority is given to environmentally sensitive areas, which in this case, is the entire Otumara field. The project area consists of 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 8.1 gives the proposed monitoring programme for the Otumara AGS project.

7.3 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.

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 recognises the need to use external environmental consultants to supplement in-house environmental specialists. To this end, the environmental consultants will continue to provide expert advice to the SPDC environmental managers throughout the development of this project.

7.4 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 recognised that to be truly effective, these audits need to be conducted within the overall structured management systems. The structured approach is aimed at disseminating information, providing advice and assistance in its application, and at corporate assurance of performance in meeting the environmental requirements/targets.

7.5 Responsibilities And Training

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

Table 7.1: Environmental Management Plan (EMP) of Otumara AGS Project

| Project Activity | Description of Impact | Rating Before Mitigation | Mitigation Measures | Rating After Mitigation | Parameters to be Monitored | Monitoring Frequency | Responsible/ Action Party |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------|--------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|---------------------------|
| Pre-mobilization and Mobilization Phase <ul style="list-style-type: none"> • Land Acquisition • Land survey • RoW Clearance, Tree felling/De-stumping, Civil Works, and Facilities • Construction site • Waste Disposal • Dredging/ Sweeping/Piling • Piling • Dredging Waste Disposal | Increased erosion potential due to removal of vegetation canopies and road paving | H | SPDC shall minimise bush clearing to what is required for construction activities SPDC shall avoid de-stumping as much as possible within the RoW | L | Site reports | Weekly /Monthly | SPDC/ FMEnv/ DPR |
| | Loss of economic trees and ecologically important vegetation (mangroves and rain forests), | H | SPDC shall minimise land-take as much as practicable SPDC shall pay adequate compensation for loss economic trees/plants | L | Site reports Community engagement records Compensation records | Weekly/ Monthly/ Quarterly | SPDC/ FMEnv/ DPR |
| | Loss of habitats for wildlife. | M | SPDC shall not cut down timber-size trees greater than 60 cm girth, as they are protected by law. Site preparation land shall be limited. Low-noise equipment shall be used. Habitat loss shall be limited as much as practicable | L | Site reports Safety records | Weekly/ Quarterly | SPDC/ FMEnv/ DPR |
| | Loss of farmland, fishponds, gin distilleries and shines may result along the pipeline routes. | H | SPDC shall pay compensation for loss of income to those affected. SPDC shall pay adequate compensation for lost economic trees/ plants. Site preparation land shall be limited. Low-noise equipment shall be used. Habitat loss shall be limited as much as practicable | L | Site reports Community engagement records Compensation records | Weekly/ Monthly/ Quarterly | SPDC/ FMEnv/ DPR |
| | Income to local workers that may be employed for the bush clearing activities | P | N/A (impact is beneficial) | P | <ul style="list-style-type: none"> • Employment records • Register of contractors • Community engagement sessions | Quarterly | SPDC/ FMEnv/ DPR |
| | Improved quality of life may result from increased project spending which will stimulate economic activity in the area. | P | N/A (impact is beneficial) | P | <ul style="list-style-type: none"> • Employment records • Register of contractors • Community engagement | Quarterly | SPDC/ FMEnv/ DPR |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| Project Activity | Description of Impact | Rating Before Mitigation | Mitigation Measures | Rating After Mitigation | Parameters to be Monitored | Monitoring Frequency | Responsible/ Action Party |
|------------------|--------------------------------------------------------------------------------------------------------------------------------|--------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|---------------------------|
| | | | | | sessions | | |
| | More infrastructures may be built or developed in the communities as part of the projects' CD initiatives. | P | N/A (impact is beneficial) | P | <ul style="list-style-type: none"> • Employment records • Register of contractors • Community engagement sessions • Records of GMoU programmes implementation. | Quarterly | SPDC/ FMEnv/ DPR |
| | Communicable disease may increase due to poor sanitation practices when more pressure is put on already poor state of housing. | H | <p>Step-up health education and sensitisation activities prior commencing construction activities and support condom donation initiatives.</p> <p>SPDC shall organise awareness session on communicable diseases related to water and sexual behaviour.</p> <p>Step-up HIV/AIDS awareness programmes. Augment the supply and issue of condoms to workers on the project and possibly extend to commercial sex workers in the vicinity if identified.</p> | M | <ul style="list-style-type: none"> • Health awareness sessions • Community engagement sessions | Quarterly | SPDC/ FMEnv/ DPR |
| | Increase in cases of sexually transmitted disease and other disease strains may result through migrant workers. | H | <p>Step-up health education and sensitisation activities prior commencing construction activities and support condom donation initiatives.</p> <p>SPDC shall organise awareness session on and sexually transmitted diseases, sexual behaviour for workers and local hands that will be employed</p> | M | <ul style="list-style-type: none"> • Health awareness sessions • Community engagement sessions | Quarterly | SPDC/ FMEnv/ DPR |
| | Accidents to workers will increase especially for local labour not sufficiently skilled for the type of work. | H | SPDC shall ensure the provision and enforcement of the use of appropriate PPEs on site. | L | <ul style="list-style-type: none"> • SPDC shall ensure the provision and enforcement of the use of appropriate | <ul style="list-style-type: none"> • Daily • Weekly • Weekly | |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| Project Activity | Description of Impact | Rating Before Mitigation | Mitigation Measures | Rating After Mitigation | Parameters to be Monitored | Monitoring Frequency | Responsible/ Action Party |
|------------------|-----------------------------------------------------------------------------------------------------------------------------------|--------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|---------------------------|
| | | | <p>SPDC shall provide adequate First Aid and functional medevac system on site.</p> <p>SPDC shall ensure that approved detailed Job Hazard Analysis (JHA) is provided by the contractor and that all the controls and barriers are adhered to.</p> <p>SPDC shall ensure that daily tool box meetings are held</p> | | <p>PPEs on site.</p> <ul style="list-style-type: none"> • SPDC shall provide adequate First Aid and functional medevac system on site. • SPDC shall ensure that approved detailed Job Hazard Analysis (JHA) is provided by the contractor and that all the controls and barriers are adhered to. • SPDC shall ensure that daily tool box meetings are held | <ul style="list-style-type: none"> • Monthly • Weekly | SPDC/ FMEnv/ DPR |
| | Increased in suspended solids in water | H | Use of silt curtain to prevent migration of plant matter, debris | L | <ul style="list-style-type: none"> • Compliance Monitoring Reports/ Impact Mitigation Monitoring reports (IMM) | <ul style="list-style-type: none"> • Monthly | SPDC/ FMEnv/ DPR |
| | Discharge of fecal waste into the water will contaminate drinking water sources and increase water related disease (cholera etc). | H | <p>Treat all waste water to DPR standards prior disposal</p> <p>Provision of mobile toilets for its work-force</p> <p>SPDC shall regularly monitor the quality of effluent to ensure that it meets regulatory standards</p> <p>SPDC shall adhere to its waste management procedure</p> | M | <ul style="list-style-type: none"> • Compliance Monitoring Reports/ Impact Mitigation Monitoring reports (IMM) | <ul style="list-style-type: none"> • Monthly | SPDC/ FMEnv/ DPR |
| | Shoreline erosion, | H | <p>SPDC shall carry-out shore protection in areas susceptible to shoreline erosion</p> <p>SPDC shall use sheet piling of the area affected.</p> | L | <ul style="list-style-type: none"> • Site reports | <p>Weekly /Monthly</p> | SPDC/ FMEnv/ DPR |
| | Disturbance of riverbed topography and re-suspension of | M | SPDC shall use the best available technology (suction dredging) to | L | <ul style="list-style-type: none"> • Compliance Monitoring Reports/ | <ul style="list-style-type: none"> • Monthly • Periodically | SPDC/ FMEnv/ |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| Project Activity | Description of Impact | Rating Before Mitigation | Mitigation Measures | Rating After Mitigation | Parameters to be Monitored | Monitoring Frequency | Responsible/ Action Party |
|------------------|------------------------------------------------------------------------------------------------------------------|--------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|---------------------------|
| | fine sediments and bottom materials | | minimize disturbance to riverbed topography | | Impact Mitigation Monitoring reports (IMM) | | DPR |
| | Increased turbidity and suspended solids, | H | SPDC shall deploy the most appropriate technology (silt curtain), to minimize loss of benthic organisms. | L | <ul style="list-style-type: none"> Compliance Monitoring Reports Impact Mitigation Monitoring reports (IMM) | <ul style="list-style-type: none"> Monthly Periodically | SPDC/ FMEEnv/ DPR |
| | Displacement of water by increased frequency of barge traffic may result in flooding of low lying communities. | M | Adherence to journey management guidelines and sensitization of boat captains | M | <ul style="list-style-type: none"> Journey management record | <ul style="list-style-type: none"> Daily/ Weekly | SPDC/ FMEEnv/ DPR |
| | Loss of juvenile fishes due to gill damage from silt particles. | H | Use of appropriate technology (suction dredging) and silt curtain to reduce turbidity | L | <ul style="list-style-type: none"> Compliance Monitoring Reports/ Impact Mitigation Monitoring reports (IMM) | <ul style="list-style-type: none"> Monthly | SPDC/ FMEEnv/ DPR |
| | Dredging improves circulation of water currents and transport of nutrients for marine life food chain. | P | Positive impact | P | <ul style="list-style-type: none"> Site reports | Weekly /Monthly | SPDC/ FMEEnv/ DPR |
| | Loss of buffer effects of shoreline vegetation may result from creek widening | H | SPDC shall Limit widening of Otumara creek or any other creek to be used for Barge movement,, to a width that will cause minimal shoreline erosion | M | <ul style="list-style-type: none"> Site reports | Weekly /Monthly | SPDC/ FMEEnv/ DPR |
| | Temporary disruption of local fishing/harvesting activities. Fish spawning habitat may also be destroyed. | H | SPDC shall ensure strict compliance with good marine journey management practice, including sensitisation of quarter masters / boat masters on how to pass fishing and commercial boat | L | <ul style="list-style-type: none"> Site inspection reports Compliance Monitoring Reports Impact Mitigation Monitoring reports (IMM) | Weekly /Monthly | SPDC/ FMEEnv/ DPR |
| | Acidification of the soil and surface water as a result of deposition of dredge spoils on the banks of the river | H | SPDC shall ensure dredge spoil is deposited at least 10 metres into the buffer zone or Cap spoil with clean sand. | L | <ul style="list-style-type: none"> Compliance Monitoring Reports Impact Mitigation Monitoring reports (IMM) | <ul style="list-style-type: none"> Monthly Periodically | SPDC/ FMEEnv/ DPR |
| | Salt water intrusion (surface and | H | SPDC shall ensure no hydraulic | L | <ul style="list-style-type: none"> Compliance | <ul style="list-style-type: none"> Monthly | SPDC/ |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| Project Activity | Description of Impact | Rating Before Mitigation | Mitigation Measures | Rating After Mitigation | Parameters to be Monitored | Monitoring Frequency | Responsible/ Action Party |
|------------------|----------------------------------------------------------------------------------------------|--------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|---------------------------------------------------------------------------------------------|--------------------------------------------------------------|---------------------------|
| | ground water)as a result of dredging activities | | connection between the sea and the coastal forest by using cofferdams and sheet piling for the shoreline approach, The use of shore protection techniques to achieve rapid stability of the excavated area for the shore approach area after the installation of offshore section of pipeline | | Monitoring Reports Impact Mitigation Monitoring reports (IMM) | • Periodically | FMEnv/ DPR |
| | Water traffic disruption with possible increase in marine accidents | H | SPDC shall ensure proper scheduling of supply boat movements so as not to interfere significantly with artisanal fishing and commercial boat activities. SPDC shall consult with the relevant Local Government and give adequate notice to the communities, of impending work and route plan, Institute good marine journey management system in-line with SPDC policy. | L | Journey Management Reports Community engagement Reports Government engagement Reports | • Daily • Weekly • Weekly • Monthly • Weekly | SPDC/ FMEnv/ DPR |
| | Impairment of hearing due to noise and vibrations | M | SPDC shall enforce the use of appropriate PPE | L | Site Reports Accident Investigation Reports | • Daily • Weekly • Weekly • Monthly • Weekly | SPDC/ FMEnv/ DPR |
| | Spoil disposal will smother epifauna and impair surface drainage especially in wetland areas | H | SPDC shall dispose dredge spoils in an environmentally-friendly manner | L | • Compliance Monitoring Reports/ Impact Mitigation Monitoring reports (IMM) | • Monthly • Periodically | SPDC/ FMEnv/ DPR |
| | Pollution of drinking water sources may occur if domestic waste is discharged directly into | H | SPDC shall adopt dredging technology that minimises re-suspension of sediments, such as Silt | L | • Compliance Monitoring Reports/Joint | • Monthly | SPDC/ FMEnv/ DPR |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| Project Activity | Description of Impact | Rating Before Mitigation | Mitigation Measures | Rating After Mitigation | Parameters to be Monitored | Monitoring Frequency | Responsible/ Action Party |
|---------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|-------------------------------------------------------------------------------|-----------------------------|---------------------------|
| | the river. | | Curtains | | Inspection Investigation | | |
| | Third Party Agitation | H | Relevant stakeholders/legacy issues shall be identified Regular consultation with stakeholders (Govt., Community, NGOs, CBOs etc.) shall be carried out to understand community perceptions, issues and concerns Effective liaison/communication channels (CIC/CROs) from the communities to the project execution team shall be established. Adequate and prompt compensation shall be made Effective Implementation of PGMoU | M | Site Reports Community Engagement Reports Government Engagement reports | Monthly/ Quarterly | SPDC/DPR/F MEnv |
| | Climate Extremes – Heavy rainfall and Lightning strikes; May increase safety hazards of the work. Delay in project schedule may increase time of delivery and cost; | H | SPDC shall make extensive use of yard pre-fabrication in order to minimise site construction activities. SPDC shall schedule site preparation and construction activities in the dry season (October to March) | L | Compliance monitoring/ Impact Mitigation Monitoring reports (IMM) | Monthly Periodically | SPDC/ FMEnv/ DPR |
| | Fatality, damage to assets due bad weather and fire | H | SPDC and Contractors shall make extensive use of yard pre-fabrication in order to minimise site construction activities. SPDC shall schedule site preparation and construction activities in the dry season (October to March) SPDC shall activate Emergency Response in the case of fire | M | Site reports HSE Reports | Weekly | SPDC/ FMEnv/ DPR |
| | Deprivation of personal liberty, injury, fatality due to Kidnapping | H | SPDC shall strictly implement its Security Policy | L | Security plan, Security records Site reports | Weekly | SPDC/ FMEnv/ DPR |
| | | | | | | | |
| Construction Phase • Pipeline/ Bulkline | In tidal swamps, this will increase surface water sediment loading and suspended solids. | H | SPDC shall deploy the most appropriate technology, to minimize loss of benthic organisms. | | • Compliance Monitoring Reports/ Impact Mitigation | • Monthly • Periodically | SPDC/ FMEnv/ DPR |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| Project Activity | Description of Impact | Rating Before Mitigation | Mitigation Measures | Rating After Mitigation | Parameters to be Monitored | Monitoring Frequency | Responsible/ Action Party |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|
| <p>Construction and Laying Optic Fibre Cable</p> <ul style="list-style-type: none"> • Trenching/ Backfilling • Welding / NDT/ Coating/Wrapping • Hydrostatic Testing • River Crossing • Waste/Spoil Disposal • Communities electrification • Transportation of Module/ Equipment • Water transportation • CPF Installation and FLB Construction • Welding • Installation, tie-in and pre-commissioning of facilities. • Unloading and installation of CPF/ Modules | | | | | Monitoring reports (IMM) | | |
| | Irreversible soil compaction which may alter the topography of the RoW. | M | SPDC shall use low pressure tracked equipment for construction | L | Site i reports | Weekly /Monthly | SPDC/ FME _{env} / DPR |
| | Salt water intrusion into ground water, through ELPS (hydraulic seepage around the circumference of the pipe) | H | <p>SPDC shall ensure no hydraulic connection between the sea and the coastal forest by using cofferdams and sheet piling for the shoreline approach,</p> <p>The use of shore protection techniques to achieve rapid stability of the excavated area for the shore approach area after the installation of offshore section of pipeline.</p> | L | <ul style="list-style-type: none"> • Compliance Monitoring Reports/ Impact Mitigation Monitoring reports (IMM) Site inspection reports | Weekly /Monthly / Periodically | SPDC/ FME _{env} / DPR |
| | Exposure to radioactivity and release of chemicals | H | <p>SPDC shall provide radiation counter to workers for monitoring individual radiation levels.</p> <p>SPDC shall provide and enforce the use of protective aprons.</p> <p>SPDC shall ensure that the activity is carried out in accordance with standard procedures.</p> | L | <ul style="list-style-type: none"> • Site Reports • Accident Investigation Reports | <ul style="list-style-type: none"> • Daily • Weekly • Weekly • Monthly • Weekly | SPDC/ FME _{env} / DPR |
| | Impairment of vision from arc welding | M | SPDC shall enforce the use of appropriate PPE. | L | <ul style="list-style-type: none"> • Site Reports • Accident Investigation Reports | <ul style="list-style-type: none"> • Daily • Weekly • Weekly • Monthly • Weekly | SPDC/ FME _{env} / DPR |
| Improper disposal of lay barge deck drainage will contaminate surface water and sediment. | M | SPDC shall ensure that effluents and solid wastes are collected for off-site disposal | L | <ul style="list-style-type: none"> • Compliance Monitoring Report | <ul style="list-style-type: none"> • Monthly | SPDC/ FME _{env} / DPR | |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| Project Activity | Description of Impact | Rating Before Mitigation | Mitigation Measures | Rating After Mitigation | Parameters to be Monitored | Monitoring Frequency | Responsible/ Action Party |
|------------------|----------------------------------------------------------------------------------------------------------------------|--------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|---------------------------|
| | Discharge of untreated test water into the receiving environment. | M | SPDC waste management specifications and guidelines (especially with regards to the discharges into the environment) shall be complied with. | L | <ul style="list-style-type: none"> Compliance Monitoring Reports/ Impact Mitigation Monitoring reports (IMM) | <ul style="list-style-type: none"> Monthly/ periodically | SPDC/ FMEEnv/ DPR |
| | Disaggregation of benthic habitats and loss of benthic organisms. | M | SPDC shall adopt due diligence to minimize adverse impacts on benthic organisms | L | <ul style="list-style-type: none"> Compliance Monitoring Reports/ Impact Mitigation Monitoring reports (IMM) | <ul style="list-style-type: none"> Monthly Periodically | SPDC/ FMEEnv/ DPR |
| | Disturbance of riverbed topography. | M | SPDC shall ensure minimal disturbance to the river bed during pipeline crossing. | L | <ul style="list-style-type: none"> Compliance Monitoring Reports/ Impact Mitigation Monitoring reports (IMM) Site inspection reports | <ul style="list-style-type: none"> Weekly/ Monthly Periodically | SPDC/ FMEEnv/ DPR |
| | Shoreline erosion | H | SPDC shall carry-out shore protection in areas susceptible to shoreline erosion | L | <ul style="list-style-type: none"> Site reports | <ul style="list-style-type: none"> Weekly/ Monthly | SPDC/ FMEEnv/ DPR |
| | Improper disposal of backfill residue will alter the morphology of the area and impede drainage. | M | SPDC shall ensure that no soil mounds are left after back-filling | L | <ul style="list-style-type: none"> Site reports | <ul style="list-style-type: none"> Weekly/ Monthly | SPDC/ FMEEnv/ DPR |
| | Increased income to local workers | P | Positive impact | P | <ul style="list-style-type: none"> Employment records Register of contractors Community engagement sessions | Quarterly | SPDC/ FMEEnv/ DPR |
| | Improved quality of life may result from increased project spend which will stimulate economic activity in the area. | P | Positive impact | P | <ul style="list-style-type: none"> Employment records Register of contractors Community engagement sessions | Quarterly | SPDC/ FMEEnv/ DPR |
| | More infrastructures may be built or developed in the communities as part of the projects' CD | P | Positive impact | P | <ul style="list-style-type: none"> Records of GMoU programmes implementation. | Quarterly | SPDC/ FMEEnv/ DPR |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| Project Activity | Description of Impact | Rating Before Mitigation | Mitigation Measures | Rating After Mitigation | Parameters to be Monitored | Monitoring Frequency | Responsible/ Action Party |
|------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------|---------------------------|
| | initiatives. | | | | <ul style="list-style-type: none"> Community engagement sessions | | |
| | Water related disease might increase due to poorer sanitation practices when more pressure is put on already poor state of housing. | H | SPDC shall strengthen health education programs. and improve healthcare institutions | L | <ul style="list-style-type: none"> Compliance Monitoring Reports/ Impact Mitigation Monitoring reports (IMM) Health awareness session | <ul style="list-style-type: none"> Monthly Quarterly Periodically | SPDC/ FMEEnv/ DPR |
| | Increase in cases of sexually transmitted disease (HIV AIDS)and other disease strains may result through migrant workers. | H | <p>SPDC shall step-up AIDS awareness programmes.</p> <p>Augment the supply and issue of condoms to workers on the project and possibly extend to commercial sex workers in the vicinity if identified.</p> | L | <ul style="list-style-type: none"> Health awareness session Health records | <ul style="list-style-type: none"> Quarterly | SPDC/ FMEEnv/ DPR |
| | Improved socio-economic activities | P | Positive impact | P | <ul style="list-style-type: none"> Employment records Community engagement sessions Register of contractors | <ul style="list-style-type: none"> Quarterly | SPDC/ FMEEnv/ DPR |
| | The size and number of barges conveying equipment, materials & personnel and the associated waves may endanger small canoes/boats and curtail fishing activities. | H | <p>SPDC shall consult with the relevant Local Government and give adequate notice to the communities, of impending work and route plan, Train marine vessel operators prior deployment.</p> <p>Adhere to journey management guidelines</p> <p>Adhere to safety procedures</p> | L | <ul style="list-style-type: none"> Journey management records | Weekly /Monthly | SPDC/ FMEEnv/ DPR |
| | Welding activities will release toxic fumes. | M | SPDC shall enforce the use of appropriate PPEs. | L | <ul style="list-style-type: none"> Compliance Monitoring Reports/ Impact Mitigation Monitoring reports (IMM) | Monthly Periodically | SPDC/ FMEEnv/ DPR |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| Project Activity | Description of Impact | Rating Before Mitigation | Mitigation Measures | Rating After Mitigation | Parameters to be Monitored | Monitoring Frequency | Responsible/ Action Party |
|------------------|------------------------------------------------------------------------------------------------------------------|--------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------|---------------------------|
| | Contamination of water with paints and corrosion inhibitors. | M | SPDC shall not discharge corrosion inhibitor dosed water into the rivers or creeks without treatment. | L | <ul style="list-style-type: none"> • Compliance Monitoring Reports/ Impact Mitigation Monitoring reports (IMM) | Monthly Periodically | SPDC/ FMEEnv/ DPR |
| | Leaks and spills of diesel fuel and lubricants into water. | M | SPDC shall ensure that appropriate containment (drip pans) and clean up procedures are adopted | L | <ul style="list-style-type: none"> • Compliance Monitoring Reports | Monthly | SPDC/ FMEEnv/ DPR |
| | Potential leakage and spills of glycol during installation. | H | <p>SPDC shall incorporate into the design and install in TEG plant, an auto transfer device for charging and topping of the glycol.</p> <p>Install glycol plant without the initial charge, and thereafter fill in glycol charge</p> | L | <ul style="list-style-type: none"> • Compliance Monitoring Reports • Impact Mitigation Monitoring reports (IMM) | Monthly Periodically | SPDC/ FMEEnv/ DPR |
| | Increased potential for injuries to personnel and damage to assets during heavy lift and positioning activities. | H | SPDC shall ensure the use of well trained personnel, and the use of appropriate use of PPEs | L | <ul style="list-style-type: none"> • SPDC shall ensure the provision and enforcement of the use of appropriate PPEs on site. • SPDC shall provide adequate First Aid and functional medevac system on site. • SPDC shall ensure that approved detailed Job Hazard Analysis (JHA) is provided by the contractor and that all the controls and barriers are adhered to. • SPDC shall ensure that daily tool box meetings are held | <ul style="list-style-type: none"> • Daily • Weekly • Weekly • Monthly • Weekly | SPDC/ FMEEnv/ DPR |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| Project Activity | Description of Impact | Rating Before Mitigation | Mitigation Measures | Rating After Mitigation | Parameters to be Monitored | Monitoring Frequency | Responsible/ Action Party |
|-----------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|---------------------------------------------------------------------------------|----------------------|---------------------------|
| | Third Party Agitation | H | Relevant stakeholders/legacy issues shall be identified Regular consultation with stakeholders (Govt., Community, NGOs, CBOs etc.) shall be carried out to understand community perceptions, issues and concerns Effective liaison/communication channels (CIC/CROs) from the communities to the project execution team shall be established. Adequate and prompt compensation shall be made Effective Implementation of PGMoU | M | Site Reports Community Engagement Reports Government Engagement reports | Monthly/Quarterly | SPDC/ DPR/FMEnv |
| | Climate Extremes – Heavy rainfall and Lightning strikes; May increase safety hazards of the work. Delay in project schedule may increase time of delivery and cost; | H | SPDC shall make extensive use of yard pre-fabrication in order to minimise site construction activities. SPDC shall schedule site preparation and construction activities in the dry season (October to March) | L | Compliance monitoring/ Impact Mitigation Monitoring reports (IMM) | Monthly Periodically | SPDC/ FMEnv/ DPR |
| | Fatality, damage to assets due bad weather and fire | H | SPDC and Contractors shall make extensive use of yard pre-fabrication in order to minimise site construction activities. SPDC shall schedule site preparation and construction activities in the dry season (October to March) SPDC shall activate Emergency Response SPDC shall train fire wardens | M | Site reports HSE Reports | Weekly | SPDC/ FMEnv/ DPR |
| | Deprivation of personal liberty, injury, fatality due to Kidnapping | H | SPDC shall strictly implement its Security Policy | L | Security plan, Security records Site reports | Weekly | SPDC/ FMEnv/ DPR |
| Commissioning and Operation Phase • Commissioning and System Operation/ Maintenance | Effluent Discharges | H | SPDC shall provide effluent and waste water treatment facilities of adequate capacity and treat effluent to DPR standards prior discharge at the Otumara logistics Base. | L | • Compliance monitoring report/ • Impact Mitigation Monitoring reports (IMM) | Monthly Periodically | SPDC/ FMEnv/ DPR |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| Project Activity | Description of Impact | Rating Before Mitigation | Mitigation Measures | Rating After Mitigation | Parameters to be Monitored | Monitoring Frequency | Responsible/ Action Party |
|------------------|---------------------------------------------------------------------|--------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|-------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|---------------------------|
| • Pigging | Discharge of untreated effluents from flowstations /CPF into water. | M | SPDC shall provide effluent and waste water treatment facilities of adequate capacity and treat effluent to DPR standards prior discharge at the Otumara logistics Base. | L | <ul style="list-style-type: none"> Compliance monitoring report/ Impact Mitigation Monitoring reports (IMM) | Monthly Periodically | SPDC/ FMEnv/ DPR |
| | Leaks and spills of TEG during storage, handling and decanting. | H | <p>SPDC shall ensure best engineering of pipeline design, construction and installation. Design to incorporate auto leak detection for pipelines.</p> <p>SPDC shall establish effective gas leak monitoring programme for the pipelines</p> | L | <ul style="list-style-type: none"> Site reports Remediation reports | <ul style="list-style-type: none"> Weekly/ Monthly Periodically | SPDC/ FMEnv/ DPR |
| | Domestic wastewater and sewage disposal from the logistic centre. | H | <p>SPDC waste management plan shall be vigorously adhered to.</p> <p>SPDC shall regularly audit the waste management practices of the contractor and recover dumped wastes as much as possible</p> | L | <ul style="list-style-type: none"> Compliance monitoring report Waste management reports IMM | Monthly Periodically | SPDC/ FMEnv/ DPR |
| | Domestic and industrial solids from the logistic centre. | H | <p>SPDC waste management plan shall be vigorously adhered to</p> <p>SPDC shall regularly audit the waste management practices of the contractor and recover dumped wastes as much as possible</p> | L | <ul style="list-style-type: none"> Waste management reports IMM | Monthly Periodically | SPDC/ FMEnv/ DPR |
| | Third Party Agitation | H | <p>Relevant stakeholders/legacy issues shall be identified</p> <p>Regular consultation with stakeholders (Govt., Community, NGOs, CBOs etc.) shall be carried out to understand community perceptions, issues and concerns</p> <p>Effective liaison/communication channels (CIC/CROs) from the communities to the project execution team shall be established.</p> <p>Adequate and prompt compensation</p> | M | <p>Site Reports</p> <p>Community Engagement Reports</p> <p>Government Engagement reports</p> | Monthly/Quarterly | SPDC/ DPR/FMEnv |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| Project Activity | Description of Impact | Rating Before Mitigation | Mitigation Measures | Rating After Mitigation | Parameters to be Monitored | Monitoring Frequency | Responsible/ Action Party |
|--------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------|---------------------------|
| | | | shall be made Effective Implementation of PGMoU | | | | |
| | Climate Extremes – Heavy rainfall and Lightning strikes; May increase safety hazards of the work. Delay in project schedule may increase time of delivery and cost; | H | SPDC shall make extensive use of yard pre-fabrication in order to minimise site construction activities. SPDC shall schedule site preparation and construction activities in the dry season (October to March) | L | Compliance monitoring/ Impact Mitigation Monitoring reports (IMM) | Monthly Periodically | SPDC/ FMEnv/ DPR |
| | Fatality, damage to assets due bad weather and fire | H | SPDC and Contractors shall make extensive use of yard pre-fabrication in order to minimise site construction activities. SPDC shall schedule site preparation and construction activities in the dry season (October to March) SPDC shall activate Emergency Response | M | Site reports | Weekly | SPDC/ FMEnv/ DPR |
| | Deprivation of personal liberty, injury, fatality due to Kidnapping | H | SPDC shall strictly implement its Security Policy | L | Security plan, Security records Site reports | Weekly | SPDC/ FMEnv/ DPR |
| DECOMMISSIONING AND ABANDONMENT • Cutting/Lifting • Waste Disposal • Restoration | Accidents from demolition activities - explosions, falling objects etc, especially when unskilled personnel are employed for the works. | H | SPDC shall provide adequate and relevant training of all staff especially local hands SPDC shall adopt safe operating procedures consistent with good statutory and SPDC HSE requirements | L | • Employment/Training records • Certification of workforce • Emergency response plan • HAZID register • Pep-talk records • Compliance monitoring • Toolbox meetings • Job Hazard Analysis (JHA) Studies | • Daily • Weekly • /Monthly • Quarterly | SPDC/ FMEnv/ DPR |
| | Poor aesthetic features from abandoned structures on site. | M | Where abandonment will lead to poor aesthetics, the structures. shall be removed | L | • Site reports | • Weekly • Monthly | SPDC/ FMEnv/ DPR |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| Project Activity | Description of Impact | Rating Before Mitigation | Mitigation Measures | Rating After Mitigation | Parameters to be Monitored | Monitoring Frequency | Responsible/ Action Party |
|------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|---------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|---------------------------|
| | Alteration of vegetation pattern and disturbance of aesthetic beauty of the original environment. | M | SPDC shall ensure that native species are employed in restoration activities | L | <ul style="list-style-type: none"> • Site reports • Site rehabilitation reports | <ul style="list-style-type: none"> • Weekly • Monthly • Periodically | SPDC/ FMEnv/ DPR |
| | Third Party Agitation | H | Relevant stakeholders/legacy issues shall be identified Regular consultation with stakeholders (Govt., Community, NGOs, CBOs etc.) shall be carried out to understand community perceptions, issues and concerns Effective liaison/communication channels (CIC/CROs) from the communities to the project execution team shall be established. Adequate and prompt compensation shall be made Effective Implementation of PGMoU | M | Site Reports Community Engagement Reports Government Engagement reports | Monthly/Quarterly | SPDC/ DPR/FMEnv |
| | Climate Extremes – Heavy rainfall and Lightning strikes; May increase safety hazards of the work. Delay in project schedule may increase time of delivery and cost; | H | SPDC shall make extensive use of yard pre-fabrication in order to minimise site construction activities. SPDC shall schedule site preparation and construction activities in the dry season (October to March) | L | Compliance monitoring/ Impact Mitigation Monitoring reports (IMM) | Monthly Periodically | SPDC/ FMEnv/ DPR |
| | Fatality, damage to assets due bad weather and fire | H | SPDC and Contractors shall make extensive use of yard pre-fabrication in order to minimise site construction activities. SPDC shall schedule site preparation and construction activities in the dry season (October to March) SPDC shall activate Emergency Response | M | Site reports HSE Reports | Weekly | SPDC/ FMEnv/ DPR |
| | Deprivation of personal liberty, injury, fatality due to Kidnapping | H | SPDC shall strictly implement its Security Policy | L | Security plan, Security records Site reports | Weekly | SPDC/ FMEnv/ DPR |

7.6 Oil and Gas Contingency Planning

Despite all care and diligence exercised in project execution, accidents do occur. Accidents could occur from equipment failure or third party sabotage, all to the detriment of the environment. Consequently, oil and gas contingency plans are usually made to handle such accidental spills.

Although serious incident is unlikely for a gas pipeline, SPDC West has in place an oil spill contingency plan, which has been activated; regularly updated with regular and periodic exercises conducted by the Department of Petroleum Resources. The Otumara AGS projects' contingency plan shall derive from and link to SPDC's plan.

7.7 Consultation

SPDC has established and maintained effective communications with authorities in government agencies (FMEnv and DPR) and other relevant groups or parties. By so doing, it has been SPDC's intention to:

- avoid conflict by addressing issues promptly;
- ensure that any fears or apprehensions about the nature, scale and impacts of the proposed project have been fully addressed;
- avoid any misunderstanding about the project.

These objectives have been addressed by a strategy of communications. SPDC's environmental management team had established sound working relationships with FMEnv and DPR, whose representatives are participating fully in all stages of environmental impact assessment studies. SPDC will present the preliminary report of the EIA to FMEnv/DPR in compliance with approved guidelines.

To further strengthen this communication base, SPDC's Public and Government Affairs Department (PAGW) has a number of communication initiatives planned, including:

- organisation of open fora, conferences and exhibitions to disseminate information and promote awareness;
- publication in the national and local news papers of SPDC's intention to undertake such a project, in accordance with the Pipelines Act of 1965;
- consultative meetings with officials of the Delta State Government in charge of the environmental issues, leaders of the Delta State House of Assembly Committee on the environment and the leaders/members of the host communities that could be affected by the project to discuss key concerns and explain the project development activities.

7.8 Future Commitments

Throughout the planning of this project, SPDC will continue to consult with the public, statutory authorities and affected individuals as well as local communities in order to ensure that construction and operation have minimum adverse environmental impacts.

To further support its policy on the environment, SPDC would undertake to:

- prepare a detailed restoration and after-care plan for reinstatement of the pipeline working width;

- monitor all environmentally sensitive areas during construction and operation to ensure compliance with SPDC's and statutory standards;
- land take for temporary use, which will require clearance, will be kept to the barest minimum, and restoration after use will be undertaken;
- at crossings of rivers normally subjected to commercial and industrial traffic, construction time will be reduced to minimum and restoration of river banks to avoid erosion will be undertaken;
- construction criteria for all major river and stream crossings will be discussed and agreed with NIWA and other appropriate authorities before commencement of work.

7.9 Waste Management

Introduction

Any development project involving bush clearing, ditching and dredging in a tidal swampy environment is bound to encounter waste management problems which need to be handled in compliance with the Petroleum (Drilling & Productions) Regulations, 1969, Sections 25, 36, 49 and (b), (c) and (d), which stipulate *inter alia* that:

"The licensee or leasee shall adopt all practical precautions, including the provision of up-to-date equipment... to prevent the pollution of inland waters, rivers, creeks, water courses, the territorial waters of Nigeria or the high seas by oil, mud or other fluids or substances which might contaminate the water, banks or shoreline or which might cause harm or destruction to fresh water or marine life, and where any such pollution occurs or has occurred, shall take prompt steps to control and, if possible, end it;"...etc.

SPDC has an effective waste management scheme in place and this project will comply with that scheme.

7.9.1 Sources and Characteristics of Wastes

Site Preparation and Construction/ Commissioning

Solid wastes likely to arise from above activities include:

- Felled trees, domestic/industrial refuse, clay and sand (dredge spoils), grits, scrap metals. Expected aqueous wastes include:
- Chemicals (Glycol), oil and grease, dredge water run-off, soil and sanitary wastes, cement slurries, corrosion inhibitors, pipe test water and sludge.
- Emissions include:
- Combustion products from construction engines, welding gas, noise, heat and light.

Residuals

An attempt has been made to quantify some residuals from site preparation and construction activities (Table 7.2), which must be disposed of in accordance with SPDC, waste disposal guidelines (Table 7.3).

Table 7.2: Anticipated Residuals from site preparation and construction.

| Type | Source | Quantity (est.) | Disposal plan |
|-----------------------|-------------------------------------------|---------------------------------|-----------------------------------------------------------------------|
| Top soil spoils | Site stripping | 5028 m ³ | Spread evenly over ROW |
| Subsoil spoils | Ditching | 10,056m ³ | Spread evenly over ROW |
| Shrubs/vegetation | Bush clearing | 142390 Nos | Allow to biodegrade <i>insitu</i> |
| Trunks/stumps | Site stripping | - | Chop and stockpile |
| Sewage | Personnel | <450 ³ /month | Treat and dispose into creek |
| Scraps | Cut-offs/Damages | 70 tons | Segregate into usable & non-usable & return to yard |
| Grit blast chips | Pipe surface cleaning | To be determined | Land fill |
| Paints/tar | Surface finishing | To be determined | Incinerate |
| Exhaust Gas Emissions | Internal Combustion Engines | To be determined | Drain into oil pit, recover & recycle |
| Lubricants | Plant Servicing at construction sites | To be determined | Recover oil & recycle |
| Condensate slug | Slug catcher/pipeline | 380m ³ /pigging | Channel into creek |
| Containers | Storage facilities | To be determined | Return to base |
| Run-off water | Dredging/drainage | To be determined | Direct back to Creek |
| Dredge spoil | Dredging | 45,000 – 230,000 m ³ | Treat & return to creek |
| Noise | Engines, piling | 78-106 dBA | Wear ear protectors |
| Hydrotest water | pipeline hydrotest | 3732m ³ | Treat & discharge to creek |
| Domestic sewage | Logistic centre, | 16640 m ³ | Segregate and dispose according to SPDC Waste Disposal Plans in Swamp |
| Food Waste | Contractors house boats, Logistic centre, | 15595 m ³ | Waste disposal Contractor |
| Packing materials | Contractors house boats /kitchens | 9356.7 m ³ | Incinerate in off-site incinerator |
| Waste batteries | Construction sites, kitchen, offices | 100kgs | Recycle |

Table 7.3: Classified Waste Treatment/ Disposal Options

| Waste Types | Management Option | | | | | | | |
|-------------------------------|------------------------------------------------|---------|-----------------------------------|--------|-------------------------|-------------------------------------|--------------|------------------------------|
| | Thermal Dissorption Plant at Forcados Terminal | Recycle | Returned to manufacturer/supplier | Reused | Dumped at SPDC landfill | Skipped and dumped in deep offshore | Incineration | Utilized by host communities |
| Drill cuttings | P/A | NA | NA | NA | X | X | NA | X |
| Drilling mud (WBM) | NA | NA | NA | A | X | P/A | NA | X |
| Drilling fluids and chemicals | NA | NA | A | A | X | X | NA | X |
| Lube oils | NA | P/A | A | A | X | | NA | X |
| Spent paints and solvents | NA | A | P/A | NA | X | X | NA | X |
| Grit (from blasting) | NA | NA | NA | P/A | A | NA | NA | A |
| Spent batteries (alkaline) | X | A | P/A | NA | X | X | X | X |
| Wood scraps | NA | P/A | NA | A | X | NA | NA | X |

| Waste Types | Management Option | | | | | | | |
|-----------------------------|------------------------------------------------|---------|-----------------------------------|--------|-------------------------|-------------------------------------|--------------|------------------------------|
| | Thermal Dissorption Plant at Forcados Terminal | Recycle | Returned to manufacturer/supplier | Reused | Dumped at SPDC landfill | Skipped and dumped in deep offshore | Incineration | Utilized by host communities |
| Empty drums and containers | NA | P/A | A | A | X | NA | NA | X |
| Scrap metal and junk | NA | P/A | A | A | X | NA | NA | X |
| Oily sludge | P/A | A | NA | NA | X | X | A | X |
| Empty food containers | NA | P/A | A | NA | A | NA | NA | X |
| Food wastes | NA | NA | NA | NA | P/A | NA | NA | NA |
| Office (Paper) waste | NA | P/A | NA | A | NA | X | X | X |
| Medical wastes | NA | X | NA | X | X | X | P/A | X |
| Felled trees | NA | NA | NA | A | NA | NA | NA | P/A |
| Soiled sorbents and fabrics | NA | NA | NA | NA | X | X | P/A | X |

CODE: P – Preferred; A – Acceptable; P/A – Preferred and Acceptable; X – Prohibited
 NA – Not Applicable.

System Operation and Maintenance

Solid Wastes: Domestic refuse, oily/sandy waxes, scrap metals, Industrial refuse;
Aqueous Wastes: Oil leaks and accidental spills, storm water run-off, maintenance lubricants and condensate leaks, soil and sanitary wastes, pigging sludges;
Gaseous Wastes: Exhaust gases, refrigerant leakage and other fugitive gas emissions, fire-fighting agents.

Abandonment

Solid Wastes: Clean-up process equipment, used pipeline, pumps, Surge vessel, flare stack, abandoned platform, domestic refuse, industrial refuse, used process equipment, spent batteries and fire extinguishers containers.
Aqueous Wastes: Domestic sewage, lubricants and grease, sludges, condensate, glycol.
Gaseous Wastes: Refrigerants, fire-fighting agents.

7.9.2 Solid Waste Management

Site Preparation and Construction

Solid wastes generated during all phases of project development fall into two categories - biodegradable and non-biodegradable. Vegetation / trunks and stumps which are by-products of ROW preparation would be chopped and spread out evenly on either side of the ROW so that local firewood traders could carry them away, otherwise they would biodegrade with time. In the like manner, residual soil from top soil stripping and trenching would be evenly spread after pipe burial so that mounds do not form and impede natural drainage.

Operation, Maintenance and Abandonment**Kitchen Waste, Packing Materials, Scraps and Containers**

These wastes are sorted out into biodegradables and non-biodegradables. The biodegradables are landfilled off-site on dry land while the non-biodegradables, such as plastics, are burnt in an on-site incinerator provided for the purpose. Scraps and containers are segregated into usable and un-usable. The un-usable are incinerated along with non-biodegradables while the usable are returned to base. The classification and quantities of solid waste disposed would be reported monthly.

7.9.3 Aqueous Waste Management**Site Preparation and Construction**

The project area is flat, tidal, primarily swampy and receives about 2500 mm annual rainfall. It is naturally poorly drained, thus, it is important that no construction activity should block the storm run-off path particularly in relation to dredge spoils deposition. Where necessary, drainage should be provided for dredge water run-off. Construction of the CPF would provide adequate drainage channels for storm water run-off. A saver pit would be used in the drainage around the base camp to collect oil and grease from equipment maintenance areas. Pipe test water would be discharged into neighbouring stream parallel to stream surface to avoid stirring-up bottom sediments. Cement slurries, which would arise from pipe coating, would be handled in accordance with SPDC/DPR guidelines for effluent disposal in swamp environment.

Operation, Maintenance and Abandonment

Part of the Otumara AG Solution project includes modifications and tie-ins to integrate the new facilities and decommissioning of Saghara flowstation. This creates the possibility of oil leaks/ accidental spills from the facilities. Any such oil spill would be handled in accordance with SPDC Oil Spill Contingency Plan, which is already in place. Maintenance lubricants and condensate leaks in the Booster Stations and the CPF would be washed into the drainage channels which, along with storm water run-off would be channelled into saver pits from where oil will be recovered until the oil content of the remaining effluent is <20 ppm before it is discharged into the receiving environment in compliance with SPDC standards.

Pigging sludges would be subjected to process heat and recycled for recovery of gas and condensate. During abandonment, sludges and condensate would be collected and burnt in an incinerator. Any dehydrant left in the system would be washed off and disposed of according to the requirements of SPDC's Safe Handling of Chemicals (SHOC) system.

Results of the analysis of oil spills from multiplicity of sources within the Otumara/Saghara/Escravos Beach Fields from 2007 to 2012 are shown in Table 7.4. It is quite interesting to observe that most of the spills resulted from Sabotage and Equipment Failure. Equally interesting is the increasing number of spills due to the aging of the pipelines (Corrosion failure). This underpins the need for replacement of aging line pipes.

Table 7.4: Analysis of Oil Spill Records in Otumara/ Saghara/ Escravos Beach Fields (2007-2012)

| | | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|----------------------------------------|---------------------------------------------------------|------------------------------------------------------------|-------------------------------------------------------------|--------------------------------------------------------------|-----------------------------------------------------------|-----------------------------------------------------|
| 1 | Number of Spills | 9 | 7 | 21 | 12 | 13 | 2 |
| 2 | Total Quantity of Spills (bbls) | 7.8 | 157.41 | 78,410.31 | 2.37 | 44.90 | NIL |
| 3 | Cause of Spills | SA = 33.3% EF = 66.7% OE = 0% UK = 0% CR=0% | SA = 57.1% EF = 28.6% OE = 0% UK = 0% CR=14.3% | SA = 38.1% EF = 42.9% OE = 4.8% UK = 0% CR=9.5% | SA = 33.3% EF = 16.7% OE = 6.7% UK = 8.3% CR=25% | SA = 7.7% EF = 39% OE = 0% UK = 7.7% CR=61.5% | SA = 0% EF = 0% OE = 100% UK = 0% CR=0% |
| 4 | Status of Spills | WC = NDA WIP= NDA NAR= NDA | WC = NDA WIP= NDA NAR= NDA | WC = 7 WIP= NDA NAR= NDA | WC = NDA WIP= NDA NAR=3 | WC = 3 WIP= 2 NAR=8 | WC = NDA WIP= NDA NAR=1 |

Legend: SA = Sabotage, EF = Equipment failure, OE = Operational error, UK = Unknown cause, WC= work Completed, WIP= work in progress, NAR= No action required, CR= corrosion, NDA = No Data Available

7.9.4 Gaseous Waste Management

Site Preparation and Construction

The gaseous waste resulting from this phase of project development is largely exhaust emissions from diesel-powered earthmovers, laybarge engines and dredging/piling power systems. The main components of this exhaust stream are Carbon Dioxide (CO₂), Carbon Monoxide (CO), Oxides of Nitrogen (NO / NO₂). These emissions, largely CO₂ and particulate depend on the combustion efficiency of the engines. Shell will monitor and quantify these emissions from each source during construction, and will ensure that the equipment used are in good mechanical condition and have high combustion efficiency.

Operation, Maintenance and Abandonment

The main objective of this project is to limit routine gas flaring to 10% of gas production with the possibility of full gas flaring if and when the main compressor fails. With all the crude oil pump gas engines replaced with electric motors, emissions will be severely reduced. The main source of emissions will be the gas turbine at Otumara, and the fugitives. The exhaust stream consists of CO₂, CO, NO / NO₂, SO₂, CH₄ and VOC.

The quantities of atmospheric emissions from a gas turbine depend on:

- Fuel - The quality of fuel gas and its combustion characteristics,
- Power Output - The thermal efficiency is proportional to the size of the turbine, hence; bigger turbines have lower atmospheric emissions per unit of power output,
- Age - Mechanical efficiency decreases with turbine age, hence more emissions with increasing age,
- Load - Thermal efficiency decreases with decreasing driven load, hence emission levels of unburnt hydrocarbons and carbon monoxide increase significantly.

Past studies of exhaust emissions (Shell Gabon, 1993) from gas gathering stations show that 99% by weight of all emissions is CO₂. SPDC will, during detailed design, conduct technical review to assess the advantages and implications of installing and "low NO_x" burners to ensure that these emissions are minimised.

Fugitive emissions are defined as those emissions, which occur as a result of leaks from components such as pipe connections, valves, rotating shafts and other components. Shell will continue to identify, monitor and inventorise all wastes and emissions with a view to minimising them through judicious application of newly developed technologies.

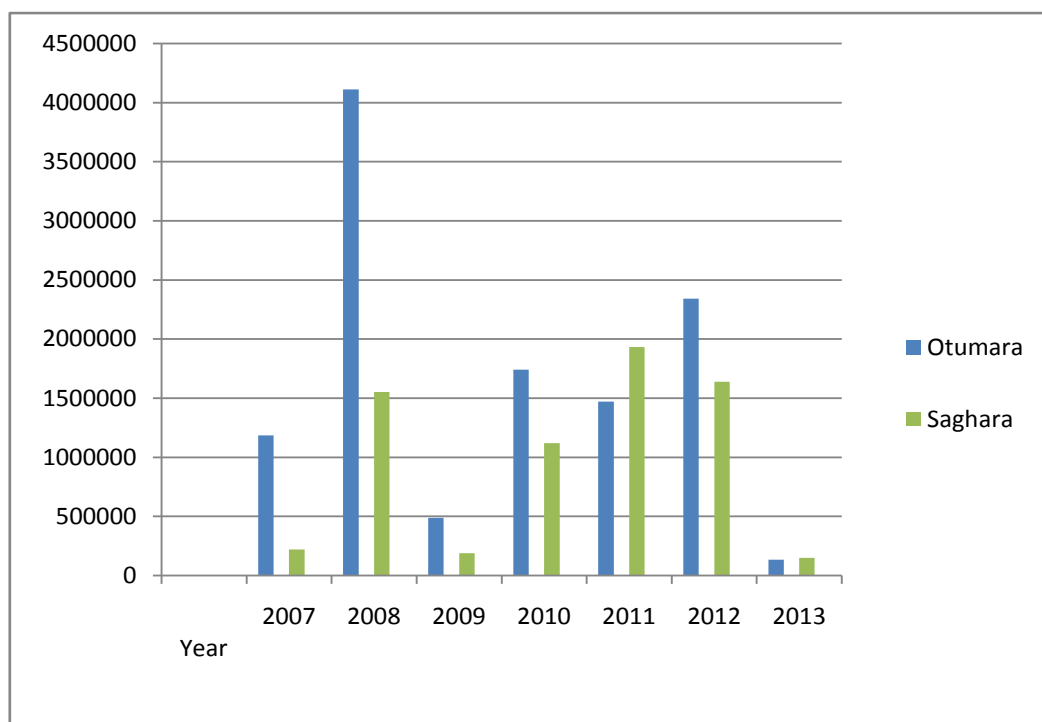


Fig. 7.1: Otumara and Saghara Gas Flare Records (scf/d)

Table 7.5: Green House Gas Emission Scenario in 2012 and 2017

| GHG | Tonnes/day | |
|------------------|-------------|------------|
| | 2012 | 2017 |
| CO ₂ | 270,105,916 | 84,959,980 |
| CH ₄ | 5216 | 1640.60 |
| N ₂ O | 4934 | 1551.98 |

The gas flares in Otumara/Saghara Fields from 2007 to 2013 are shown in Fig. 7.1, while calculated Green House Gas emissions in both fields are compared in Table 7.5 for the years 2012 and 2017, when the Gas Plant is expected to be functional. The table shows significant reduction in gas flares and GHG emissions, thus justifying the project.

7.9.5 Non-operational Gas Flares

Section 3.3.3 of this report outlined the conditions for gas flaring at the CPF and the flowstations after the commissioning of the project in 2015. If this happens, all the

Associated Gas produced in the field, less 20mmscf/d gas turbine consumption, will be flared. The CPF will still be equipped with pilot flares to facilitate emergency flaring when the need arises. Because of the possibility of this emergency flaring, it is recommended that vertical flare stacks be used. There should be some audible warning system against an impending emergency gas flare, which will likely come as an explosion.

CHAPTER EIGHT

CONCLUSIONS AND RECOMMENDATIONS

The results of the study showed that the air quality of Otumara field will substantially improve as a result of Mothballing of the Flowstation. Thus, the project will enhance air quality and reduce Nigeria's contribution to global warming potential. All construction activities will take place on the existing RoW, hence no additional land will be required. Since no dredging is involved, the ecology of the project area will not be significantly compromised. The project will provide employment opportunities for young people during all phases of the development. The extension of electric power to the communities will enhance socioeconomic activities in the project area. Based on the foregoing, we pray that this EIA Report be approved for implementation.

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GLOSSARY AND DEFINITION OF TERMS

Air Quality: The concentration in air of one or more pollutants.

Algae: Extremely simple unicellular or multicellular plants which utilize the process of photosynthesis for life.

Aquifer: An underground water-bearing layer of porous rock, e.g. sandstone, in which water can be stored and through which it can flow after it has infiltrated from either the surface or another underground source.

Bacteria: Class of small organisms usually 1 μm in diameter, unicellular or coccoid, do not possess chlorophyll and multiply rapidly, by division.

Benthos: The plants and animals that live in and on the bottom of a water body.

Biochemical Oxygen Demand: A standard water treatment test which is an empirical measurement of the relative oxygen requirement of waste waters, effluents and polluted waters. It measures the amount of oxygen utilized during a specific incubation period, usually 5 days, for the biochemical degradation of organic material.

Biodegradation: The ability of natural decay processes to break down man-made and natural compounds to their constituent elements and compounds, for assimilation in, and by, the biological renewal cycles, is decomposed to carbon dioxide and water.

Biosphere: The transition zone between solid earth and the upper atmosphere, where most living things are found.

Biological concentration: The mechanism whereby filter feeders such as oysters and other shellfish concentrate heavy metals or other stable compounds present in dilute concentrations in sea or fresh water.

Biological indicator: The use of living organisms of plants and animals to detect environmental changes.

Biomass: The mass of living organisms forming a prescribed population in a given area of earth's surface. It is usually expressed in grams per square metre (g/m^2)

Bioremediation: The use of biological methods to remediate/restore contaminated land. Typical methods make use of tailored microbes and break down phenols which are major contaminants.

Borehole: A hole drilled into the ground to tap an aquifer for water supplies or gas field for oil or gas. Once the well has been drilled it must be completed, that is, the hole is cased to prevent collapse with a slotted casing to allow water to enter.

Carbon dioxide: Gas produced by the complete combustion of carbonaceous materials, by decay of organisms such as aerobic decomposers, by fermentation, and by the action of acid on limestone. It is exhaled by plants and animals and utilized in photosynthesis in the carbon cycle.

Carbon monoxide: A colourless odourless gas, lighter than air, formed as a result of incomplete combustion. It is a chemical poison when inhaled, as it is absorbed into the blood stream where it combines with haemoglobin of blood cells and thus deprive the brain and heart tissues of oxygen.

Cathodic protection: Cathodic protection works by applying a d.c. power source to reverse the natural flow of electrical current caused by galvanic corrosion. This stops the steel reinforcement in a structure from rusting.

Chemical Oxygen Demand: The amount of oxygen consumed in the complete oxidation of carbonaceous matter in an effluent sample. This is done in a standard test, which uses potassium dichromate as the oxidizing agent.

Clay: Fine-grained sedimentary rock of low permeability which is capable of being shaped when moist. Consists of fine grains less than 4 μm in diameter.

Coliforms: A group of bacteria whose absence from drinking water is a guarantee of freedom from pathogenic bacteria.

Contaminant: A compound which is present in the environment in concentrations higher than the background level, but not necessarily causing a negative impact.

Contingency plan: A document setting forth an organised, planned and coordinated course of action to be followed in order to prevent pollution incidents, and limit potential pollution in case of fire, explosion or discharges of hazardous waste constituents which could threaten human health and the environment.

Cost-benefit analysis: A techniques which purports to evaluate the social costs and social benefits of investment projects in order to help decide whether or not such projects should be undertaken.

Crude oil: Petroleum in its natural form before it is subjected to any refining process.

Decibel: A logarithmic measure used to compare the sound level of interest with a reference level. If we are concerned with sound power then reference is made to the smallest sound power that can be heard by someone with normal hearing at 1000 Hz.

Decommissioning: The final closing down and putting into a state of safety of an industrial plant or device when it has come to the end of its useful life.

Decomposers: Organisms, usually bacteria or fungi, which use dead plants or animals as sources of food. They break down this material, obtaining the energy needed for life and releasing minerals and nutrients back into the environment to be assimilated by other plant and animal life.

Dispersion: The dilution and reduction of concentration of pollutants in either air or water. Air pollution dispersion mechanisms are a function of the prevailing meteorological conditions.

Disposal: The introduction of waste into the environment through any discharge, deposit, emission or release to any land, water or air by means of facilities designed, constructed and operated so as to minimize the effect on the environment.

Dissolved oxygen: The amount of oxygen dissolved in a stream, river or lake is an indication of the degree of health of the stream and its ability to support a balanced aquatic ecosystem. The oxygen comes from the atmosphere by solution and from photosynthesis of water plants.

Ecological indicators: Organisms whose presence in a particular area indicates the occurrence of a particular set of water, soil and climatic conditions.

Ecology: The study of the relationships between living organisms and between organisms and the environment, especially animal and plant communities, their energy flows and their interactions with their surroundings.

Ecosystem: The plants, animals and microbes that live in a defined zone and the physical environment in which they live comprise together an ecosystem. The ecosystem embraces the food chain through which energy flows together with the biological cycles necessary for the recycling of essential nutrients.

Environment: The air, land, water and other external conditions or influences in which man, animals and plants live or develop.

Environmental audit: This is an account by manufacturers and industries of the products produced and their effects on the environment - energy use policies, materials use policies, waste output and their effects on the environment.

Environmental impact: A change in environmental quality. The word 'impact' connotes that a value judgement has been made on the importance of an environmental effect or change.

Environmental impact assessment: An activity designed to identify and predict the impacts of petroleum operations on the surrounding biogeophysical environment including man's health and well being and to interpret and disseminate information about those impacts.

Environmental impact statement: Assembling the results of the environmental impact assessment into a document which contains a discussion of beneficial and adverse effects considered to be relevant to the petroleum operations.

Environmental quality: The state of the environment as perceived objectively in terms of measurements of its components, or subjectively in terms of its attributes such as beauty and worth.

Environmental sensitivity: The susceptibility of a particular environment or area to any disturbance.

Estuary: Tidal coastal body of water where salinity is intermediate between fresh and salt water.

Eutrophication: The natural ageing of a lake or land-locked body of water which results in organic material being produced in abundance due to a ready supply of nutrients accumulated by man over a period of time.

Fauna: The animals of a distinct region.

Flora: The plants of a distinct region.

Freshwater: Surface and subsurface water in its natural state useful for domestic livestock, irrigation, industrial, municipal and recreational purposes and which will support aquatic life and contains less than 0.5 ‰ salinity

Fungi: Simple plants either unicellular or made up of cellular filaments; they contain no chlorophyll. They are agents of decay in all natural organic materials, food, timber, plant debris, etc.

Artificial Gas lift: Associated gas re-injected into a producing oil well, to augment the natural hydrostatic pressure.

Greenhouse effect: The mechanism whereby incoming solar radiation is trapped by a glass sheet or the presence of carbon dioxide and other greenhouse gases in the atmosphere. As these gases are transparent to solar radiation, the short-wave incoming radiation is transmitted. However they are opaque to long wave re-radiation from the earth's surface or from any other object underneath, thus heat is trapped and the underlying surface is thereby warmed.

Greenhouse gases: Collective term for those gases that have influence in the greenhouse effect, that is, chlorofluorocarbons, carbon dioxide, methane, nitrous oxide, ozone and water vapour.

Groundwater: Water occurring within the saturation zone of an aquifer is the only part of all subsurface water which is properly referred to as groundwater or phreatic water.

Groundwater may be of variable chemical quality ranging from wholesome potable waters to highly mineralized brines.

Habitat: The chemical, physical and biological setting in which a plant or animal lives.

Hazardous waste: Refuse which because of its inherent nature and quantity requires special disposal techniques to avoid creating health hazards, nuisances or environmental pollution. Hazardous wastes are toxins or poisons, corrosives, irritants, strong sensitizers, flammables, explosives, infectious wastes condemned foods, etc. Flammable wastes include explosive plastics, paper, paper products and the like.

Hazen unit: A unit of measurement for colour in water. It is based on the colour produced by 1 mg platinum per litre in the presence of a cobalt-based compound.

Heavy metal: Any of the following elements: antimony, arsenic, beryllium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver, thallium, vanadium, or zinc.

Hydrocarbons: Chemical compounds consisting wholly of hydrogen and carbon.

Hydrogen sulphide: Dense colourless gas with a smell of rotten eggs which is extremely toxic. It is produced under anaerobic decay conditions and can accumulate in sewers.

Hydrology: The science concerned with the occurrence and circulation of water in all its phases and modes and the relationship of these to man.

Inorganic matter: Matter which is mineral in origin and does not contain carbon compounds, except as carbonates, carbides, etc.

Insolation: The amount of direct solar radiation incident per unit horizontal area at a given level, measured in mW/m^2 .

LC₅₀: The lethal concentration of a substance in air or water necessary to kill 50% of test organisms within a specified time under standard conditions.

LD₅₀: The lethal dosage of a substance necessary to kill 50% of a sample population of test animals as determined from exposure to the substance, by any route other than inhalation within a specified time under standardized conditions.

Leachate: Any liquid, including suspended materials which it contains, which has percolated through or drained from special waste facility.

Marine water: Includes estuarine and coastal water, where estuarine means a semi-enclosed coastal body of water having free connection to the sea and having a chloride ion concentration in excess of 1000 mg/L.

Microbes: Microscopic organisms, usually bacteria of which some are pathogenic, e.g. *Salmonella*, which is associated with food poisoning in man. They are essentially scavengers of organic material breaking down dead plant and animal remains, sewage and even toxic wastes that are organic in origin.

Micron: One-millionth of a metre, hence the more correct term micrometre. It is commonly used for particle sizing. Symbol μm in SI units.

Minamata disease: Minamata is a town on the west coast of Kyushu Island (Japan) where an extreme case of heavy metal poisoning from methyl mercury ingested in the staple fish diet of the inhabitants caused severe disablement and death between 1953 and 1956. The symptoms include numbness in fingers and lips and difficulty in speech and hearing.

Noise: Sound that is socially or medically undesirable, that is, any sound that intrudes, disturbs or annoys. Very high levels of sound can cause hearing damage.

Nutrients: The raw material necessary for life which are consumed during the metabolic process of nutrition. Their type and consumption vary according to the particular plant or animal species. The main categories are proteins, carbohydrates, fats, inorganic salts, minerals and water.

Oligotrophic: An aquatic environment which has low concentrations of nutrients present and therefore has low plant and animal life productivity.

Organic matter: Material containing carbon combined with hydrogen often with other elements (oxygen, nitrogen), e.g. plastics, vegetable matter.

Pathogen: A living organism usually a micro-organism that causes disease.

Petroleum: A naturally occurring mixture of predominantly hydrocarbons in the gaseous, liquid or solid phase.

pH: A measure of the alkaline or acid strength of a substance. The pH value of any solution in water is expressed on a logarithmic scale to the base 10. It is defined and calculated as the logarithm of the reciprocal of the hydrogen-ion concentration of a solution.

Photosynthesis: The process whereby plants utilize radiant energy from the sun and carbon dioxide from the atmosphere, in the presence of chlorophyll, to manufacture organic matter.

Phytoplankton: Free floating minute plants in sea, lake and river surface waters where sufficient sunlight is available for photosynthesis.

Pig: A scraping tool forced through a pipeline or flowline to clean out accumulations of water, wax, rust, scale, and debris from the walls of the pipe.

Pollutant: A contaminant exerting significantly adverse effects on biota including ecological systems.

Pollution: Pollution is the introduction into the environment of substances or effects that are potentially harmful or interfere with man's use of his environment or interfere with species or habitats.

Recompletion: A drilling process which brings oil and gas wells into production.

Refuse: Discarded materials, substances or objects.

Remediate: To remove, eliminate, limit, correct, counteract, or mitigate the negative effects on the environment or human health of one or more contaminations.

Receiving water: Any body of surface water into which a discharge of leachate or effluent may flow. Receiving waters wholly contained within a permittee's property are not included in this definition, provided that pollutants in such waters cannot be transported outside the property.

Run-off: The volume of water derived from rain falling on a surface and which does not permeate into the soil.

Salinity: Total amount of dissolved material expressed in terms of kilograms of material per million kilograms of feed water, that is, parts per million (ppm) of total dissolved solids.

Sample: A part of a population selected with the object of estimating some characteristics of the whole population. Can be random or spot.

Sediment: The deposit of silt and accumulated organic and/or inorganic materials at the bottom of rivers, lakes, seas, etc.

Silt: Normally a wet mixture of particles between 4 and 60 μm diameter often found in the bottom of streams, rivers, etc. Intermediate between clay and mud.

Species: In botany or zoology, a group of closely-related individuals showing constant differences from allied groups.

Standard deviation: The most common measure of spread or deviation in a set of observations. It is the square root of the average of the squares of the differences (Variance) of each observation from the mean of those observations.

Tar balls: Lumps of oil, weathered to a high density, semi-solid state.

Total dissolved solids: The solids residue after evaporating a sample of water or effluent expressed in mg/litre.

Toxicity: The capability of a poisonous (toxic) compound to produce deleterious effects in organisms.

Treatment: The handling or processing of special waste in such a manner as to change the physical, chemical or biological character or composition of the special waste in order to eliminate or reduce the volume, or one or more hazardous properties of the special waste.

Waste: Any unavoidable material resulting from an up-stream operation for which there is no economic demand and which must be disposed of.

Waste oil: Automotive lubricating oil, cutting oil, fuel oil, gear oil, hydraulic oil or any other refined petroleum based oil or synthetic oil where the oils through use, storage or handling have become unsuitable for their original purpose due to the presence of impurities or loss of original properties.

Weathering: Natural influences such as temperature, wind, light, bacteria, that alter the physical and chemical properties of oil.

Wetland: Any land such as a tidal flat, marsh, swamp, bog or fen which is frequently inundated and for that reason has developed an organic soil and occurs in an area which is lower lying than its surroundings.

Ultraviolet radiation: Radiation which falls between visible light waves and X-rays. The longest UV waves have wave lengths slightly less than those of violet light, the limit of the human eye.

Variance: A statistical term - the square of the standard deviation.

Volatile organic compounds: Organic compounds, (e.g. ethylene, propylene, benzene, styrene, acetone) which evaporate readily and contribute to air pollution directly or through chemical or photochemical reactions to produce secondary air pollutants, primarily ozone and peroxyacetyl nitrate.

Water table: The upper surface of the saturation zone below which all void spaces are filled with water.

Zooplankton: The floating, drifting or weakly swimming aquatic animal life of the open water.

APPENDICES

APPENDIX 1



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

TERMS OF REFERENCE (TOR)

For the

**OTUMARA ASSOCIATED GAS (AG) SOLUTION EIA
PROJECT**

DECEMBER 2011

ABBREVIATIONS AND ACRONYMS

| | |
|--------------------|---------------------------------------------------------------------|
| ALARP | As Low As Reasonably Practicable |
| AGG | Associated Gathering Gas |
| AG | Associated Gas |
| AQ | Air Quality |
| Bcf | Billion cubic feet |
| BOD ₅ | Biological Oxygen Demand |
| Bscf | Billion standard cubic feet |
| CAS | Catch Assessment Survey |
| CAPEX | Capital Expenditure |
| CBO | Community Based Organisation |
| CBR | Crude Birth Rate |
| CDR | Crude Death Rate |
| CEC | Cation Exchange Capacity |
| CITES | Convention to regulate International Trade in Endangered Species |
| COD | Chemical Oxygen Demand |
| CRI | Cutting Re-Injection |
| DO | Dissolved Oxygen |
| DOMGAS | Domestic Gas |
| DPR | Department of Petroleum Resources |
| DSM _{Env} | Delta State Ministry of Environment |
| EC | Electrical Conductivity |
| EIA | Environmental Impact Assessment |
| ELPS | Escravos Lagos Pipeline System |
| EMP | Environmental Management Plan |
| EPF | Early Production Facility |
| FDP | Field Development Plan |
| FEED | Front-End Engineering Design |
| FEPA | Federal Environmental Protection Agency |
| FGD | Focus Group Discussion |
| FID | Final Investment Decision |
| FM _{Env} | Federal Ministry of Environment |
| GEM | Gender Empowerment Measure |
| GIIP | Gas Initially in Place |
| GW | Groundwater |
| HAZID | Hazard Identification |
| HAZOP | Hazard Operability |
| HDI | Human Development Index |
| HIA | Health Impact Assessment |
| HPI | Human Poverty Index |
| HSE | Health, Safety, Environment |
| HSE-MS | Health, Safety and Environment Management System |
| IA | Impact Assessment |
| IFC | International Finance Corporation |
| ISO | International Organisation for Standardisation |

| | |
|---------|----------------------------------------------------------------------|
| IUCN | International Union for Conservation of Nature and Natural Resources |
| km | Kilometres |
| LGA | Local Government Area |
| MAC | Mid Arm Circumference |
| MEDEVAC | Medical Emergency Evacuation Response |
| MoU | Memorandum of Understanding |
| MMbbl | Million Barrel |
| MMboe | Million Barrel of oil Equivalent |
| MMscf/d | Million Standard cubic feet of gas per day |
| MMstb | Million stock tank barrel |
| NAG | Non Associated Gas |
| NDPC | Niger Delta Peace Coalition |
| NDT | Non Destructive Test |
| NERC | National Electricity Regulatory Commission |
| NFA | No Further Activity |
| NGO | Non Governmental Organisation |
| NIWA | National Inland Waterways Authority |
| NPF | Nigeria Police Force |
| OML | Oil Mining License |
| PRA | Participatory Rural Appraisal |
| Q1 | Quarter one |
| Q4 | Quarter four |
| QA/QC | Quality Assurance/Quality Control |
| QRA | Quantitative Risk Assessment |
| RoW | Right of Way |
| RF | Recovery Factor |
| SCD | Sustainable Community Development |
| SD | Sustainable Development |
| SED | Sediment |
| SIA | Social Impact Assessment |
| SMART | Specific, Measurable, Achievable, Realistic and Time-based |
| SPDC | Shell Petroleum Development Company of Nigeria Limited |
| SS | Soil Sample |
| SSAGS+ | Southern Swamp Associated Gas Solution Plus Project |
| SSIOGP | Southern Swamp Integrated Oil & Gas Project |
| SW | Surface Water |
| SWL | Static Water Level |
| TDS | Total Dissolved Solid |
| THC | Total Hydrocarbon |
| Tcf | Trillion cubic feet |
| ToR | Terms of Reference |
| Tscf | Trillion standard cubic feet |

| | |
|-----|-------------------------|
| TSS | Total Suspended Solid |
| UR | Ultimate Recovery |
| VAR | Value Assurance Review |
| VEG | Vegetation |
| VOC | Volatile Organic Carbon |

INTRODUCTION

The Shell Petroleum Development Company of Nigeria Limited (SPDC), on behalf of the Joint Venture partners (Nigerian National Petroleum Corporation, Nigerian Agip Oil Company, and Total), plans to embark on the Otumara Node (Otumara & Saghara flow stations) Associated Gas Solution Project to meet the business objectives of Domestic Gas supply and gas flares down. At present, most of the associated gas produced at the Otumara flow station is being flared. Produced associated gas is currently used as fuel gas for the pumps and generators, for lift gas, and the excess flared.

The SPDC Business Plan forecast for Otumara showed that substantial Further Oil Development (FOD) activities may commence in the field, and will need disposal of AG and probably more lift gas. In view of this, it is considered that a pre-investment in AG pipeline from Otumara to Escravos beach will be required, by installing a 12''x 17km pipeline to the Escravos-Lagos Pipeline System (ELPS) to accommodate 20 mmscf/day.

1.1 Project Location

The proposed project is mainly a facility upgrade of the existing Otumara flow station through the installation of new facilities in order to harvest Associated Gas (AG) from the Otumara field in Delta State of Nigeria (fig 1). Otumara Node is situated in OML43, 65km northwest of Warri. The field was discovered in 1969 and put on production in 1972. Mixtures of stabilized crude and produced water are pumped from the flow stations via a delivery line into the Trans-Escravos trunk line and thence to the Forcados Terminal some 45km away.

There is a leased gas lift compressor station installed on a barge next to the flow station of capacity 15mmscf/d. The existing flow station is piled. The inhabitants of the project area are mostly Ijaw speaking communities.

1.2 Terms of Reference (ToR) Preparation

This Terms of Reference (ToR) is developed in an integrated manner to include the Scope of Work for Biophysical, Social and Health Impact Assessments. This is in compliance with regulatory requirements and the SPDC Environmental Impact Assessment (EIA) process. It also aims at giving equal coverage to the Biophysical, Social and Health aspects of the environment. The purpose of the Terms of Reference is to identify, for the public and the study executors, information required by government regulatory agencies for an Impact Assessment (IA) report for the proposed project.

1.3 Executing Arrangements.

SPDC is responsible for the preparation of the EIA report which shall conform to the approved regulatory guidelines as well as the SPDC IA Process Manual. SPDC intends to carry out the EIA through a contractual arrangement with accredited EIA consultants.

The field is a brown field and some previous studies had been carried out in the area see Section 2.3. SPDC had earlier secured approval from DPR (in the meeting of Wednesday November 30, 2011 held in DPR Lagos office - Annex conference room), this study shall involve a one-season sampling regime for biophysical studies and cross-sectional survey for Social and Health aspect of the environment. The result will be the establishment of current environmental condition for the existing facilities and operations, baseline environmental conditions for the current project, identification of potential impacts, development of mitigation measures and an Environmental Management Plan (EMP).

1.4 Institutional and Legislative Framework

The EIA study and project implementation shall be in accordance with the following laws, guidelines, standards and conventions:

1.4.1 Federal Regulations/Guidelines

- The Environmental Impact Assessment (EIA) Act No. 86 of 1992;
- Environmental Guidelines and Standards for the Petroleum Industry in Nigeria, 2002 Department of Petroleum Resources (DPR);
- Department of Petroleum Resources (DPR) Mineral Oils Safety Regulations 1997;
- FEPA (now FMENV) EIA Procedural Guidelines, 1995;
- S.I.8 - National Environmental Protection (Effluent Limitations) Regulations of 1991;
- S.I.9 – National Environmental Protection (Pollution Abatement in Industries and Facilities Generation Wastes);
- S.I.15 – National Environmental Protection (Management of Solid and Hazardous Wastes) Regulations of 1991;
- The Petroleum Act No. 51 of 1969;
- The Petroleum Drilling and Production Regulations – 1969;
- The Oil Pipeline Act and Oil and Gas Pipeline Regulation of 1995;
- Endangered Species Control Act of 1985;
- Land Use Act of 1978;

- National Inland Waterways Authority (NIWA) Act 13 of 1997;
- Factory Act 1992;
- Revised National Health Policy, 2004;
- National Health Act 2005; and
- National Guidelines and Standards for Environmental Protection 1991.

1.4.2 State Regulations

- Delta State Environmental and Planning Edict 1999;
- Delta State Ecology Law, 2006
- Bendel State Forestry Law Cap 59, , 1976(Now applicable to Delta State)
- Delta State Waste Management law, 2006
- Delta State Revenue Edict, 1997
- Delta State Internal Revenue Consolidation Law, 2009
- Endangered Species Act, 1985

1.4.3 Relevant International Conventions, Guidelines and Standards

- International Union for Conservation of Nature and Natural Resources (IUCN) Guidelines, 1996;
- World Bank Guidelines on Environmental Assessment, 1991;
- World Bank Operational Directive 4.00, Annex A: "Environmental Assessment"
- Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention), 1979;
- Convention on Biological Diversity (Rio Summit), 1992;
- Convention Concerning the Protection of the World Cultural and Natural Heritage Sites (World Heritage Convention), 1978;
- Basel Convention on the Control of Trans-Boundary Movements of Hazardous Wastes and their Disposal, 1989;
- Convention to Regulate International Trade in Endangered Species of Fauna and Flora (CITES), 1973; and
- International Finance Corporation (IFC), Environmental and Social Standards (Equator Principle) Revised Edition, 2006.

1.5. Objectives of the EIA

The objectives of the EIA study are to:

- Determine the current status of the Environment and impacts of the existing SPDC facilities and operations in the project area.
- Determine baseline conditions of the environment as well as the socio-economic and health conditions of the host communities;
- Determine and evaluate the potential impacts of the proposed project activities on the environment, using the current environmental conditions as the baseline;
- Identify and evaluate the potential socio-economic effects of the project on the communities including impacts on cultural properties, social infrastructures, natural resources and impact on lifestyles / values as well as analysis of the opportunity cost to chemical spills during project activities;

- Identify health hazards that may result from the different phases of the project during execution (including operation & decommissioning) and evaluate local population exposure to these hazards;
- Develop cost effective mitigation measures and appropriate Environmental Management Plan (EMP) for all identified impacts.

2.0 DESCRIPTION OF PROJECT ACTIVITIES

The new facilities for installation at the Otumara flowstation in order to handle the associated gas currently being flared and convert it to economic use are; High Pressure Associated Gas compressor, Low temperature separation vessel, TEG dehydration system and electric power generator. The estimated land coverage for the new facility is about 100 square meters within the existing Otumara flow station area on a swamp-piled foundation. Saghara flowstation shall be decommissioned, preserved and mothballed and convert to a free-flow manifold. As part of the Otumara flowstation upgrade, a 12''x17 km gas pipeline with pigging facilities would also be constructed using existing SPDC pipeline Right of Way (ROW) for 15km and fresh land acquisition for 2km with 15 m width in order to inject the harvested associated gas into the Escravos-Lagos Pipeline System (ELPS) at Escravos. While as part of the Saghara flowstation mothballing, an inlet manifold, 4''x5km pipeline and a 6''x5km pipeline shall be installed to free-flow Saghara wells to Otumara flowstation for processing.

Project also involves the design, supply, construction and commissioning of a 44-man Field Logistics Base (for staff accommodation) at Otumara. The estimated land coverage for the new FLB is about 100m x 200m, land shall be sand-filled.

2.1 Facilities Project Scope

1. Otumara Central Processing Facility (CPF) of 20 mmscf/d nominal capacity
 - Gas processing Module- Nominal 30 mmscf/day
 - Gas Compression - Nominal 20 mmscf/day
 - Power generation/utility modules- Circa 5.5 MW ISO
 - Flare systems relief
 - Blow down systems.
2. Otumara Flow station brown field works
 - Modifications and tie-ins to integrate the new facilities.
 - Site preparation and civil works including all dredging, piling and shoring works.
3. Design, construction and commissioning of a 44-bed FLB
4. Decommission, preserve and mothball Saghara flow station, and convert to a free-flow manifold

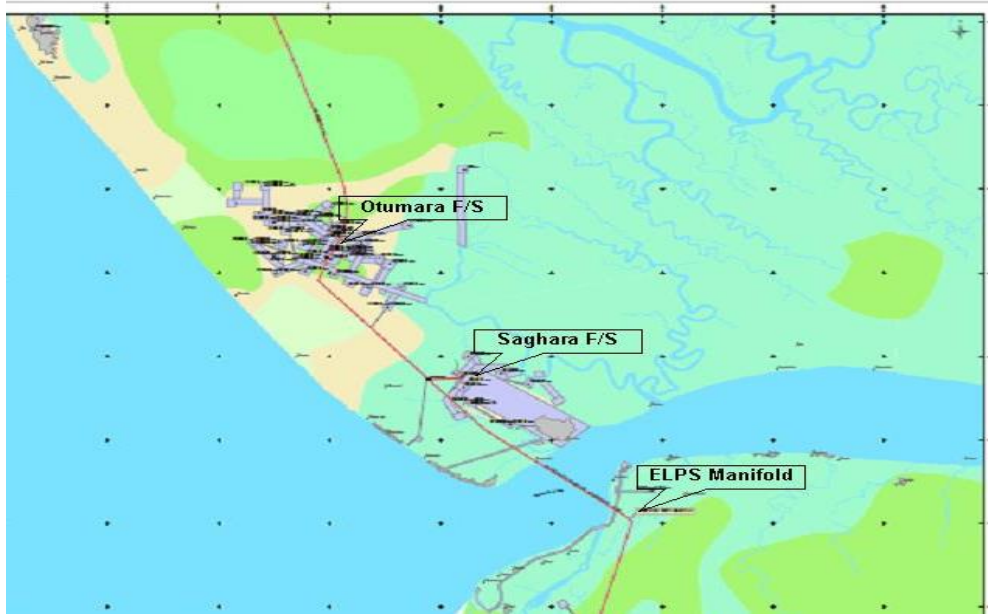


Figure 3: Otumara Node Location Map.

2.2 Pipeline Project Scope

- i. Corrosion Inhibition Lines - 2" x 5km (From Otumara CPF to Saghara Manifold)
- ii. Test Line - 4" x 5km (from Saghara Manifold to Otumara F/S)
- iii. Bulk line - 6" x 5km (from Saghara Manifold to Otumara F/S)
- iv. Gas Export line - 12" x 12km (from Otumara CPF to ELPS manifold at Escravos Beach)
- v. Flowlines – 15km (Re-routing of 7nos Otumara wells from Saghara F/S to Otumara F/S).
- vi. Manifolds and Pigging facilities (launcher and receiver)
- vii. Cathodic protection system
- viii. 21km Fibre Optic cable for data transmission

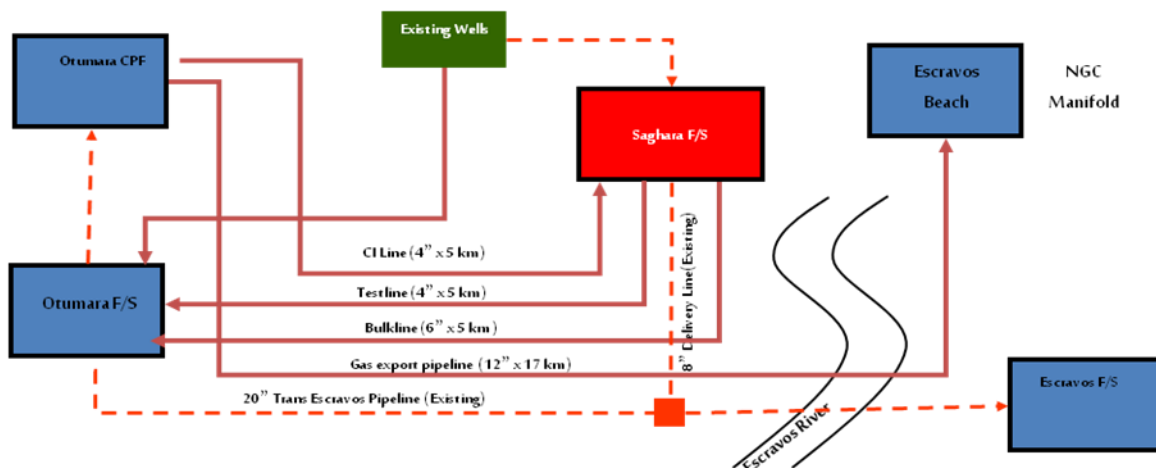


Figure 4: Otumara Node Project Schematic

2.3 Previous Studies in the Area

The following environmental studies have been carried out by SPDC.

Studies approved by FMEnv in the project area include:

- Otumara Field Associated Gas Solution 2008 (Desktop)
- Saghara Field Associated Gas solutions 2008 (Desktop)
- Otumara Deep Exploration and 2FE wells 1999 (Desktop)

2.4 Project objectives

The objectives of the Otumara Node AGS project are:

- Align with government’s aspirations by contributing to SPDC’s plan to meet its assigned DOMGAS contributory quota and thus deliver 100 MMscf/d gas to the Western domestic gas market.
- Implement the drive for reliability and standardisation of major facilities using industry standards.
- Achieve Flares down and thus minimize impact on the environment and enhance the socio-economic development of the host communities in the area through sustainable development of the project over its life cycle.
- Provide Lift Gas for Secondary Recovery
- Maintain Reputation
- Maintain LTO
- Secure Developed reserves
- Enable Maturation/booking of undeveloped reserves
- Alignment with Stakeholders aspiration

2.6. Project Options

The project development alternatives considered were;

- Do Nothing,
- Develop the project via distributed compression concept
- Develop the project via distributed compression concept

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

Table 1.0: Project Alternatives/ Options Considered

| S/N | Options | Advantages | Disadvantages |
|-----|-----------------------|----------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. | Do nothing | No Capital Expenditure No negative impact of project on the environment | <ul style="list-style-type: none"> • No Gas to sustain supply to the Gas Plant • Government aspirations to improve power supply by year 2014 will not be met • Environmental degradation from gas flare will persist. • Gas supply to domestic market will not be met • Loss of revenue |
| 2. | Build on New location | Requires land acquisition and therefore more money to the community. Employment opportunities Contract opportunities | <ul style="list-style-type: none"> • Increased pressure on existing social-economic infrastructures in view of influx of people. |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| S/N | Options | Advantages | Disadvantages |
|-----|----------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|
| 3. | Build on existing location | <ul style="list-style-type: none"> • No land take • Employment opportunities • Contract opportunities • No negative impact on project schedule • Minimal vegetation clearing • Improved environmental performance | <ul style="list-style-type: none"> • Increased pressure on existing facility in view of influx of people. |

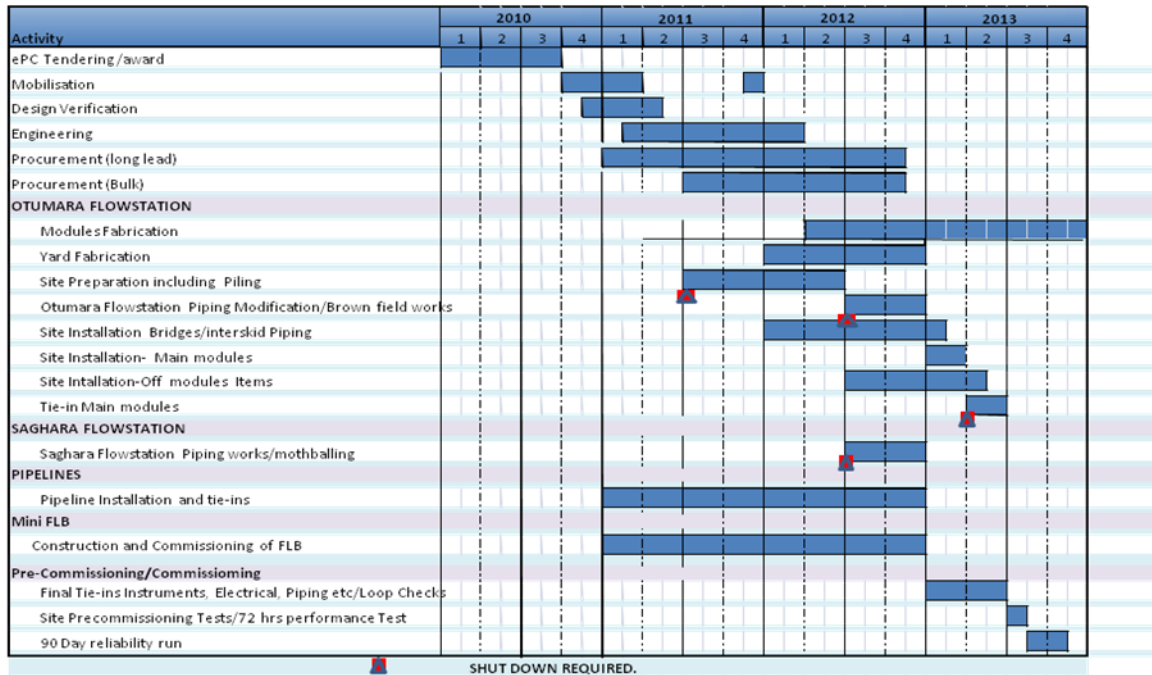


Fig 5: Project Activities and schedule

3.0 EIA Scope of Work

The general scope of the EIA will cover all the activities that constitute the project. It will outline the techniques and methodology to be used in generating data including the description of the data sources. The following categories will be covered:

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

The scope of work incorporates the issues and concerns that arose from the Scoping Workshop attached as Appendix 3 and 4 as well as the experience and professional judgements of consultants and regulators based on similar projects (Tables 2 to 8). The

detailed scope for each of the environmental components is presented in the following sections.

3.1 Baseline Data Acquisition

3.1.1 Literature Review

3.1.1.1 Biophysical

Review relevant FMEnv and DPR approved EIA reports and previous baseline studies for the proposed project areas, as well as other available literature on Niger Delta ecology. The review shall focus on:

- Defining the spatial boundaries of the study area
- Identifying the data gaps, if any, in the previous environmental studies, in order to enable proper characterisation of the environmental components.
- Establishing the conservation status of the area and its relationship to any protected areas in the country.
- Obtaining relevant secondary data on regional environmental features from local and national agencies (Nigerian Meteorological Agency, Nigerian Institute for Oceanography and Marine Research, etc.)

3.1.1.2 Social

- Identify and obtain all relevant data from secondary sources such as Government agencies (National Population Commission, National Bureau of Statistics, Nigeria Police Force (NPF) and other Security Agencies etc.), Regulators, SPDC Reports, Journals, etc.
- Establish baseline data on the project area, including its people, culture, language, tradition, local governance, trend of population change, geographical area, livelihood activity systems, infrastructure, archaeological and historical artefacts, traffic analysis and potential impacts of the project.
- Identify all stakeholders including National and International authorities, Non-Governmental Organisations (NGOs), Community Based Organisations (CBOs) Local/ State government authorities, regulators, community leaders and groups that could be involved in the project and state the basis of their involvement.

3.1.1.3 Health

- Identify and obtain all relevant data on the health conditions of the communities over time from Bayelsa and Delta States Ministries of Health, Hospitals Management Boards, Local Government Primary Health Care Departments and private clinics in the study area.
- Determine the population and disease trend over time in the study communities from the National Population Commission, Bayelsa and Delta States Ministries of Health and National Bureau of Statistics, etc.
- Acquire information on health budget, local health situation, policies and programmes, regulations, conflicting goals/priorities.
- Establish history of any health issues in the study communities.
- Determine effects of seasonal changes on the health of the people from the Ministries of Health (Public Health Departments).

- Identify necessary health standard requirements and standards.

The baseline conditions for biophysical, social and health parameters will be determined through existing literature, fieldwork, laboratory analyses and data analyses. Adequate data shall be acquired during the one season fieldwork and shall be backed up with secondary data to enable proper characterisation of the environment.

3.1.2 Field Data Acquisition

3.1.2.1 Biophysical

The fieldwork will involve determination of relevant environmental parameters under appropriate quality control/quality assurance measures.

The status of the environmental components and indices that should be established during the baseline data acquisition has been outlined in Table 2. All the samples collected during the fieldwork will be analysed for the different parameters as provided in Table 3.

The quantities of samples to be acquired in the study are presented in Table 4. All samples collections shall be geo-referenced as shown in Table 5. Four control stations located at 3, 6, 9 and 12 O'clock of the study area for groundwater; soil, sediment, vegetation and ambient air will be collected at appropriate and accessible points. The detailed proposed sampling points are presented in Appendix 1- Sampling map.

3.1.2.1.1 Sampling Rational

The sampling plan for the field data gathering was developed in a way to ensure that the biophysical components collect during field work are true representation of the environmental status. This was achieved as follows:

- Samples will be collected within a boundary of 2 kilometers radius of any flow station, at intervals of 150, 300 and 500 meters on the four cardinal points of the flow station. After the 500 meters interval from the flow station, sampling points are staggered in such a way that helps determine the current status of the environment, putting into consideration, the existing/proposed wells and facilities.
- Samples will be collected within a boundary of 100 meters on both sides of pipeline right of way and spaced 200 meters interval along the pipeline.
- Samples will be collected from each community's source of portable water in addition to the ground water samples around the facilities. The boreholes will be drilled in triangular form to aid determination of direction of flow of the ground water.
- Air quality sampling will take place in each of the communities as well as the four cardinal points of the facilities. Also air quality sampling will be staggered in the study area to capture a better coverage of the area.
- Vegetation samples will be collected from every soil sampling point.
- Sediment samples will be taken from every surface water sampling point.

Table 2.0: Data Requirements and Environmental Indicators (Biophysical Aspect) for the EIA

| Environmental Component | Environmental Aspect | Data Acquisition | Potential Environmental Impact Indicator |
|--------------------------------------------|--------------------------------------------|---------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Climate/ Meteorology | Microclimate/Regional Climatic features | <i>In situ</i> measurement, secondary data | Temperature, Rainfall, Relative humidity, Wind direction and speed, visibility, cloud cover and their local effects. |
| Air Quality | Local and Regional | <i>In situ</i> / laboratory analysis | Particulate, NO _x , SO _x , CO ₂ , CO, VOCs, H ₂ S Heavy metals (Fe, Cd, Cr, Pb, Ni, V, Zn) |
| Noise | Local | <i>In situ</i> measurement | Ambient noise level dB(A), communication interference. |
| Surface Water /Sediment Characteristics | Hydrology/ Hydrodynamics | <i>In situ</i> /secondary data | River depth, width, flow direction, flow rate, current/tidal information, drainage characteristic, sediment transport, river bank erosion |
| | Physicochemical Features | <i>In situ</i> measurements, Composite samples for laboratory analysis | Colour, alkalinity, TDS, TSS, Turbidity, EC, THC, pH, DO, Redox potential, BOD ₅ , COD, Oil & Grease, Anions/Cations, NH ₄ ⁺ , NO ₃ ⁻ , NO ₂ ⁻ , PO ₄ ³⁻ , SO ₄ ²⁻ , SiO ₂ , Na ⁺ , K ⁺ , Ca ²⁺ , Mn ²⁺ , Mg ²⁺ Heavy metals (Fe, Cd, Cr, Ni, V, Pb, Zn, Hg). |
| | Hydrobiology | Composite samples for laboratory analysis | Species composition, distribution, diversity and abundance and seasonality of Phytoplankton, Zooplankton, Benthos, Aquatic macrophytes, Macrophyte-associated macrofauna |
| Surface Water /Sediment Characteristics | Fisheries | Direct observations/interviews, <i>In situ</i> measurements, composite samples for laboratory analysis | Species composition, catch-composition, Fisheries activities (including aquaculture) catch-per-unit of effort and price, fishing gears/methods, population in fisheries, spawning grounds, migration routes and patterns, productivity and pathology, Population of Fisher- Folks Proportion of male/female, Adult/Children etc |
| | Microbiology (surface water) | Composite samples for laboratory analysis | Total heterotrophic bacteria, fungi, Total hydrocarbon utilizing bacteria and fungi, total and faecal coliforms. |
| | Sediments | Composite grab samples for laboratory analysis | Colour, Texture, Temperature, pH, Redox potential, THC, Oil & Grease , Sediment geochemistry (Fe, Ni, V, Cd, Cr, Hg etc.), Sediment microbiology |
| | Water Use | Direct observation/ interviews | Traditional use of rivers and water bodies (navigation, sand mining, food processing, aquaculture, domestic etc) |
| Ground Water Characteristics | Physicochemical Features | <i>In situ</i> / laboratory analysis | Colour, odour, alkalinity, TDS, TSS, Turbidity, EC, THC, DO, pH, Redox potential, BOD ₅ , COD, Oil & Grease, Anions/Cations, NH ₄ ⁺ , NO ₃ , NO ₂ , PO ₄ , SO ₄ , SiO ₂ , Na, K, Ca, Mn, Mg, Heavy metals (Fe, Cd, Cr, Ni, V, Pb, Zn, Hg). |

Environmental Impact Assessment (EIA) of Otumara AGS Project

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

Table 3.0: Sampling Specifications and Parameters for Laboratory Analysis for Biophysical Samples for the EIA

| Environmental Component | Environmental Aspect | Data Acquisition | Potential Environmental Impact Indicator |
|----------------------------------|--------------------------------------------|---------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Climate/ Meteorology | Microclimate/Regional Climatic features | <i>In situ</i> measurement, secondary data | Temperature, Rainfall, Relative humidity, Wind direction and speed, visibility, cloud cover, sun shine duration and their local effects. |
| Air Quality | Local and Regional | <i>In situ</i> / laboratory analysis | Particulate, NO _x , SO _x , CO ₂ , CO, VOC, H ₂ S, BTEX Heavy metals (As, Fe, Cd, Cr, Pb, Ni, V, Zn) |
| Noise | Local | <i>In situ</i> measurement | Ambient noise level dB(A), communication interference. |
| Surface Water Characteristics | Hydrology/ Hydrodynamics | <i>In situ</i> /secondary data | River depth, width, flow direction, flow rate, current/tidal information, Drainage characteristic, sediment transport, river bank erosion |
| | Physicochemical Features | <i>In situ</i> measurements, Composite samples for laboratory analysis | Colour, Total alkalinity, carbonate alkalinity, Total hardness, TDS, TSS, Turbidity, EC, pH, salinity, DO, , BOD ₅ , COD, Oil & Grease, TOC, THC, TPH, Phenol, H ₂ S, NH ₃ , SiO ₂ , Anions/Cations, (NO ₃ ⁻ , NO ₂ ⁻ , PO ₄ ³⁻ , SO ₄ ²⁻ , CN ⁻ Ca ²⁺ , Mg ²⁺ , Mn ²⁺), Heavy metals (Fe, Ba, Cd, Cr, Cu, Ni, V, Pb, Zn, Hg). |
| | Hydrobiology | Composite samples for laboratory analysis | Species composition, distribution, diversity and abundance of Phytoplankton, Zooplankton, Aquatic macrophytes, Macrophyte-associated macrofauna |
| Surface Water Characteristics | Fisheries | Direct observations/interviews , <i>In situ</i> measurements, composite samples for laboratory analysis | Species composition, catch-composition, Fisheries activities (including aquaculture) catch-per-unit of effort and price, fishing gears/methods, population in fisheries, spawning grounds, migration routes and patterns, productivity and pathology. |
| | Microbiology (surface water) | Composite samples for laboratory analysis | Total heterotrophic bacteria & fungi, Total hydrocarbon utilizing bacteria & fungi, total bacterial count, total and faecal coliforms. |
| | Sediments | Composite grab samples for laboratory analysis | Colour, Texture, pH, Redox potential, TOC, Available PO ₄ -P, Total-N, Oil & grease, THC, TPH, heavy metals (Fe, Ni, V, Ba, Cd, Cr, Mn, Cu, Pb, Zn, Hg, etc.), |
| | Sediment Biology/Microbiology | Composite grab samples for laboratory analysis | Species composition, distribution, diversity and abundance of Benthos, Total heterotrophic bacteria & fungi, Total hydrocarbon utilizing bacteria & fungi. |
| | Water Use | Direct observation/ interviews | Traditional use of rivers and water bodies (navigation, sand mining, food processing, aquaculture, domestic, potable etc) |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| Environmental Component | Environmental Aspect | Data Acquisition | Potential Environmental Impact Indicator |
|-----------------------------|--------------------------|----------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Groundwater Characteristics | Physicochemical Features | <i>In situ</i> / laboratory analysis | Temperature, colour, total alkalinity, carbonate, Hardness , TDS, TSS, Turbidity, EC, DO, pH, , BOD ₅ , COD, H ₂ S, Oil & Grease, THC, TPH, PAHs, TOC, Phenol, NH ₃ , Anions/Cations, (Cl ⁻ , NO ₃ ⁻ , NO ₂ ⁻ , PO ₄ ³⁻ , SO ₄ ²⁻ , CN ⁻ , Ca ²⁺ , Mg ²⁺), Heavy metals (As, Fe, Ba, Cd, Cr, Cu, Ni, Mn, V, Pb, Zn, Hg). |
| | Microbiology | Composite samples for laboratory analysis | Total heterotrophic bacteria, fungi, Total hydrocarbon utilising bacteria and fungi, total bacterial count, total and faecal coliforms. |
| | Groundwater dynamics | <i>In situ</i> | Static Water Level (SWL), Flow direction/ Flow Rate. |
| | Hydrogeology | Laboratory analysis, secondary data sources | Stratigraphy, Aquifer characteristics |
| Geology | Local and Regional | Secondary data, laboratory analysis | Regional geology, Stratigraphic / Lithologic properties, etc. |
| Soil | Physical characteristics | In situ/ composite auger samples for lab analysis, Soil profile pits | Permeability, porosity, bulk density, texture (grain size), colour, temperature |
| | Chemical characteristics | Composite samples for laboratory analysis | pH, TOC, exchangeable Cations, exchangeable acidity and cation exchange capacity (CEC), available PO ₄ -P, Total-N., Oil and grease, heavy metals (As, Fe, Ba, Cd, Cr, CU, Ni, Mn, V, Co, Pb, Zn, Hg), THC, TPH |
| | Soil microbiology | Composite samples for laboratory analysis | Total heterotrophic bacteria and fungi, Total hydrocarbon utilizing bacteria and fungi |
| Land Use/Cover | Land cover | Secondary data sources | Land Use types: Recreational, agricultural, forestry, industrial, residential, institutional, commercial. Trends and time lapse mapping. |

Environmental Impact Assessment (EIA) of Otumara AGS Project

| Environmental Component | Environmental Aspect | Data Acquisition | Potential Environmental Impact Indicator |
|-------------------------------------------------------|----------------------|------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Biodiversity Status & issues relevant to biodiversity | Wildlife | Transect, direct observation, interviews, secondary data sources | Species composition/distribution (vegetational map of locality), seasonality, exploitation methods/level (kill rates/month/year, estimates of wildlife population etc). IUCN categorisation |
| | Vegetation | Transect, herbarium studies, tissue analysis | Type, diversity, Habitat status, floral composition, density and distribution, vegetation structure, plant pathology, plant tissue chemical analysis. |
| | Conservation | <i>In situ</i> observation, interviews, secondary data | Conservation status (rare, threatened or endangered species), conservation areas (forest reserves etc), environmentally sensitive areas – wetlands and swamps), local conservation practices. |

* *Aufwuchs* = biota growing on aquatic vegetation and suspended materials

** The width and length of transect shall be determined by the nature and type of terrain and field topographical status. The limit to the number of transects shall be dependent on features of interest.

Table 4: Quantities of samples to be obtained during fieldwork

| S/N | Environmental component | No. of sampling points | Control sampling points | Rationale/Description of sampling points |
|-----|-------------------------|------------------------|-------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | Surface Water | 20 | 3 | Number of samples as determined by the available surface water. Sampling points concentrated within influence zones of proposed facilities |
| 2 | Ground Water | 7 | 3 | Sampling points concentrated within influence zones of proposed facilities |
| 3 | Sediment | 20 | 3 | Number of samples as determined by the available surface water. Sampling points concentrated within influence zones of proposed facilities |
| 4 | Vegetation | 31 | 3 | Sampling points concentrated within influence zones of proposed facilities |
| 5 | Soil | 31 | 3 | Sampling points concentrated within influence zones of proposed facilities |
| 6 | Ambient Air Quality | 16 | 3 | Sampling points concentrated within influence zones of proposed facilities and within the host communities |

Table 5: Proposed Sampling Locations/Co-ordinates

| SURFACE | WATER | SAMPLE |
|-----------|---------|----------|
| CODE NAME | EASTING | NORTHING |
| SW1 | 306500 | 175598 |
| SW2 | 307784 | 176498 |
| SW3 | 308683 | 177199 |
| SW4 | 306408 | 178270 |
| SW5 | 306963 | 180017 |
| SW6 | 304476 | 178614 |
| SW7 | 305310 | 180996 |
| SW8 | 305416 | 182319 |
| SW9 | 303775 | 182027 |
| SW10 | 303617 | 183721 |
| SW11 | 303134 | 182867 |
| SW12 | 302426 | 184514 |
| SW13 | 302042 | 184131 |
| SW14 | 300918 | 183218 |
| SW15 | 301381 | 182570 |
| SW16 | 302147 | 182779 |
| SW17 | 309530 | 175334 |
| SW18 | 308564 | 174633 |
| SW19 | 307268 | 172635 |
| SW20 | 306567 | 170992 |
| SWC1 | 310664 | 178228 |
| SWC2 | 305059 | 174474 |
| SWC3 | 305448 | 183160 |

| GROUND | WATER | SAMPLE |
|-----------|---------|----------|
| CODE NAME | EASTING | NORTHING |
| GW1 | 302730 | 183311 |
| GW2 | 301844 | 182649 |
| GW3 | 303259 | 182623 |
| GW4 | 305283 | 179831 |
| GW5 | 304887 | 179236 |
| GW6 | 305985 | 179448 |
| GW7 | 308022 | 169076 |
| GWC1 | 303028 | 186262 |
| GWC2 | 308511 | 166814 |
| GWC3 | 311713 | 175387 |

| SEDIMENT | SAMPLE | |
|-----------|---------|----------|
| CODE NAME | EASTING | NORTHING |
| SD1 | 306500 | 175598 |
| SD2 | 307784 | 176498 |
| SD3 | 308683 | 177199 |
| SD4 | 306408 | 178270 |
| SD5 | 306963 | 180017 |
| SD6 | 304476 | 178614 |
| SD7 | 305310 | 180996 |
| SD8 | 305416 | 182319 |
| SD9 | 303775 | 182027 |
| SD10 | 303617 | 183721 |
| SD11 | 303134 | 182867 |
| SD12 | 302426 | 184514 |
| SD13 | 302042 | 184131 |
| SD14 | 300918 | 183218 |
| SD15 | 301381 | 182570 |
| SD16 | 302147 | 182779 |
| SD17 | 309530 | 175334 |
| SD18 | 308564 | 174633 |
| SD19 | 307268 | 172635 |
| SD20 | 306567 | 170992 |
| SDC1 | 310664 | 178228 |
| SDC2 | 305059 | 174474 |
| SDC3 | 305448 | 183160 |

| VEGETATION | SAMPLE | |
|------------|---------|----------|
| CODE NAME | EASTING | NORTHING |
| VG1 | 305865 | 179130 |
| VG2 | 304794 | 179871 |
| VG3 | 304781 | 178932 |
| VG4 | 305614 | 179686 |
| VG5 | 306950 | 180003 |
| VG6 | 305614 | 177900 |
| VG7 | 304675 | 177834 |
| VG8 | 301897 | 182305 |
| VG9 | 304582 | 180427 |
| VG10 | 306051 | 180744 |
| VG11 | 303669 | 180308 |
| VG12 | 302135 | 180361 |
| VG13 | 304503 | 183020 |

| VEGETATION | SAMPLE | |
|------------|--------|--------|
| VG14 | 302863 | 182702 |
| VG15 | 303339 | 183985 |
| VG16 | 303180 | 184316 |
| VG17 | 302161 | 184462 |
| VG18 | 301712 | 183655 |
| VG19 | 300614 | 182398 |
| VG20 | 302982 | 181763 |
| VG21 | 301936 | 181485 |
| VG22 | 311355 | 174990 |
| VG23 | 309199 | 173984 |
| VG24 | 307360 | 173654 |
| VG25 | 308657 | 171894 |
| VG26 | 307704 | 170704 |
| VG27 | 309345 | 169883 |
| VG28 | 308035 | 169460 |
| VG29 | 307268 | 169500 |
| VG30 | 305998 | 169870 |
| VG31 | 307440 | 168600 |
| VGC1 | 303028 | 186262 |
| VGC2 | 308511 | 166814 |
| VGC3 | 311713 | 175387 |

| SOIL | SAMPLE | |
|-----------|---------|----------|
| CODE NAME | EASTING | NORTHING |
| SS1 | 305865 | 179130 |
| SS2 | 304794 | 179871 |
| SS3 | 304781 | 178932 |
| SS4 | 305614 | 179686 |
| SS5 | 306950 | 180003 |
| SS6 | 305614 | 177900 |
| SS7 | 304675 | 177834 |
| SS8 | 301897 | 182305 |
| SS9 | 304582 | 180427 |
| SS10 | 306051 | 180744 |
| SS11 | 303669 | 180308 |
| SS12 | 302135 | 180361 |
| SS13 | 304503 | 183020 |
| SS14 | 302863 | 182702 |
| SS15 | 303339 | 183985 |
| SS16 | 303180 | 184316 |

| SOIL | SAMPLE | |
|-----------|---------|----------|
| CODE NAME | EASTING | NORTHING |
| SS17 | 302161 | 184462 |
| SS18 | 301712 | 183655 |
| SS19 | 300614 | 182398 |
| SS20 | 302982 | 181763 |
| SS21 | 301936 | 181485 |
| SS22 | 311355 | 174990 |
| SS23 | 309199 | 173984 |
| SS24 | 307360 | 173654 |
| SS25 | 308657 | 171894 |
| SS26 | 307704 | 170704 |
| SS27 | 309345 | 169883 |
| SS28 | 308035 | 169460 |
| SS29 | 307268 | 169500 |
| SS30 | 305998 | 169870 |
| SS31 | 307440 | 168600 |
| SSC1 | 303028 | 186262 |
| SSC2 | 308511 | 166814 |
| SSC3 | 311713 | 175387 |

| AIR | QUALITY | SAMPLE |
|-----------|---------|----------|
| CODE NAME | EASTING | NORTHING |
| AQ1 | 305892 | 179170 |
| AQ2 | 304966 | 179858 |
| AQ3 | 304767 | 179064 |
| AQ4 | 305641 | 179845 |
| AQ5 | 306884 | 178429 |
| AQ6 | 304648 | 177860 |
| AQ7 | 304582 | 180480 |
| AQ8 | 305985 | 180652 |
| AQ9 | 302770 | 182305 |
| AQ10 | 301447 | 182332 |
| AQ11 | 302082 | 183059 |
| AQ12 | 303392 | 183456 |
| AQ13 | 303789 | 184223 |
| AQ14 | 300838 | 183734 |
| AQ15 | 309133 | 173918 |
| AQ16 | 308035 | 169619 |
| AQC1 | 303028 | 186262 |
| AQC2 | 308511 | 166814 |

| AIR | QUALITY | SAMPLE |
|-----------|---------|----------|
| CODE NAME | EASTING | NORTHING |
| AQC3 | 311713 | 175387 |

3.1.2.2 Social

The fieldwork will involve gathering of socio-economic and cultural data using interview schedules, questionnaire administration, Focus Group Discussion (FGD) and key informants. The relevant communities to the project, which shall be covered in the social impact assessment, have been listed in Table 3.0. Photographic documentation of pertinent socio-economic attributes shall also be obtained.

Table 6.0: List of Study Communities and Local Governments

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

Necessary data and information on the communities as detailed in Table 4.0 will be collected

Table 7.0: Socio-economic Data Needs

| S/N | Social Features | Variables |
|-----|-----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | Demography | Population size and distribution (age, gender, ethnic groupings, population density, dependency and sex ratio), marital status, educational attainment, primary and secondary school drop out rates, history and trend of migration, net enrolment ratios for primary and secondary schools, etc. |
| 2 | Livelihood | Income distribution and consumption patterns, employment status, occupation, occupational mobility and adjustment, poverty profile, land use and tenure system, and other economic activities. |
| 3 | Social Infrastructure | Major means of transportation; educational institutions, water supply, electricity, communication, recreational facilities, waste management facilities, housing (type, pattern and quality) etc, |
| 4 | Cultural Properties | Value system, social norms, location and spatial distribution of historical sites, archaeological artefacts, shrines, sacred forests/scenic areas; religion, plants/animal species of cultural value, festivals, marriage practices, cultural calendar etc. |

| S/N | Social Features | Variables |
|-----|-----------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 5 | Natural Resources and Land Use | Values and use of natural resources including rights over private, rental, common ownership and access to resources – especially with respect to women; local conservation practices (closed seasons/closed locations) etc. |
| 6 | Perception of the project | Perception of associated project risks and impacts on quality of life, rating of relationship with SPDC, pleasure/displeasure with proposed project, expectations etc. |
| 7 | The role of women and children | Rights and privileges, contribution to socio-economic development; activity systems and political organisation, women trafficking, child labour etc. |
| 8 | Physically Challenged | Rights and privileges, contribution to socio-economic development; activity systems, social exclusion etc. |
| 9 | Social Structure and Organisation | Settlement history, ethnic groups, social organisation and traditional governance – power and authority structure; history of conflicts and their resolution including the role of women |
| 10 | Vehicular Traffic Analysis | Vehicular volume count, origin and destination survey |
| 11 | Sex Trade | Population, Frequency, Nature, types, origin, and socio-economic aspects etc. |

3.1.2.3 Health

About 3 (14 fishing camps) communities have been identified for Health survey as shown in Table 3.0. The fieldwork will involve *in situ* determination and study of health determinants and conditions/outcomes in the communities. The fieldwork data gathering approach will be:

- Oral Interviews
- Physical observation
- Focus group discussion (FGD)
- Administration of questionnaires
- Environmental sample collection (potable water, air quality-indoor/outdoor, soil with emphasis on bio-chemical contaminants like parasites, heavy metals etc)
- *In situ* testing and assessment of clinical status of the population (e.g. nutritional status assessment in children, etc)

The following health data as detailed in Table 5.0 will be acquired.

Table 8.0: Health Data Needs

| S/N | Health Parameters | Data Requirements |
|-----|----------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | Demographic profile of the Communities | Population, age-sex distribution, migration pattern, occupation, religion, marital status, educational attainment, fertility rate, crude birth rate (CBR), life expectancy. |

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

3.2 Consultation/Stakeholder Engagement

The relevant stakeholders have been identified in section 1.0. About seven (7) communities will be impacted by project activities. Consultation is a continuous process that spans the life cycle of the project. Stakeholders' engagement shall be encouraged at various phases of the EIA process (fieldwork, laboratory analysis, etc).

3.2.1: Sampling Activities and Parameters

Environmental components, parameters, number of sampling stations and number of samples are presented in Tables 6.0 below while summary of environmental parameters and sampling methodologies for field work are presented in Table 7.

Table 9.0: Environmental Components, Sampling Points and No of Samples

| S/N | Environmental component | No. of sampling points | Control sampling points | Rationale/Description of sampling points |
|-----|-------------------------|------------------------|-------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | Surface Water | 20 | 3 | Number of samples as determined by the available surface water. Sampling points concentrated within influence zones of proposed facilities |
| 2 | Ground Water | 7 | 3 | Sampling points concentrated within influence zones of proposed facilities |
| 3 | Sediment | 20 | 3 | Number of samples as determined by the available surface water. Sampling points concentrated within influence zones of proposed facilities |
| 4 | Vegetation | 31 | 3 | Sampling points concentrated within influence zones of proposed facilities |
| 5 | Soil | 31 | 4 | Sampling points concentrated within influence zones of proposed facilities |
| 6 | Ambient Air Quality | 31 | 3 | Sampling points concentrated within influence zones of proposed facilities and within the host communities |

Table 10.0: Summary of Environmental Parameters and Sampling Methodologies to be used in the field

| Environmental/Study Aspect | Methodology |
|-------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Soil Quality | Soil samples collected with Dutch hand Auger. Sample description with Munsell colour chart |
| Land use/cover | Direct/physical observation, interviews of key informants and sample collections, direct physical observations. |
| Vegetation | Field maps, (topographic/vegetation, direct observations, transects, key informant interviews, FGD, questionnaires. |
| Hydrogeology | Boreholes (drilled by percussion) and geophysical surveys and mechanical properties and measurements. |
| Surface water | Water sampler, pH meter, DO meter, sediment grab, TDS meter, turbidimeter and conductivity meter, observation |
| Fauna (wildlife) Terrestrial invertebrates Amphibians, Reptiles, Birds, Mammals) | Key information interviews (local hunters), direct sitings and observations of game catches displayed, focus group discussions (FGD) |
| Air Quality/Noise | Electronic in-situ air quality monitor, High volume sampler, Noise meter |
| Microbiology | Use of hydrobios sampler to collect water into sterile McCartney bottles. Soil samples with soil auger into aluminium foil. Sediments samples with Eckman grab sampler into aluminium foil. |
| Aquatic biology Sediment Phytoplankton Zooplankton Fish species and fisheries | Collection with plankton net Collection with sediment grab Collection with plankton net Collection with plankton net Observation, collection, interviews with fishermen |

Laboratory Analyses

All the samples collected during the fieldwork will be analysed for the different parameters as provided in Table 2.0.

3.3 Evaluation and Prediction of Potential Impacts

From all facets of data gathering and analysis, the EIA shall identify the associated and potential impacts of the proposed project, specifically covering the following:

(i). Identification and prediction of potential environmental, social and health impacts associated with the various phases of the project as follows:

Mobilisation of personnel and equipment

Pre-Construction

- Vegetation clearing/ Land Survey and Acquisition
- Site preparation/Dredging piling and shoring works

Installation of surface facilities

- Excavation / trenching
- Gas processing Module- Nominal 30 mmscf/day
- Gas Compression - Nominal 20 mmscf/day
- Power generation/utility modules- Circa 5.5 MW ISO
- Flare systems relief
- Blow down systems.

Installation of flow lines and Bulk lines

- Excavation / trenching
- Cleaning, bevelling and pipe field bending
- Stringing, Pipe weld and lay, coating and testing, Inspection and Non Destructive Test (NDT) of welds
- Hydro testing of flow lines, Bulk lines and export line
- Tie-in and backfilling

Pre-commissioning and commissioning

De-mobilisation

(i). The assessment should distinguish between significant positive and negative impacts, direct/indirect, immediate, short and long term impacts, which are unavoidable and irreversible. As much as possible, impacts shall be described quantitatively in terms of environmental costs and benefits explaining any uncertainties and deficiencies associated with impact predictions.

(ii). Quantification, evaluation and prediction of the significance of the identified impacts using appropriate models and indicators [air dispersion models, Human Development Index (HDI), Human Poverty Index (HPI), Gender Empowerment Measure (GEM) etc.].

(iii). Comprehensive risk analysis covering all aspects of the project activities on environmental components – biophysical, socio-economic and health status of project area.

(iv). Evaluation and prediction of the cumulative impacts of project activities on the environment.

3.4 Determination of Appropriate Mitigation Measures

The proposed mitigation measures shall be Specific, Measurable, Achievable, Realistic, and Time-bound (SMART). Mitigation measures proposed shall include:

- Recommendations on feasible and cost-effective measures to prevent or reduce significant negative impacts to acceptable levels.
- Suggestion of strategies to enhance beneficial impacts of the project.
- Determination of the non-mitigatable impacts (residual).
- Evaluation of the effectiveness of any mitigation measures identified.
- Provision of a comprehensive and detailed plan covering mitigation of impacts.

The mitigation plan shall include the following:

- Strategies to manage all environmental, social and health issues to levels as low as reasonably practicable (ALARP).
- Strategies to establish communication and trust of all stakeholders
- Action Plan for implementing appropriate mitigation strategies in a tabular format to address:
 - Impacts
 - Prevention
 - Reduction
 - Enhancement

3.5 Environmental Management Plan (EMP)

The EMP shall be prepared and reported as a stand-alone chapter as outlined in the Federal Ministry of Environment (FMEnv), EIA Procedural Guidelines under the following sub-headings to cover all the stages of the life-cycle of the project:

- Project activities and their Impacts
- Proposed mitigation measures
- Rating before and after mitigation
- Scope of monitoring
- Parameters to be monitored and frequency of monitoring
- Monitoring schedule
- Responsible action parties

The phases in the life-cycle of the Otumara Project shall include:

- Otumara Central Processing Facility (CPF) of 30 mmscf/d nominal capacity
 - Gas processing Module- Nominal 30 mmscf/day
 - Gas Compression - Nominal 20 mmscf/day
 - Power generation/utility modules- Circa 6.5 MW ISO
 - Flare systems relief
 - Blow down systems.

- Otumara Flow station brown field works
 - Modifications and tie-ins to integrate the new facilities.
 - Site preparation and civil works including all dredging, piling and shoring works.
- Design, construction and commissioning of a 44-bed FLB
- Decommission, preserve and mothball Saghara flow station, and convert to a free-flow manifold

Pipeline Project Scope

- i. Corrosion Inhibition Lines - 2" x 5km (From Otumara CPF to Saghara Manifold)
- ii. Test Line - 4" x 5km (from Saghara Manifold to Otumara F/S)
- iii. Bulk line - 6" x 5km (from Saghara Manifold to Otumara F/S)
- iv. Gas Export line - 12" x 12km (from Otumara CPF to ELPS manifold at Escravos Beach)
- v. Flowlines – 15km (Re-routing of 7nos Otumara wells from Saghara F/S to Otumara F/S).
- vi. Manifolds and Pigging facilities (launcher and receiver)
- vii. Cathodic protection system
- viii. 21km Fibre Optic cable for data transmission

The EMP shall therefore:-

- Identify and discuss the management and /or implementation of commitments to stakeholders, as identified during the Stakeholders Scoping Workshop exercise and other consultation procedures identified in the report;
- Discuss how to implement the mitigation measures, as identified in the report,
- Design and implement an appropriate post-EIA monitoring process according to the identified schedule for implementation.
- Confirm the availability of a budget for implementation measures and monitoring
- Put in place a system for obtaining all necessary regulatory approvals for all the aspects of the project from the start to de-commissioning.
- Propose appropriate waste management plans to include management and disposal of wastes from:
 - Pre-construction activities (site preparation, vegetation clearing etc.)
 - Construction activities (Gas facilities and Pipelines)
 - Drilling of wells (Oil and NAG)
 - Pre-commissioning and Commissioning
 - Operational and maintenance activities
 - Decommissioning/Abandonment

3.6 Report Preparation

The EIA report of the proposed project shall be in the format laid down by the Federal Ministry of Environment and Department of Petroleum Resources as outlined below:

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

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

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

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

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

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

Chapter Six, - Associated and Potential Environmental Impacts, - Scoping, impact prediction methodology, impacts of project activities (mobilisation of personnel and equipment, site preparation, vegetation clearing, drilling, construction of Flowlines / Bulklines and Hook-up phase, transportation, excavation, hydro testing of flowlines, tie-in and backfilling, etc), impacts on resource utilisation, process impacts (operation), short term/long term impacts, reversible/irreversible impacts, cumulative impacts, direct/indirect impacts, adverse/beneficial impacts, risk assessment (HAZOP, HAZID, QRA), social impacts, health impacts, etc.

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

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

Chapter Nine, - Conclusions and Recommendations

References

Appendices

4.0 CONSULTING TEAM

A competent consulting team shall be engaged which should be accredited by FMEnv, DPR, Bayelsa and Delta States Ministries of Environment.

5.0 DELIVERABLES

- Programme for field studies
- EIA specific programme for stakeholder consultation.
- Defined SIA/HIA programme that meets EIA requirements and also provides the clear bridge to CD programme.
- Prepared Environmental Management Plan (EMP) that is/or can be integrated within HSE-MS and ISO 14001
- Monthly reports on progress on all accomplishments toward the agreed objectives for the EIA
- Documentation of issues and areas for improvement in the EIA Manual
- Field Reports of sampling
- Draft EIA Report.
- Final EIA Report.

APPENDIX 2

2.0 METHODS OF STUDY

2.1 Overall study Approach

2.1.1 Introduction

The fieldwork was undertaken between 22nd and 30th May 2006. The study programme covered the areas demarcated for the project, totalling 233.25 sqkm. The field study areas covered include meteorology and air quality, soil, forestry, wildlife, fisheries, water quality, geology/hydrogeology, ecology, noise, social and health impact assessments.

A number of *in-situ* measurements were made for water, air quality and noise, while samples of water and soil were collected for physico-chemical analysis, while vegetation samples were collected for herbarium studies. Climate, air quality and noise were also studied using direct reading electronic meters for pollutants concentration.

2.1.2 Sampling rationale

The field programmed was designed to cover both the terrestrial and aquatic stations for water chemistry, ecological studies, soil, underground water, socio-economics and cultural studies. For the water and ecological studies, wherever possible, measurements were made *in situ*, while for other parameters samples were brought back to base for laboratory analysis. Control stations were established far from the expected zone of influence of the project. Health, Socio-economic and cultural studies were focused on the population within and outside the anticipated zone of project impact. Questionnaires were administered by the consultants and local recruits in settlements within the study area.

Underground water samples were collected from a number of monitoring boreholes drilled for the purpose. Chemical analyses of the samples were carried out to detect seepage of pollutants into the groundwater as well as determining extent of pollution if any. Geological and environmental data were obtained to identify the geomorphic zones of the area. Finally the legal and relevant legislations were reviewed, as well as a comparison made, of DPR, FEPA and world wide criteria and standards.

2.1.3 Logistics

The study site which was accessible by land and water were visited from the hours of 9 am to 6 pm daily. From the nature and scope of work, the logistics called for a multi-disciplinary team of scientists to cover the four sites within the time frame of the field work.

2.1.4 Quality Assurance

2.1.4.1 Field procedures

To assure the accuracy and reliability of *in situ* field measurements, field instruments were calibrated prior to use and cross-checked from time to time. The field portable pH meter was calibrated using pH4, pH7 and pH9 buffer solutions. The conductivity and dissolved solid meter was checked against known conductivities and solutions with known dissolved solid

concentrations. Water sample containers were washed with detergent and thoroughly rinsed first with clean water and finally with distilled water. Water and soil samples for special analysis were kept frozen or refrigerated before the time for analysis. Biological specimens for tissue analysis were wrapped in clean aluminium foils and stored in ice, in portable coolers.

2.1.4.2. Laboratory Procedures

Samples for wet chemical analysis were refrigerated and immediately analysed for nitrate and phosphate later in the day. Standard laboratory quality control procedures were adhered to for wet chemical analysis of water samples. These included determination of reagent blanks, use of fresh standards and replicate analysis for confidence limit, and cleaning of glasswares and other containers. Water samples for hydrocarbon determination, and microbiological analysis for the above determination were similarly treated.

2.1.4.3 Data verification

Field data sheets were carefully kept and inspected at the end of the day's field work to make sure that no samples were missed out. Laboratory data for wet chemistry were subjected to analysis such as plotting of chloride values vs. conductivity or conductivity vs. TDS to draw attention to those stations whose values fell outside of the observed range. Such station samples were given closer scrutiny in subsequent data analysis to see whether the particular values could be explained. If no reasons could be found for the anomalous values, the conclusion was drawn that the values were in error.

2.2 Chemical Programme

2.2.1 Introduction

The overall objective of the chemical programme was to produce a ground database for a number of parameters in water, soils and sediments. A flow diagram of the components of the chemical studies programme is shown in Fig. 2.2.1. Water, soil and sediment samples were collected for laboratory analysis of petroleum hydrocarbons (PHCs), and major trace elements. Water samples were analyzed for wet chemistry parameters, including biochemical oxygen demand (BOD), chemical oxygen demand (COD), nutrients, pH, dissolved oxygen (DO), total alkalinity (TA), and total suspended solids (TSS). *In situ* field measurements of pH, DO, conductivity, temperature and transparency were made at each station. Conductivity and transparency, together with the wet chemistry parameters, were needed for the interpretation of the biological data collected during the study.

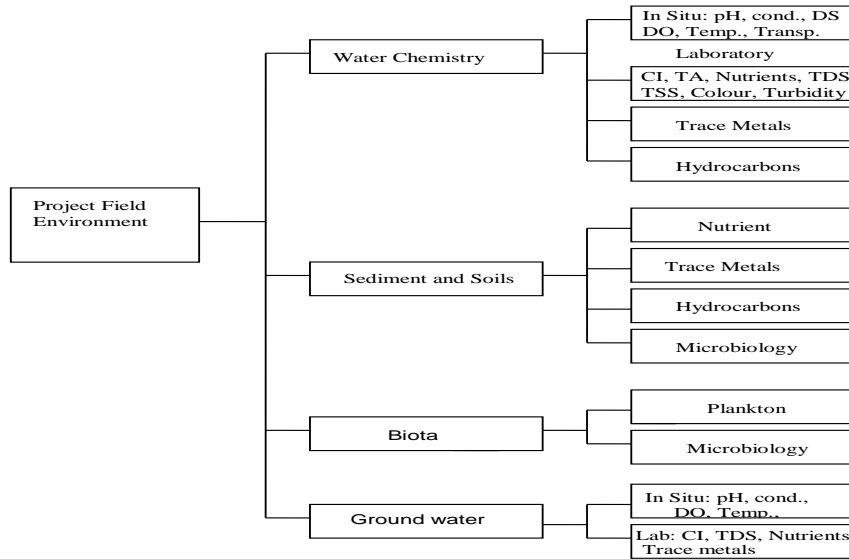


Fig. 2.2.1: Diagram Showing the Different Components of the Chemical Studies Programme.

2.2.2 Field and Laboratory Procedures

2.2.2.1 Climate and Air Quality

2.2.2.1.1 Climate

Field monitoring of the microscale climate of the project sites was carried out by a weather station set up during the period of the field study (Plate 2.2.2.1). Wind speed and direction were monitored using a cup anemometer and wind vane respectively. Rain gauge was used to measure the daily precipitation in the field while relative humidity was determined using an automatic self recording Hydrograph.

In the laboratory, historical data collected on the climatic variables were analyzed to provide the general characteristics of the mesoscale climate of the project area. Using historical and field data for the region, wind roses (frequency and speed) were constructed for the different seasons. Also from historical data, substantiated by local field readings, the annual total rainfall, number of rainy days, frequency and distribution of the rainfall, expected mean onset and cessation dates of rainy season and the occurrence of flash floods were also determined. The main features of humidity examined were the mean, maximum and minimum relative humidity, all calculated from the historical data of the project region. On the whole, data on climatic factors were used to prepare and compute:

- Wind roses and a picture of historical wind direction and speed.
- Aridity Index using rainfall and temperature data according to the formula of Ewer and Hall (1979).

$$\text{Aridity Index} = \frac{12 p}{T + 10}$$

where P is mean monthly rainfall (mm), and T is mean monthly air temperature (°C).

- Flood flow maps in relation to seasonal spatial distribution of rainfall.

2.2.2.1.2 Air Quality

(a) Field Procedures

An air sampling field equipment was set up in the field. This comprised an electrically driven vacuum pump and a box containing air sampling trains for SO₂, total nitrogen oxides (NO_x), O₃, NH₃ and particulates.

(b) Laboratory Procedures

The details of the analytical methods including the principles and laboratory procedures for the different components are shown below:

(i) Sulphur Dioxide (SO₂)

Principle

The para-rosaniline method was used. The method is essentially specific for sulphur dioxide. It involves the use of a scrubbing solution containing tetrachloromercurate ion to collect sulphur dioxide from air. The SO₂ is trapped as dichlorosulphitomercurate ion. This complex is stable and is later reacted with formaldehyde and pararosanine to produce pararosanine methyl sulphonic acid, which has an intense red-violet colour with maximum absorbance at 549 nm. The sensitivity of the procedure is normally 5 µg/m³. In this exercise a detection limit of 20 µg/m³ was achieved by scrubbing 30 litres of air through 10 ml of scrubbing solution.

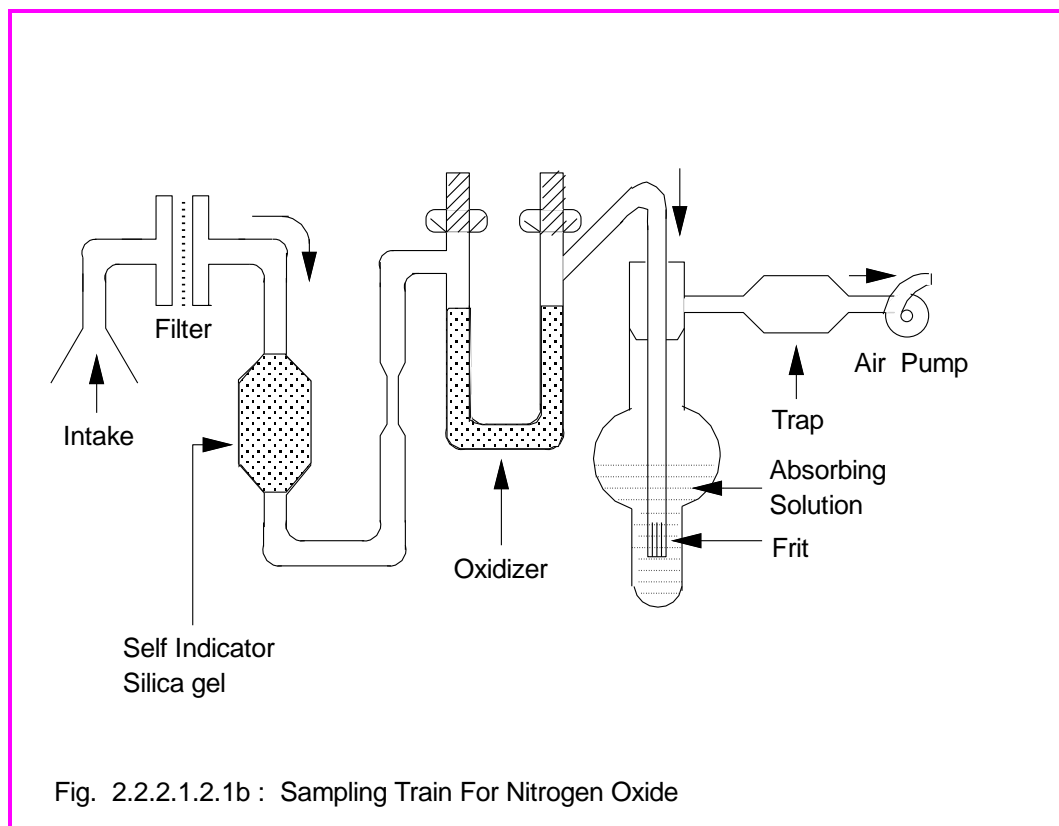
Reagents

- (a) Absorbing solution: This was prepared from analytical reagent grade chemicals and double-distilled water. It was prepared by dissolving 10.96 g mercuric chloride, .066 g disodium salt of ethylenediamine-tetraacetic acid and 6.0 g potassium chloride in 1000 ml distilled water.
- (b) Sulphamic acid solution: The solution was prepared as required by dissolving 0.6 g sulphamic acid in 100 ml solution.
- (c) Formaldehyde: This was also prepared as required by diluting 5 ml 36% formaldehyde to 1000 ml.
- (d) Stock iodine solution: 12.7g iodine and 40.0g potassium iodine were dissolved in 25 ml water and made up to one litre in a standard flask to give 0.10 N stock iodine solution. From this solution, 0.010 N iodine was prepared as required, by diluting 50.00 ml to 500.0 ml.
- (e) Starch indicator: A paste of 0.4 g starch and 0.002 g mercuric iodine was added to 200 ml boiling water and kept boiling to dissolve.
- (f) Stock sodium thiosulphate solution: The solution was prepared by using freshly boiled and cooled distilled water to dissolved 25 g sodium thiosulphate. 0.50 g Na₂CO₃ was added to the mixture before making up to 1000 ml. It was standardised against dried (190°C) potassium iodate. From this, 0.01 N solution was prepared as required by diluting 100 ml of the stock solution to 1000 ml using standard flask.

- (g) Standard sulphite-TCM solution: Standard sulphite solution was first prepared from sodium sulphite (0.5 g sodium sulphite per 500 ml solution using fresh double distilled water) and standardised by back-titration using excess iodine and standard thiosulphate solution. The standard sulphite-TCM solution was then prepared by making up 2.00 ml of the sulphite standard to 100.0 ml in a standard flask using the absorbing solution.
- (h) Pararosaniline reagent: 20.0 ml of 0.20% purified pararosaniline and 25 ml of 3 M orthophosphoric acid were diluted to 250 ml with water in a standard flask.

Laboratory Procedure

- (a) Sample Analysis: A minimum of 30 min was allowed to elapse after sampling before analysis commenced. This is recommended to allow for the complete decomposition of any ozone in the sample. The absorbing solution was quantitatively transferred into 25ml standard flask, using minimum amount of water for rinsing. 1.0 ml of 0.6% sulphamic acid was added and allowed to react for 10 min to destroy any absorbed oxides of nitrogen. 2.0 ml of 0.2 % formaldehyde solution and 5 ml pararosaniline solution were then added to the flask. The mixture was allowed to stand for exactly 30 min before making up to mark with freshly boiled and cooled distilled water. The absorbance (A_2) of the solution was taken at 549 nm in 10 mm cell, using distilled water as reference. A blank was prepared by similar treatment of 10 ml of unexposed absorbing solution. A control was also prepared by taking a mixture of 2 ml standard sulphite-TCM solution and 9 ml absorbing solution through the same process as the sample solutions. The absorbances of the blank (A_0) and the control were taken at 549 nm in 10 mm cell.



- (b) Calibration of Laboratory Procedure: 0.50, 1.0, 2.0, 3.0, 4.0 ml of the sulphite-TCM standard solution were measured into separate 25 ml standard flasks. 9.5, 9.0, 9.0, 7.0, 6.0 ml absorbing solutions were added in that order to the flasks containing the standards. The colour reaction was carried out as described for the sample and absorbances were measured at 549 nm in 10 mm cell. A calibration graph (absorbance vs. concentration of SO_2) was plotted and the calibration factor, reciprocal of the slope of the calibration line, as calculated and used as the calibration factor.
- (c) Calculation: The ambient SO_2 concentration was calculated from the experimental data as follows:

$$\text{Con } (\mu\text{g SO}_2 / \text{m}^3) = \frac{(A_s - A_o) \times (10^3) \times (F)}{V}$$

A_s = Absorbance of sample

A_o = Absorbance of reagent blank

F = Calibration factor

V = volume of sample (ml).

(ii) *Nitrogen oxides (NO_x)*

Principle

Total nitrogen oxides (nitric oxide and nitrogen dioxide) were determined by the Griess-Saltzman reaction as described in ASTM standard method D3609.77T. Essentially, the method involves sampling air at the rate of 0.4 litre/min for one hour in a sampling train with an oxidant to convert nitric oxide to nitrogen dioxide and with an absorbing reagent which immediately converts the total nitrogen dioxide to a red-violet azo-dye which absorbs at 550 nm. The procedure operated at a detection limit of 4 µg/m³.

Reagents

- (a) Absorbing solution: The absorbing solution was prepared by first dissolving 5.0 g of anhydrous sulphanilic acid in a mixture of 140 ml glacial acetic and 700 ml water. The mixture was heated to dissolve the sulphanilic acid. The cooled mixture was transferred into a litre standard flask. 20 ml of 0.1 % N-(1-naphthyl)-ethylenediamine dihydrochloric acid and 10 ml acetone were added to the flask. The mixture was made up to one litre with distilled water and mixed thoroughly. The solution was stored in a brown reagent bottle and kept in a refrigerator when not in use.
- (b) Chromic acid oxidant: This was prepared by dissolving 17 g of chromium (VI) oxide in 100 ml distilled water.
- (c) 0.1% N-(1-Naphtyl)-ethylenediamine dihydrochloric acid: 0.10 g of the compound was dissolved in 100 ml of water and stored in a brown bottle. The solution was normally kept in a refrigerator when not in use.
- (d) Standard sodium nitrite solution: A stock solution containing 2.5 g sodium nitrite was prepared and standardised. The strength of the solution was adjusted to 2.16 g/litre. From this stock solution a working nitrite standard solution containing 2.16 mg sodium nitrite per litre (equivalent to 20.0 mg NO₂/L) was prepared by dilution as and when required.

Laboratory Procedure

- (a) Sample Analysis: The absorbances of the red-violet colour of the samples were read at 550 nm.
- (b) Calibration of Laboratory Procedure: 0.10, 0.20, 0.40, 0.60, 0.90 and 1.00 ml of the standard nitrite solution were measured into separate 25 ml standard flasks. Each one was diluted to mark with the absorbing reagent. After fifteen minutes, the absorbances of the standards were read at 550 nm. A calibration graph (Absorbance vs. concentration of NO_x) was plotted and the calibration factor (reciprocal of the slope of the calibration line) was calculated.
- (c) Calculation: The ambient NO_x concentration was calculated from the experimental data as follows:

$$\text{Conc } (\mu\text{g NO}_x / \text{m}^3) = \frac{(A \times F \times 10^3 \times v)}{V}$$

A = Absorbance of sample

F = Calibration factor

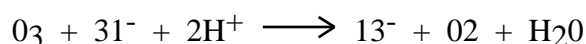
V = Volume of sample (ml)

v = volume of absorbing solution (ml)

(iii) Ozone (O₃)

Principle

The neutral buffered potassium iodide-potassium bromide-thiosulphate method was used. The sampling train is operated at about 400 ml/min and ozone is absorbed in sodium thiosulphate containing potassium iodide and buffered at pH 6.9. Excess thiosulphate is destroyed by iodine after sampling. The amount of iodine consumed in the latter operation is compared with standard to determine the amount of ozone in the air sampled. The detection limit is 45 µg/m³. The absorption reaction is:



Reagents

Water used in the preparation of these reagents was triple demineralized water polished by passing through a column of washed mixed-bed resin sealed at the delivery end with glass fibre filter.

- The Neutral buffered K₁-KBr solution: This solution was prepared by dissolving 2.72 g KH₂PO₄, 7.16 g Na₂PO₄.12H₂O, 20 g KBr and 10 g K₁ in one litre solution. It was stored in a brown bottle.
- Standard solution of iodine: 13 g iodine and 40 g potassium iodide were dissolved in 25 ml water and made up to 1000 ml in a standard flask. The solution was standardised against standard thiosulphate solution. Its concentration was carefully adjusted to 0.100 M. It was stored in a dark bottle.
- Standard thiosulphate solution: The solution was prepared by using freshly boiled and cooled distilled water to dissolve 13 g sodium thiosulphate. 0.5 g Na₂CO₃ was added to the mixture before making up to 1000 ml. It was standardised against dried (190°C) potassium iodate, using starch indicator. By repeated dilution and re-standardisation, its concentration was adjusted to exactly 0.0500 M.
- Absorbing solution: The absorbing solution was prepared from the stock reagents as required. 5.00 ml of the 0.0500 M thiosulphate solution was diluted to 100 ml with the buffered K₁-KBr solution. 2.00 ml of the diluted solution was further diluted to 200 ml with the buffered K₁-KBr solution to obtain the absorbing solution.

The sampling train consists of air-intake (inverted glass funnel), a membrane filter, a critical orifice, an all-glass midjet impinger and an air-pump, similar to that illustrated in Fig.

2.2.2.1.2.1 A parallel line which included an activated carbon tube, served as air-blank. The connecting tubes were PTFE-tube. Sampling was at a flow-rate of about 500 ml/min for one hour. 10.00 ml absorbing solution was used in the midget impinger. The sampling train was housed in a covered box to protect the system from direct sunlight.

Laboratory Procedure

- (a) Working iodine standard solution: This was prepared by diluting 3.00 ml of the stock iodine solution to 100 ml with buffered K1-KBr solution. 10.00 ml of this solution was further diluted to 250 ml, again with buffered K1-KBr solution.
- (b) Sample Analysis: Within 24 hrs after sampling, 5.00 ml of the working iodine standard was added to the sample solution in the impinger and made up to the 20.0 ml mark on the calibrate impinger. The absorbance of the mixture was measured at 352 nm within 10 min of adding the iodine solution. The air blank was similarly treated. Reagent blank as obtained in a similar manner except that air was not drawn through the absorbing solution used for reagent blank.
- (c) Calibration of Laboratory Procedure: 0.10, 0.20, 0.40, 0.60, 0.90 and 1.00 ml of the iodine working standard were measured into separate 100 ml standard flasks. Each one was diluted to mark with the buffered K1-KBr solution. The absorbances of the standard iodine solutions were measured at 352 nm and plotted, after correcting for blank, against iodine concentration. The reciprocal of the calibration graph was used as conversion factor for the change in the absorbance of standard iodine as a result of reaction with ozone in the samples.
- (d) Calculation: The ambient O₃ concentration was calculated from the experimental data as follows:

$$\text{Conc } (\mu\text{g O}_3/\text{m}^3) = 17F (A_s - A_b) \times 10^3 / V$$

A_s = Absorbance of sample

A_b = Absorbance of air blank

F = Calibration factor

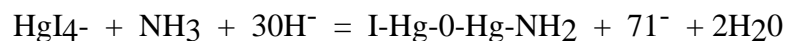
V = Volume of sample (ml).

(iv) *Ammonia (NH₃)*

Principle

Ammonia was absorbed in dilute acid solution and the resulting solution was treated with Nessler's Reagent. The reagent is an alkaline solution of mercury (II) ion in the stoichiometric quantity of potassium iodide required to produce tetraiodo mercurate (II) ion. The product of the reaction between ammonia and this reagent is yellow to orange-brown, depending on the concentration of ammonia. Its absorbance is measured at 410 nm for the low end concentration end of the wavelength range.

The reaction is:



Reagents

- (a) The absorbing solution: The absorbing solution was 0.01 M HCl solution.
- (b) Nessler's Reagent: 100 g reagent grade mercury (II) chloride and 70 g reagent grade potassium iodide were dissolved in about 200 ml ammonia-free distilled water. The mixture was added gradually and with continuous stirring to a solution of 160 g NaOH in 500 ml water. The solution obtained was made up to one litre and stored in a dark borosilicate reagent bottle.
- (c) Standard ammonia solution: Stock ammonia standard (1000 ppm) was prepared by dissolving 3.919 g analar grade ammonium chloride (dried at 100°C) in one litre water in a standard flask.

From this solution, 10.0 ppm ammonia standard was prepared as required by diluting 10.0 ml to one litre in a standard flask.

Laboratory Procedure

- (a) Sample Analysis: 2.0 ml of the Nessler's reagent was added to the sample solution. 10 min was allowed for colour development. Absorbance measurement was made at 410 nm.
- (b) Calibration of Laboratory Procedure: 0.0 (blank), 2.0, 4.0, 9.0, 10.0, 12.5, 15.0 and 20.0 ml of the ammonia working standard were measured into separate 100 ml standard flasks and made up to mark with ammonia-free water. 10.0 ml of each standard was measured into a tube. 2.0 ml Nessler's reagent was added to each and absorbances were read at 410 nm. The reciprocal of the calibration graph was used as the calibration factor. Distilled water used for preparing the reagent was used as reference.
- (c) Calculation: The ambient NH₃ concentration was calculated from the experimental data as follows:

$$\text{Conc } (\mu\text{g O}_3 / \text{m}^3) = \frac{17 F (A_s - A_b) \times 10^3}{V}$$

A_s = Absorbance of sample

A_b = Absorbance of air blank

F = Calibration factor

V = Volume of sample (ml)

(v) *Particulate*

Laboratory Procedure

The filter paper was dried at 105° C for one hour. After cooling in a dessicator to room temperature, it was weighed to the nearest milligram. Particulate level was calculated as follow:

$$\text{Conc } (\mu\text{g} / \text{m}^3) = \frac{(M_s - M_o) \times 10^3}{V}$$

M_s = Mass of filter paper after sampling

M_o = Mass of filter paper before sampling

V = Volume of sample (ml).

2.2.2.2 Water Studies

2.2.2.2.1 Hydrology

Our approach in gathering baseline data for assessing the impact of the project on the hydrologic regime of the project area considers transport of toxic and non-toxic substances along surface water bodies. In essence, we are evaluating the likely changes in flow characteristics as they affect transport of elements that alter the environment.

Stream Flow Measurements

Stream flow velocity measurements were made by the use of the current meter. Velocity measurements were taken at fixed intervals across the stream at 0.6 m depth measured from the surface. The water sampling point is contained in the sectional plane where velocity and depth measurements are made.

The discharge at a section was computed by the area - velocity method. It is essentially a weighted mean method that is based on a represented area of flow in which velocity is considered to be the velocity of that area.

2.2.2.2.2 Water Quality

For physico-chemical and biological studies, water sampling stations were chosen from the waterways within the vicinity of the proposed project. Fig.4.1 shows the sampling stations. The following physical and chemical parameters were then measured, some *in situ* and others in the laboratory.

(a) *Temperature*

Air and surface water temperatures were determined *in situ* using a mercury-in-glass thermometer while sub-surface water temperatures at depths of between 0.5 and 1 m from the bottom were taken *in situ* with a temperature probe.

(b) *Transparency*

Water transparency was determined *in situ* using a white metallic Secchi disk lowered into the water and the average of the point of disappearance and appearance recorded as the water transparency.

(c) *Colour (True)*

Colour may be expressed as "apparent" or "true" colour. The apparent colour includes that from dissolved materials plus that from suspended matter. By filtering or centrifuging out the suspended materials, the true colour can be determined. The true colour was determined by a modified method of APHA (1999) using a HACH model 2000 Environmental laboratory spectrophotometer.

(d) Total, Dissolved and Suspended Solids

Total solids (TS) is the solid matter in water, also referred to as residue. It has two components, suspended solids (SS) and dissolved solids (DS). The dissolved solid component was determined *in situ* in the field using the HACH dissolved solid meter. The field results were cross-checked gravimetrically in the laboratory. Total solids (TS) in water was determined gravimetrically by evaporating to dryness 100 ml of unfiltered water in a pre-weighed and pre-dried evaporating basin. Dissolved solids were determined as above using filtered water and the difference in weight between total and dissolved solids gave the suspended solids.

(e) Hydrogen ion concentration (pH)

pH was determined using a Hach-One pH Meter.

(f) Alkalinity (mg l^{-1})

Phenolphthalein and total alkalinity were determined using the Hach Digital Titration Method with phenolphthalein and Bromocresol Green Methyl-Red as indicators and titrating with 1.600N sulphuric acid. This is a modification of the titrimetric method of the Standard Methods for the Examination of Water and Waste water (APHA, 1999).

(g) Dissolved Oxygen (DO)

Dissolved oxygen (DO) was determined by the Azide modification of Winkler Method adapted for the HACH equipment from Standard Methods. Clean 60 ml glass-stoppered BOD bottles were filled to overflowing with water samples directly from source. Fixation in the field was carried out by adding the contents of Dissolved Oxygen 1 and Dissolved Oxygen 2 powder pillows, and the bottle stoppered and thoroughly mixed by rotation and inversion until a flocculent brownish precipitate was produced. The bottles were stored away in darkened containers under water until their contents were titrated in the laboratory. Before titration, the content of Dissolved Oxygen 3 powdered pillow (sulphamic acid) was added, thoroughly mixed, and aliquots of 20 ml titrated with 0.200 N sodium thiosulphate using the HACH Digital Titrator, until the sample changed from yellow to colourless. Using starch indicator towards the end of the titration remarkably improved the end point from deep blue to colourless. The number of digits from the digital counter window multiplied by 0.1 gave the concentration of dissolved oxygen in mg l^{-1} .

(h) *Conductivity (μScm^{-1})*

This is the capacity of water for conveying electrical current and is directly related to the concentrations of ionized substances in the water. Conductivity was measured *in situ* using a HACH Portable Conductivity Meter.

(i) *Salinity (‰)*

Water salinity was determined *in situ* in the field using an Oceanographic Salinity Measuring Bridge, Model MC5 equipped with a platinized electrode and supplied by Kents Industrial Measurements Ltd., Huttington, UK. The field readings were confirmed in the laboratory by the Harvey's (1955) titrimetric method with an accuracy of $\pm 0.1\%$.

(j) *Sulphate*

The procedure employed to determine sulphate is a modification of the Barium Sulphate Turbidimetric Method using the HACH equipment.

(k) *Available Phosphorus (Reactive)*

Phosphorus as reactive orthophosphate was determined using the stannous chloride method specially suited for determining low amounts of phosphate concentrations. In this method molybdophosphoric acid is formed and reduced by stannous chloride to intensely coloured molybdenum blue. The colour produced was determined photometrically after correction with a blank at 700 nm wavelength. This is a very sensitive method which makes feasible measurements down to 7 $\mu\text{g P}$ per litre.

(l) *Nitrate and Nitrite Nitrogen*

The low range nitrate test employed in the analysis of water is the HACH modification of the cadmium reduction method using a very sensitive chromotropic acid indicator. The test registers both nitrates and nitrites present in the water sample.

(m) *Sodium and Potassium*

Sodium and potassium were analyzed by flame photometry.

(n) *Calcium*

Calcium was determined by the EDTA titration method using CalVer 2 Calcium Reagent in a HACH modification of the Standard Methods according to APHA (1999). A 100 ml water sample was taken in a clean titration flask and 2 ml of 9N KOH was added and swirled to mix. The content of one CalVer 2 Calcium Reagent indicator was added and the content of the flask titrated with 0.900N EDTA solution using the HACH digital titrator until the colour changed from pink to blue. The concentration of calcium hardness is read from the digital counter as mg/L CaCO_3 .

(o) *Magnesium*

Magnesium hardness (as CaCO₃) was determined by subtracting the amount of calcium hardness from the results of the total hardness test. Total hardness of water was determined using the ManVer 2 total Hardness reagent (erichrome black T) as indicator after adding 2 ml of buffer solution. This was titrated with a standard EDTA titrant until the last reddish tinge disappeared. Magnesium hardness was converted to mg/L magnesium by multiplying with 0.243.

(p) *Heavy Metals*

(i) Zinc, Copper, Nickel, Lead, Chromium, Cadmium and Manganese Flame atomic absorption spectrophotometry was used. The water sample is sprayed through a nebulizer into an air-acetylene flame. Free atoms of the elements were generated in the flame. Resonance line of the element, generated in a hollow cathode lamp, was simultaneously passed through the flame. The absorbance of radiant energy by the element of interest was related to its concentration in the water sample by Beer-Lambert law.

Sample Pre-treatment

A preliminary test showed that the levels of metals in the samples were generally close to or below the current detection limit of the atomic absorption spectrophotometer used (Table 2.2.2.2.1). To raise the signal measured to an order above this detection limit without resort to unnecessarily high electronic scale expansion with its attendant noise, a preconcentration step was included in the analytical procedure. The detection limits achieved are adequate for environmental decision-making purposes. 200 ml of the sample (filtered when necessary) was placed in an evaporating dish on a hot plate. It was gently evaporated to about 15 ml and then made up to 20 ml in a standard flask.

Table 2.2.2.2.1: Detection limit of the Atomic Absorption Spectrophotometer

| Metal | * Sensitivity Check | ! Operational Detection Limits |
|-----------|---------------------|--------------------------------|
| Lead | 25 | 0.05 |
| Copper | 4 | 0.01 |
| Cadmium | 1.2 | 0.02 |
| Zinc | 0.9 | 0.01 |
| Nickel | 7 | 0.05 |
| Vanadium | 75 | 0.10 |
| Mercury | 350 | 0.002 ⁺ |
| Chromium | 4 | 0.05 |
| Manganese | 2.5 | 0.005 |

* Concentrations which give an absorbance of 0.2 at peak instrumental performance. The current performance level of the instrument used was 90 % of peak performance level.

! Determined for the instrument used at current optimum performance level.
+By cold vapour technique without preconcentration.

Instrument Calibration and Sample Analysis

The instrument was set up and optimized for each metal as recommended by the manufacturer. Working standards prepared from dilution of 1000 ppm stock standards, and in concentration range of the same order of magnitude as in the concentrated samples, were used to standardise the instrument. The instrument was operated in the absorbance mode in cases where the sample absorbances were very close to the lower end of the linear response range for the element. Otherwise the instrument was operated in the direct concentration mode.

The concentrated samples were aspirated into the flame and absorbances or concentrations were read as appropriate. Absorbances were converted to concentration using the calibration graph for each element. The reference was double-deionised water concentrated ten-fold as the samples. Allowance was made for the concentration factor in tabulating final results.

(ii) *Vanadium*

Vanadium was also analysed by flame atomic absorption spectrophotometry, but using nitrous oxide-acetylene flame and a concentration factor of 20.

(iii) *Mercury*

Because of the very poor sensitivity of AAS in flame mode for mercury, the cold-vapour mode was used. Here the mercury is reduced to elemental state in aqueous phase. Taking advantage of the high volatility of elemental mercury, air was used to sweep the reduced mercury into a cell with quartz window in the path of mercury resonance line in an atomic absorption spectrophotometer. The peak absorbance signal is proportional to the concentration of mercury in the sample.

Reagents

All reagents used were analytical grade and water was double-deionised water.

- (a) Stannous chloride: 75 g of stannous chloride was dissolved, with heating, in 100 ml 1:1 HCl.
- (b) Hydroxylamine hydrochloride: 50g hydroxylamine hydrochloride was dissolved in 250 ml solution in water.
- (c) Mercury Standard: 1.354 mercury (II) chloride was dissolved in one litre aqueous solution made 5% with respect to nitric acid and 0.01 % in potassium dichromate.

Procedure

The samples were analysed without pre-concentration. 10.0 ml sample was placed in the reaction vessel (Fig.2.2.2.3). Two (2) ml stannous chloride and 4 ml hydroxylamine hydrochloride were added and the reaction vessel was immediately coupled into the flow

system. The ground state mercury atoms generated were swept by air flowing at a rate of 1200 ml/min into the atom-cell. The absorbance peak was recorded. The system was calibrated with standards in the range 2.0 ppb to 40 ppb, each one treated as the samples. The reciprocal of the calibration graph was used to convert the sample absorbance to concentration.

(iv) *Iron*

Iron was determined colorimetrically by the very sensitive ferrozine method of the HACH spectrophotometer which allows measurement down to 4 µg/l of the element in water.

(v) *Hydrocarbon Content*

Principle

Total hydrocarbon in the water sample was extracted with CCl₄ at pH 5. The height of the C-H stretching band peak at 2950 to 2900 cm⁻¹ was compared with height of the peaks of standards for quantitative purposes.

Reagents

All reagents used were analytical grade.

- Dilute sodium hydroxide acid: 4.0 g sodium hydroxide was dissolved in water.
- Dilute hydrochloric acid: Concentrated acid was diluted 10 times with water.
- Solid sodium chloride:
- Solid anhydrous sodium sulphate.
- Silica gel.
- Total hydrocarbon standard: Forcados Natural Crude was used as standard mixed hydrocarbon.

1.0 of the standard was diluted to 100.0 ml solution in CCl₄. This stock standard was used as 10,000 ppm THC.

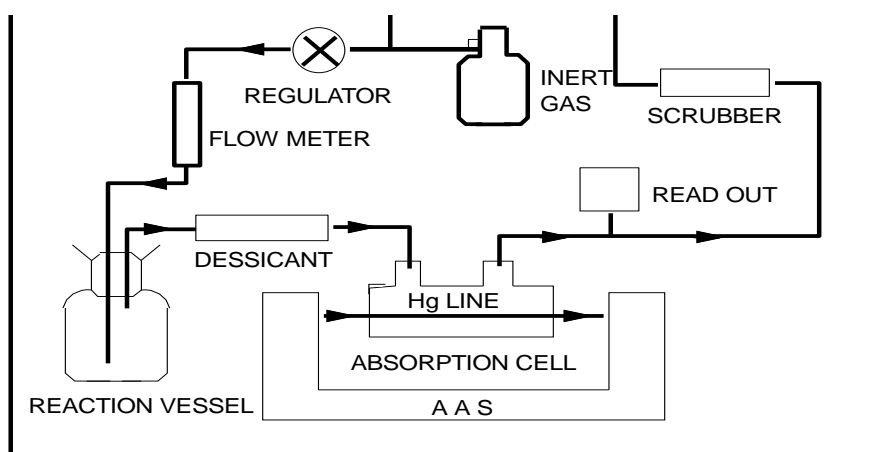


Fig 2.2 2.2.2: Cold Vapour sector for mercury determination

Sample Analysis

750 ml of sample was placed in a one litre separating funnel. The pH of the sample was adjusted to 5 using diluted hydrochloric acid or diluted sodium hydroxide as necessary. A pH meter was used to monitor the pH. About 1g sodium chloride was added to the sample and taken to dissolve. 10 ml tetrachloromethane was added to the separating funnel. The funnel was stoppered and the separating funnel was shaken gently for 15 min to extract total hydrocarbon from the sample.

The phases were allowed to separate. The tetrachloromethane layer was run through a filter paper containing anhydrous sodium sulphate into 25 ml standard flask.

The sample was re-extracted with a second 10 ml portion of tetrachloromethane. The extract was also filtered through anhydrous sodium sulphate into 25 ml standard flask. The combined extract was made up to 25 ml.

The diluted extract was run through silica gel column for clean up. The IR spectrum of the samples was scanned from 3100 to 2900 cm^{-1} . The height of the C-H stretch band at 2950 cm^{-1} was calculated and converted to concentration using the calibration graph.

Calibration

From the stock standard, 0, 10, 20, 40, 60, 60 90, and 100 ppm standards were prepared as required. The standards were scanned as for the samples and height of the peak at 2950 cm^{-1} was plotted against concentration and used as calibration graph.

2.2.2.2.3 Geology/Hydrogeology Studies

(a) Drilling technique, logging and borehole development.

The drilling method employed used a manually driven auger combined with simple jetting procedure. A stream of water was forced to the upper end of the drilling pipe, down to the well collar and out to the bit. The jet of water carried with it cuttings from various depth levels of the hole. The drill pipe was rotated manually so that the chisel-like point at the lower end (the bit) cut loose earth materials. As the drilling progressed, additional pipes were attached to the drill stem until the desired depth was attained.

In order to avoid collapsing of the well wall, especially in very loose sandy horizons, drilling mud was introduced by mixing it with the drilling fluid.

There is no doubt that the drill cuttings samples collected during the drilling operation were those coming from the depth level of the bit. These samples were however physically and chemically disturbed. For the purpose of the study, the latter had serious implications to the interpretation of the chemical analyses of the drill cuttings since they had been contaminated

by whatever constituents were present along the uncased well wall, as well as constituents present in the drilling fluid.

At the appropriate depth specified by the consultant, the drilling crew installed the screen and cased the rest of the well section. Borehole completion was done following standard practice.

(b) Physical and chemical analyses

Physical and chemical analyses of the drill cuttings and borehole waters were carried out as for the methods already described for soil and water.

(c) Geophysical Studies

(i) General

Groundwater in sedimentary terrains is typically found in pores of rocks such as sandstones or in interstitial spaces of deposits like sand. These rock bodies have specific resistivities which are very different from those of clay bodies when groundwater is present but not exploitable. The object of geophysical exploration, specifically the electrical resistivity method is to locate the water bearing zones. As electrical resistivity of a medium is dependent on a number of factors like size of grains constituting the medium, porosity, as well as the nature of the fluid itself, it is possible to identify saline water intrusion if there is enough resistivity contrast with the other rock bodies. Saline water intruded sediments will be characterized by very low resistivity because of the high degree of electrolytes present in the medium.

Given the swampy nature of the project environment, VES study was not undertaken.

Pump Test Analysis

Analysis of the data required a curve matching procedure after Neuman (1975). The solution to the flow problem is

$$S = \frac{Q W(U_A, U_B, n)}{\sqrt{4 \pi T}} \dots \dots \dots (1)$$

where $w(U_A, U_B, n)$ is the well function for the unconfined aquifer. The arguments of the well functions are:

$$U_A = \frac{r^2 S}{4Tt} \quad \text{for early time-drawdown data...}(2)$$

$$U_B = \frac{r^2 S_Y}{4Tt} \quad \text{(for late time-drawdown data) ...}(3)$$

$$n = \frac{r^2 K^1}{m^2 K} \dots \dots \dots (4)$$

$$h_0 - h^1 = \Delta s^1 = \frac{2.30}{4\pi T} \log \frac{t}{t^1} \dots\dots\dots(5)$$

- Where: M = initial saturated thickness, (m)
 K = horizontal conductivity, m/day
 K¹ = vertical conductivity, m/day
 S_y = specific yield,
 s = drawdown,
 t = interval over total pumping (in minutes)
 T = horizontal transmissivity, m²/day
 S = storativity or storage coefficient,
 r = distance from pumping well to observation well, (m)
 s¹ = residual drawdown (m)
 h₀ = initial water level, (m)
 h¹ = level at time t¹, (m)
 U_A = early time drawdown data
 U_B = late time - drawdown data
 n = Neuman's constant
 Q = constant discharge, m³/day

2.2.2.3 Soil, Sediment, Landuse and Agriculture

2.2.2.3.1 Soil

Introduction

The soils of the project area were investigated to determine their physico-chemical, erosional and nutrient characteristics so as to evaluate the probable impacts of the activities of the proposed project on them. These activities included (a) Site investigation and preparation, (b) Facilities Construction (c) Plant Operation and (e) Waste disposal.

Methodology:

Field Sampling

In order to adequately cover the study site, four transects radiating from a focal point, usually in the middle of the proposed site were cut running East to West and North to South. At each sampling point, composite soil samples were collected by means of a stainless steel auger at 0 - 15 cm and 15 -30 cm depths. In addition, random samples taken off the transects, were collected. All the soil samples collected were clearly labelled and sent to the laboratory as soon as possible for analysis.

Laboratory Analysis

Samples collected from the field were air dried, except for those meant for analysis of NH_4^+ , NO_3^- and NO_2^- , sieved through 2 mm sieve and analysed for the following physico-chemical parameters.

Hydrogen ion concentration (pH)

This was determined in a 1:1 soil/water suspension with a glass electrode pH meter.

Electrical conductivity

The conductivity of the saturation extract of the soils was determined using a Hilgar portable conductivity meter. Results were expressed in micro-siemens (μS) per cm.

Mechanical Analysis

Particle size distributions were determined by the method of Bouyoucus as described by Day (1965); textural classes were obtained from soil textural triangle shown in Fig 2.2.2.3.1.

Organic Carbon

This was determined by the Chromic acid oxidation method of Walkley and Black (1937). The organic carbon determined was expressed as percentage of the sample taken.

Available Phosphorus

The available phosphorus of the soil was extracted with Bray 1 solution (0.03N NH_4F + 0.02N HCl) and the phosphate in solution assayed by the ascorbic acid - molybdenum blue colour method of Murphy and Riley (1972).

Total Nitrogen

A sample of the fine earth was digested using a model D20 Tecator digester and the nitrogen content determined on a Technicon auto analyzer II.

Exchangeable Bases

The exchangeable bases of the soils were extracted using 1N neutral ammonium acetate. Calcium and magnesium were determined volumetrically by the EDTA titration method while Na^+ and K^+ were determined by flame photometry.

Exchangeable Acidity (EA)

The EA of the soils was extracted with 1M KCl solution and titrated for acidity with 0.1M NaOH solution. Results were expressed in milli-equivalents per 100 g soil.

Extractable Ammonium (NH_4^+)

For the determination of ammonium in the soils, field fresh samples were extracted with acidified 1.7 M NaCl and the ammonium in the extract assayed by the alkaline phenate method.

Nitrate and Nitrite (NO_3^- , NO_2^-)

The nitrate and nitrite nitrogen in the soils were extracted from fresh samples with 1 M sodium acetate solution. Nitrate in the extract was determined by the brucine method of Greweling and Peech (1964), while nitrite nitrogen was determined by the alpha-naphthol method.

Sulphate (SO_4^{2-})

The sulphate sulphur in the soil was extracted with a solution of potassium orthophosphate and the sulphate determined by the turbidometric method.

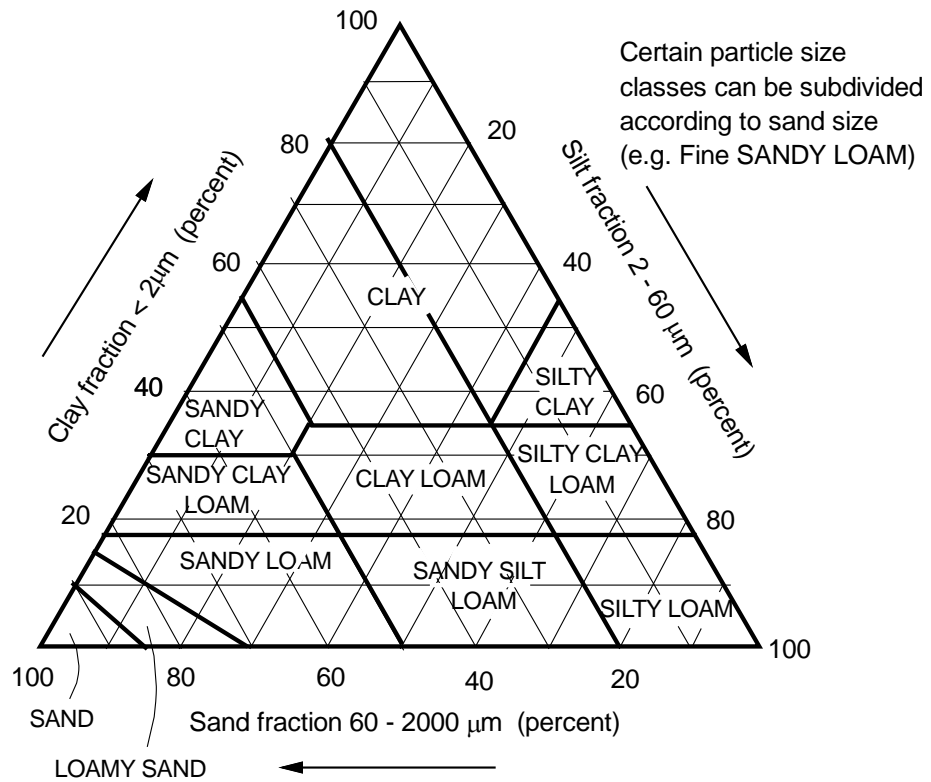


Fig. 2.2.2.3.1: Textural triangle showing the percentages of Clay(below 0.002MM) Silt (0.002 - 0.05MM), and Sand (0.05 - 2.0MM) in the basic soil textural classes.

Heavy metals

The trace elements in digested soil extracts were determined as in the procedure for water.

Hydrocarbon Content

The hydrocarbon content of soil samples was determined by shaking 5g of air-dried soil with 10 ml of carbon tetrachloride and the concentration in mg l^{-1} of oil in the extract was determined by means of a spectrophotometer at 420 nm. A calibration curve was prepared from the readings obtained from known concentrations of oil standards in the extract.

2.3 Ecological Programme

2.3.1 Field and laboratory Procedure

2.3.1.1 Phytoplankton Composition and Diversity

In each of the fourteen water sampling stations, phytoplankton were collected just below the water surface with a quantitative 55 micron mesh tow net attached to a cowl with an aperture diameter of 17 cm. Fixed into the inside of the cowl was a flow meter which measured the flow rate of the water which passed through the net. Each tow was made for 5 min. At an approximate speed of 9 km per hour. The catches were immediately removed from the net, bottled and preserved in a solution of 4% formaldehyde. The phytoplankton were examined in the laboratory using a Leitz Orthoplan Universal Wide-field Research Microscope equipped with tracing and measuring devices. One ml of the concentrated sample was introduced into a counting chamber and an average of 10 rows counted. The average frequency distribution of the different species was recorded.

2.3.1.2 Vegetation Studies

(a) Field Studies

In order to acquire baseline information on the vegetation, study sites, based on habitats earlier identified during reconnaissance visits were established within the study area. Information on species composition and structure were obtained using 100m^2 quadrats established at each site where soil samples were also collected. Within each plot, all plants were identified to species level, and their heights estimated. The number of strata in the vegetation was noted and the dominant species recorded. Where counting of individuals are not possible as in situations where there are creeping plants, cover was measured using the Braun-Blanquet scale (Sutherland, 1997). The population density of the key economic species was determined using 100m^2 quadrats. The frequency of occurrence refers to the chance of finding a taxon in a sampling unit (Kershaw and Looney, 1995). Unique and endangered species were listed while the state of the vegetation was visually assessed. Samples of plants not identified on the field were collected and carried to the herbarium for correct identification. The health status of the vegetation was visually determined. Where a disease symptom was noticed, samples of the plant organ(s) were taken to the laboratory for correct identification of causative organism(s). Incidence of exotic or invasive plants were also recorded.

(b) Herbarium Studies

Unidentified pressed specimens were taken to the laboratory and identified using the Flora of West Tropical Africa (Hutchinson and Dalziel, 1959 - 1969) and reference to herbarium

specimens in the University of Benin. Using the above results, profile diagrams along the transects were constructed following the method outlined by Raunkiaer (1934).

(c) *Crop and Plant pathology*

The state of health of crops and vegetation were noted while infected crops and vegetation were collected and kept in moistened polythene bags and transported to the laboratory for further studies. Laboratory studies included isolation and characterization of pathogenic fungi and bacteria from infected plant materials.

(d) *Phytochemistry*

Plant tissues were dried and milled to ensure homogeneity of samples and then 1 g aliquot of each sample was re-dried in the oven at 105°C for 1 h prior to acid digestion. 0.1 g sample of the plant material was weighed into a conical flask and digested with sulphuric and nitric acid mixture until white fumes of sulphuric acid were evolved and complete digestion of the sample material was achieved. The digest was cooled, diluted to 25 ml and two heavy metal ions (Ni and Va) in the digest were determined as in the case of soil. The results were expressed in mg kg⁻¹.

2.3.1.3 Zooplankton Composition and Diversity

For qualitative studies, zooplankton hauls were made with a 55 micron mesh tow net fitted with a flow meter. The net was towed behind an engine powered boat for five minutes at a slow speed of about 9 km per hour. Zooplankton collected were preserved in buffered 4% formalin in 200 ml plastic containers. For quantitative studies forty (40) litres of water were filtered through a 55 micron mesh plankton net and reduced to 50ml concentration. In the laboratory, counting was done in a 1 ml Koltwitz counting chamber with grids. Row after row of the counting chamber was examined by means of an Olympus Vanox Research Microscope and the numbers of individual species recorded. Zooplankton numbers were computed from the equation:

$$\frac{N \times S \times 1000}{V}$$

Where

N = number of zooplankton in 1 ml of sample

S = Volume of sample (50 ml)

V = initial volume of sample (40 l).

2.3.1.4 Fauna

The fauna of the study sites consisted of invertebrates and vertebrates inhabiting the inter-tidal/terrestrial zones, the bottom sediments and the roots of floating macrophytes mainly water hyacinth (*Eichhornia crassipes*). These communities were investigated by the methods outlined below.

(a) *Inter-tidal fauna*

These were sampled along four transects, each 500 m long. These were surveyed for both qualitative and quantitative faunal species. The quadrat method was used to estimate the populations of fauna enclosed within the area of 1 sq. m at each sampling station. During low tide, the fauna within the designated area were hand-picked, and at high tide, the light dredge (500 µm mesh size) was used for sampling. The benthos in-fauna in the bank root biotopes of creeks and rivers were sampled with a hand net (154 µm mesh size) using the kick technique (Lenat *et al*, 1991).

(b) *Fauna of bottom sediments of rivers and creeks*

The Ekman grab was used in collecting benthic samples from the bottom of the aquatic systems. The bottom samples were sieved in the field using a set of Tyler sieves of different mesh apertures (150 µm, 300 µm, 500 µm, 650 µm, 1 mm and 2 mm). The sampling stations which coincided with water sampling stations are shown in Figs. 1.3.1 to 1.3.4 (back pocket)

(c) *Fauna of Floating macrophytes (Water hyacinth)*

These fauna were collected by dipping a bunch of water hyacinth into a bucket containing 10% formaldehyde and shaking vigorously to dislodge the organisms inhabiting the roots. Ten samples from all the study fields were collected during the study period.

(d) *Preservation*

All organisms collected were preserved in 10% formaldehyde.

(e) *Laboratory analysis*

All samples collected during the field work were sorted using the binocular dissecting microscope. Identifications were made using relevant identification manuals and literature.

(f) *Statistical analysis*

Indices of species diversity and evenness were used to characterize the faunal community structure. Collections are believed to be representative of the community at the site of collection and the numbers of taxa and their relative abundance are the essential properties. The Margalef's index (d) of taxa richness, Shannon-Wiener index of general diversity (H) and Evenness (E) were used to express the descriptive properties.

Margalef's Index (d): $d = s-1/\ln N$

where s = number of taxa

N = total number of individuals

Shannon-Wiener Index (H):

$$H = \frac{N \log N - \sum n_j \log n_j}{N}$$

where N = total number of individuals
 K = total number of species
 n_i = number of individuals in the i th species

The Evenness component of diversity expresses the degree of uniformity in the distribution of individuals of each taxon in the collections.

$$E = H/H_{\max}$$

where $H_{\max} = \log K$ (Zar, 1993).

The system of Slack et al (1979) was used in the determination of dominant, subdominant, common and rare groups of genera. Taxonomic groups or genera comprising

- 15% or more of the total number of individuals collected = Dominant
- 5 - 14% = Subdominant
- 1 - 4% = common
- Less than 1% = Rare.

2.3.1.5 Fisheries

Delineation of the important species and harvest methodology were arrived at, through:

1. Inspection of catches by local fishermen both in the field and in fishing camps.
2. Interviews of fishermen in camps regarding catch composition.
3. Survey of the fishes on sale in market-places and interview with the fisheries middlemen about the source of their fishes.

Fish Analysis

(a) Laboratory Analysis

The species collected from the environment around the project site were used for laboratory analyses. Specimens were thawed at room temperature, coded and identified. The following parameters were determined prior to anatomical examination: Total and standard length (cm), body weight (g), sex which was confirmed when the fishes were dissected by noting the presence of testes or ovaries.

(b) External Examination

Each specimen was closely examined for disease signs with a magnifying glass beginning from the head, mouth, teeth (if present), sensory barbels (when present), bronchial slits and number, trunk scales, fins (including adipose fin when present).

(c) Internal Examination

Each specimen was laid on its side on a flat board and an incision made with a pair of scissors from just above the vent, along the top of the rib cage, and forward through the pectoral girdle and the fifth non-respiratory gill arch marking the ear of the opercular cavity. This was done carefully so that internal organs were not damaged. The flap was pulled downwards to open the

body cavity, freeing the forward edge of any changing mesenteries. The wall was then cut along the bottom to fully expose the internal organs.

This method of opening a fish is useful in general examination and inspection for parasites. The stomach, liver, pyloric caeca (when present), spleen and kidney were individually examined for health and the length of the intestine was measured. Slices through the white muscle of fish were made in order to detect any haemorrhagic areas and free or encysted larvae of nematodes and cestodes that can readily be seen without magnification. Finally, the stomach and the entire intestine were cut open and the content washed out in 5% formalin solution into specimen bottles following which contents were examined under the microscope. The parasites of fishes recorded were present by different method. The slides were prepared by the Lactophenol method of Franlin and Gooday (1949), and later viewed under a binocular microscope.

(d) *Calculation*

(i) Fultons condition factor = $w/L^3 \times 100$ is an index of the well being for whole fish where.
 w = wt of fish; L = length.

(ii) Gonado-somatic index: - This is the percentage of the whole weight of the ovary (gm) over the whole weight of the fish (gm). The gonado-somatic index changes in accordance with the breeding cycle and serves as an independent quantitative means of determining the season or period of highest gonadal development and maturity. It is also an indicator of the well being of the gonads.

(iii) Length - weight relationship.

The length - weight relationship was calculated using the formula described by Le Cren (1951):

$$w = a L^b \text{ ----- (1)}$$

The data were transformed into logarithms before the calculations were made. Thus equation (1) was transformed into:-

$$\text{Log } w = \text{log } a + b \text{ log } L \text{ ----- (2)}$$

Where w = weight of the fish in g
 L = Total length of the fish in cm
 a = constant and
 b = an exponential value.

(e) *Gustatory analysis*

Questionnaire were given out to families so as to evaluate the test, flavour, and quality of the flesh of the fishes of different species collected from the various stations during the course of this study.

2.4 SOCIO-CULTURAL PROGRAMME

2.4.1 Field and Laboratory Procedures

2.4.1.1 Noise, Vibration and Thermal Stress

2.4.1.1.1 Noise and Vibration

2.4.1.1.1.1 Instrumentation

The noise studies consisted of background noise measurements at the proposed project site and the environs. The measurements were made with Precision Sound Level Meter Type CEL 450. The microphone was a 13mm diameter condenser microphone, B & K Type 4165, fitted with wind shield and mounted on flexible extension boom/input adaptor Type B & K JJ2614. The sound level meter was held at 1.5 meters above the ground to minimize ground effects, and at full arms-length to minimize body effects of the observer. The sound level meter was calibrated with B & K pistonphone Type 4420 prior to commencement of measurements.

2.4.1.1.1.2 Noise Survey

Detailed noise survey was undertaken at the flowstation, host and impact communities.

2.4.1.2 Archaeology

The areas under study are essentially wet lands with no inhabitants in the immediate vicinity of the project sites. This situation called for several archaeological methods to be used, first to detect larger areas and then narrow the detection to more specific sites.

2.4.1.2.1 Field Reconnaissance Archaeology

We undertook archival literature study to gather necessary cultural/historical information on the people (Izon). Available maps were also studied. Because of the tidal nature of most of the areas under study, reconnaissance through the swamps was found very difficult especially during the rainy season.

2.4.1.2.2 Interview Method

Using questionnaires which were administered along with socio-economic studies, information on oral traditions were obtained from the settlements outside the immediate vicinity of the project sites.

2.4.1.2.3 Rescue Archaeology and Ethnography

This phase of the work was undertaken during the dry season, when the sites already identified by the previous methods, were explored in detail, using scientific probes, Auger, diggers, shovels etc.

2.4.1.3 Socio-economics

The principal objective of this socio-economic study is to identify and examine the specific effects of the project on the socio-economic life of the area in which the projects are to be executed. This objective was pursued by carrying out a series of investigations to collect and collate data on the prevailing situation.

2.4.1.3.1 Methodology

The socio-economic environment can be identified as including:

- (a) Population structure and dynamics
- (b) Land use and settlement patterns
- (c) Labour supply and employment structure
- (d) Production, income distribution and consumption
- (e) social organisation and institutions.

Two broad categories of methodologies were utilized in this study, viz., and ethnographic and socio-demographic survey method.

2.4.1.3.2 Ethnographic Method

This method entails visiting and interacting with the settlers in the project vicinity and observing, asking questions and recording information gathered. The study criss-crossed the host and impact communities. In some settlements where no settlers spoke nor understood English language, services of interpreters were enlisted as assistants.

The ethnographic method is ideal for studying social organisation and institutions such as marriage and family, religion, economy and polity of the localities and their land/water use and settlement pattern. In places where there are schools, services of school teachers were enlisted.

2.4.1.3.3 Socio-Demographic Survey

In studying the socio-demographic structure and dynamics of the localities, we concentrated on inquiring into the population structure (age, sex and other compositional characteristics) and dynamics (birth, death, migration and marriage rates) of the settlement. We emphasized the educational, occupational and work statuses of the population of the settlements.

2.5 Microbiology

The total surface viable count for heterotrophic petroleum degrading bacteria and fungi was done by the miles and misra method using nutrient agar, Saborou Dextrose agar (SDA) and petroleum degrading agar as previously described (Cruickshank *et al*, 1975) Miles and Misra method of Surface Viable Count.

A serial dilution of 1 in 10 dilution in normal saline was made from each sample and an aliquot of 0.02 ml was inoculated with the aid of a calibrated Pasteur pipette unto nutrient agar, SDA and petroleum degrading agar. The nutrient agar was incubated for 24 to 49 hours after which the colony was count was taken. The SDA and Petroleum degrading agar were incubated for up to four days before the count on each plate was taken. The coliform and *E. coli* count was done with MacConkey agar as previously described. (Cruickshank *et al*, 1975). See details below.

Examination For Coliform Organisms

Quantitative estimation of the number of organisms was carried out by the MPN method viz:

Presumptive Coliform Test

Three set of tubes, each with an inverted Durham tube was set up as follows:

- I. five 10 ml sterile double strength MacConkey broth in MacConkey bottles
- II. five 5 ml single strength MacConkey broth in Bijoux bottles
- III. five 5 ml single strength MacConkey broth in bijoux bottles.

First set (I) were inoculated with 10 ml water sample; second set (II) inoculated with 1 ml and set (III) were inoculated with 0.1 ml of the sample respectively.

All tubes were incubated at 37°C for 49 hours, tubes which showed acid production (colour change from red to purple) and gas were recorded as positive. Reference was made to McCrady's probability table for MPN (Cruickshank *et al*, 1975).

Confirmatory Test (Eijkman Test)

Two set of Bijoux bottles were set up: A with MacConkey broth and B with peptone water. All three positive tubes from the presumptive test were inoculated each to a MacConkey broth tube and peptone water tube respectively.

All tubes were inoculated at 44°C for 24 hours to decide whether or not *E. coli* was present. At the end of the incubation period, tubes showing acid and gas were regarded as *E. coli*. Peptone water tubes showing positive test with Kovac's reagent together with acid and gas formation in the second set of tubes were regarded as containing typical coliform Bacilli. McCrady's probability table was again consulted from statistical interpretation of result.

Completed Test

From the positive tubes of the presumptive test, MacConkey agar plates were inoculated and incubated at 37°C for 24 hours. Pinkish red colonies with a diameter of 3-5 mm were inoculated into peptone water, incubated at 44°C for 24 hours and 2 to 3 drops of Kovac's reagent was added, positive tubes gave an upper reddish ring colouration and negative did not. This test distinguishes typical coliform Bacilli from the irregular types of coliform organisms.

2.6 Health Studies

2.6.1 Literature Review

Literature review will cover:

- Review of International Guidelines for conducting HIA, such as WHO, IFC World Bank and Asian Development Bank, publications of the International Health Impact Assessment Consortium (IMPACT). Review of past HIAs for energy projects, such as Oil and Gas development.

2.6.2 *Data Collection*

The following data gathering techniques will be applied:

- Interviews of randomly selected members of each village within each community including health personnel, literate and non-literate private individuals, males and females, young and old, residents and immigrants.
- Administration of structured questionnaires (details in the Appendix 11) with the assistance of trained local nurses and other residents with knowledge of the community structure to include the above groups.
- Visual appraisal (on the spot) during walks through the communities to evaluate the availability, accessibility, and utilisation of the healthcare delivery services to members of the community.
- Examination of hospital records and extraction of relevant statistics particularly the strength and quality of staff, equipment or facilities available, health services provided, etc.
- Physical and clinical examinations to obtain direct assessment of the health status and diseases prevalent in the communities. The medical examination included measurement of blood pressure, weight and height, in adults; circumferences of thigh, arm and head in children, checking for anaemia and jaundice, body rashes etc. Information gathered also included infection according to age, sex and occupation.
- Statistical analyses of data to develop a health risk matrix for evaluation of group vulnerability and health risks attributable to the project following the procedures of Birley (1995).
- Observation of environmental health conditions e.g. sources and quality of drinking water, toilet facilities, houses (including ventilation), waste disposal, erosion, flooding, noise, air pollution, entire surroundings of houses, animal disease vectors (mosquitoes, houseflies, stray/reared domestic animals in the community).
- Community health capacity will be assessed using Table 2. 6.2.

| Table 2.6.2: VARIABLES USED IN ASSESSING COMMUNITY HEALTH CARE CAPACITY | |
|------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| Variable | Data to Collect |
| Hospital use vs. out-patient care | Hospital visits per population in defined time period |
| | Out-patient visits per population in defined time period |
| | Beds per population |
| | Average in-patient stay by disease category |
| Qualifications, experience, and competence of (local) health professionals | Distribution of medical staff |
| | Doctors per 10,000 population |
| | Nurses per 10,000 population |
| | Median number of years of practice for doctors and nurses |
| Range, quality, and availability of medical supplies, medicines, and emergency equipment | Availability of specified medical supplies, medicines, equipment (e.g. lab, dialysis) |
| | Storage conditions and expiration dates for specified medicines |
| | Minimum quantity of specified supplies |
| | Working condition of specified equipment |
| | Re-supply of medicines |

| Table 2.6.2: VARIABLES USED IN ASSESSING COMMUNITY HEALTH CARE CAPACITY | |
|-------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|
| Variable | Data to Collect |
| | Reordering of supplies |
| Standards of local medical facilities, including intensive care | Standard treatment procedures for specified conditions |
| | Use/availability of treatment standards/protocols |
| | Availability of telephone |
| | Referral practices |
| | Availability of ambulance |
| Social insurance system; access to health care | Social insurance system; access to health care |
| Public Health Systems | Waste disposal, access to safe water supply, sanitation, maternal and child care including immunisations etc. |

APPENDIX 4

SOCIAL IMPACT ASSESSMENT QUESTIONNAIRE

Macgill Engineering & Technical Services Ltd has been commissioned to carry out a detailed Social Impact Assessment Study (SIA) for OTUMARA EIA. The result of this study will enable us evaluate possible socio-economic impacts so far, on your environment, and thus recommend ways to enhance positive impacts and minimize negative ones. Please kindly answer the following questions.

1.0 NEIGHBORHOOD/COMMUNITY/SETTLEMENT

- 1.1 Name of interviewee.....
- 1.2 Date of interview.....
- 1.3 Neighborhood/Community/Settlement.....
- 1.4 Local Government Area.....
- 1.5 State.....

2.0 RESPONDENTS PERSONAL INFORMATION

- 2.1 Sex (Male/Female).....

2.2 Age:

- 2.2.1 10 – 20 years
- 2.2.2 21 – 30 years
- 2.2.3 31 – 40 years
- 2.2.4 41 – 50 years
- 2.2.5 51 - 60 years
- 2.2.6 61 – 60 years

Above 70 years

2.3 How would you describe yourself in this Community/Neighborhood?

- 2.3.1 Indigene
- 2.3.2 Settler
- 2.3.3 Visitor
- 2.3.4 Tenant

2.4 How long have you lived in the Community/Neighborhood?

- 2.4.1 Less than 5 years
- 2.4.2 6 – 10 years
- 2.4.3 11 – 15 years
- 2.4.4 16 – 20 years
- 2.4.5 Above 20 years

2.5 Marital Status

- 2.5.1 Single
- 2.5.2 Married
- 2.5.3 Divorced/Separated
- 2.5.4 Widow/Widower

2.6 What is your family type?

- 2.6.1 Nuclear family

- 2.6.2 Extended family
- 2.6.3 Polygamous
- 2.6.4 Other (specify).....

- 2.7 What position do you hold in the Community?
 - 2.7.1 Traditional Ruler
 - 2.7.2 Religious Leader
 - 2.7.3 Family Head
 - 2.7.4 Chairman, Social Club
 - 2.7.5 None
 - 2.7.6 Other (specify).....

- 2.8 What is your level of Education?
 - 2.8.1 Primary
 - 2.8.2 Secondary
 - 2.8.3 Tertiary
 - 2.8.4 Vocational
 - 2.8.5 Adult education
 - 2.8.6 No Formal Education

3.0 DERMOGRAPHIC CHARACTERISTICS

- 3.1 Sex of household head
 - 3.1.1 Male
 - 3.1.2 Female
- 3.2 Family Size (Husband, Wife/Wives and Children)
 - 3.2.1 1 – 3
 - 3.2.2 4 – 6
 - 3.2.3 7 – 10
 - 3.2.4 11 – 15
 - 3.2.5 Above 15
- 3.3 Sex distribution: How many are:
 - 3.3.1 Males.....
 - 3.3.2 Female.....

3.4 Age structure

3.4.1 Household members' age

| Age | Male | Female | Total |
|-----------|------|--------|-------|
| 0-4 years | | | |
| 5-12 | | | |
| 13-18 | | | |
| 19-25 | | | |
| 26-59 | | | |
| 60-65 | | | |
| Above 65 | | | |

- 3.5 Household Literacy
 - 3.5.1 Education level of household members

| School | Males | Females | Total |
|-----------------|-------|---------|-------|
| Primary | | | |
| Secondary | | | |
| Vocational/Tech | | | |
| Tertiary | | | |
| Any other | | | |

3.6 How many births in your family in the last 12 months?

- 3.6.1 0
- 3.6.2 1
- 3.6.3 2
- 3.6.4 3
- 3.6.5 4

3.7 How many deaths in your family in the last 12 months? Kindly specify their age(s)

- 3.7.1 0
- 3.7.2 1.....
- 3.7.3 2.....
- 3.7.4 3.....
- 3.7.5 4.....

4.0 ECONOMIC ENVIRONMENT

4.1 What is your primary Occupation?

- 4.1.1 Farming
- 4.1.2 Fishing
- 4.1.3 Hunting
- 4.1.4 Civil Servant
- 4.1.5 Trading
- 4.1.6 Business
- 4.1.7 Artisan
- 4.1.8 Gin Distilling
- 4.1.9 Industrial Worker
- 4.1.10 Logging
- 4.1.11 Other (Specify).....

4.2 How long have you been in the Occupation?

- 4.2.1 0 – 5 years
- 4.2.2 6 – 10 years
- 4.2.3 11- 20 years
- 4.2.4 21 – 30 years
- 4.2.5 Above 30 years

4.3 Which of these is your secondary Occupation?

- 4.3.1 Farming
- 4.3.2 Fishing
- 4.3.3 Hunting
- 4.3.4 Civil Servant
- 4.3.5 Trading

- 4.3.6 Business
- 4.3.7 Artisan
- 4.3.8 Gin Distilling
- 4.3.9 Industrial Worker
- 4.3.10 Logging
- 4.3.11 None
- 4.3.12 Other (Specify).....

- 4.4 If you are engaged in farming, what type of crop do you cultivate?
 - 4.4.1 Cassava
 - 4.4.2 Maize
 - 4.4.3 Melon
 - 4.4.4 Yam
 - 4.4.5 Beans
 - 4.4.6 Cocoa yam
 - 4.4.7 Plantain
 - 4.4.8 Banana
 - 4.4.9 Other (specify).....

- 4.5 How would you describe farm yield in the last five years?
 - 4.5.1 It has increased steadily
 - 4.5.2 It has increased rapidly
 - 4.5.3 It has declined steadily
 - 4.5.4 It has declined rapidly
 - 4.5.5 It is the same or stable

- 4.6 If declining what do you think is responsible? (Record answer verbatim)
 - 4.6.1
 - 4.6.2

- 4.7 What type of crop management do you practice?
 - 4.7.1 Sole cropping
 - 4.7.2 Mixed cropping
 - 4.7.3 Mixed farming
 - 4.7.4 Other (specify).....

- 4.8 Where do you normally sell your produce?
 - 4.8.1 At your farm
 - 4.8.2 Local markets
 - 4.8.3 Interstate markets
 - 4.8.4 Export market
 - 4.8.5 At home
 - 4.8.6 Landing site
 - 4.8.7 Hawking/House to house
 - 4.8.8 Other (specify)

- 4.9 How do you normally transport your farm produce?
 - 4.9.1 Vehicle
 - 4.9.2 Motor cycle
 - 4.9.3 Bicycle
 - 4.9.4 Head porterage
 - 4.9.5 Wheelbarrow
 - 4.9.6 Other (specify).....

- 4.10 Give an estimated distance between your farm and the point where you sell your produce.
 - 4.10.1 0.5km
 - 4.10.2 1km
 - 4.10.3 2km
 - 4.10.4 Above 2km

- 4.11 At present, do you have any access to agricultural credit? If yes, please state source
 - 4.11.1 Government
 - 4.11.2 Banks
 - 4.11.3 NGOs
 - 4.11.4 Relatives
 - 4.11.5 Oil operating company.....
 - 4.11.6 Other (specify).....

- 4.12 What is your estimated income per month?
 - 4.12.1 N1,000 -N5000
 - 4.12.2 N5,001 – N10,000
 - 4.12.3 N10,001 – N15,000
 - 4.12.4 N15,001 – N20,000
 - 4.12.5 N20,001 – N25,000
 - 4.12.6 N25,001 – N30,000
 - 4.12.7 N30,001 – N35, 000
 - 4.12.8 N35,001 – N40,000
 - 4.12.9 N40,001 – N45, 000
 - 4.12.10N45,001 – N50,000
 - 4.12.11N50,001 and above

- 4.13 How much do you realize from other activities/sources in a month?
 - 4.13.1 N0.00 – 500.00
 - 4.13.2 N501.00 – 1,000.00
 - 4.13.3 N1, 001.00 – N1, 500.00
 - 4.13.4 N1, 501.00 – 2,000.00
 - 4.13.5 Above N2, 000.00
 - 4.13.6 None

- 4.14 How much do you spend on your family a week?

- 4.14.1 N250.00 – N500. 00
- 4.14.2 N501.00 – N1, 000.00
- 4.14.3 N1, 001. 00 – N1, 500. 00
- 4.14.4 N1, 501.00 – N2, 000. 00
- 4.14.5 N2, 500. 00 – N3, 000. 00
- 4.14.6 N3, 001. 00 – N3, 500. 00
- 4.14.7 Other range.

4.15 On what do you mostly spend on your family a week?

- 4.15.1 Food items
- 4.15.2 Household item
- 4.15.3 Clothing
- 4.15.4 Education of Children
- 4.15.5 Medical Care
- 4.15.6 Other range (specify).....

4.16 How much are you able to save in a year?

- 4.16.1 N10, 000.00 – N20, 000 .00
- 4.16.2 N21, 000.00 – N30, 000.00
- 4.16.3 N31, 000.00 – N40, 000.00
- 4.16.4 N41, 000.00 – N50, 000.00
- 4.16.5 N51, 000.00 – N60, 000.00
- 4.16.6 Other range.....
- 4.16.7 No savings

4.17 Which of these properties do you own?

- 4.17.1 Bicycle
- 4.17.2 Motor Cycle
- 4.17.3 Motor Vehicle
- 4.17.4 Out Board Engine Boat
- 4.17.5 Canoe
- 4.17.6 Generator
- 4.17.7 Television
- 4.17.8 Radio set
- 4.17.9 Gas cooker
- 4.17.10 Refrigerator
- 4.17.11 Cable (Dstv, HiTv etc.)
- 4.17.12 Other (Specify).....

4.18 Please state the number of your household members who have attained 18 years and above but are not employed.

- 4.18.1 None
- 4.18.2 1
- 4.18.3 2
- 4.18.4 3
- 4.18.5 4

- 4.18.6 5
- 4.18.7 6
- 4.18.8 Others (specify).....

4.19 How many members of your household are employed in Crude Oil related Companies operating in this area?

- 4.19.1 None
- 4.19.2 1
- 4.19.3 2
- 4.19.4 3
- 4.19.5 4
- 4.19.6 5

4.20 Does any member of your household have any form of technical training related to the operations of Oil Companies in the area? If yes how many?

- 4.20.1 1
- 4.20.2 2
- 4.20.3 3
- 4.20.4 4
- 4.20.5 5

4.21 Please briefly specify the nature of the training and indicate the number of person who has such training.

- 4.20.1
- 4.20.2
- 4.20.3
- 4.20.4

5.0 SOCIAL/CULTURAL ENVIRONMENT

5.1 What is your Religion?

- 5.1.1 Christianity
- 5.1.2 Islam
- 5.1.3 Traditional
- 5.1.4 Other (specify).....

5.2 Which of the following do you have around this Neighborhood/ Community: (please show us the location)

- 5.2.1 Shrines
- 5.2.2 Scared Ground/Forest.....
- 5.2.3 Historical/Archaeological site
- 5.2.4 Religion House
- 5.2.5 Sacred plant/animal.....
- 5.2.6 Other (Specify).....

5.3 Kindly state the names, date and purpose of traditional festivals in this community?

.....
.....
.....

5.4 Which of these social problems do you have in your Community/Neighborhood?

- 5.4.1 Youth/Juvenile delinquency/unrest
- 5.4.2 Land dispute
- 5.4.3 Chieftaincy problem
- 5.4.4 Inter-village problem
- 5.4.5 Inter- family problem
- 5.4.6 Unemployment
- 5.4.7 Other (Specify).....

5.5 How is conflict resolved in this community?

- 5.5.1 Elders-in-Council
- 5.5.2 Religious leaders
- 5.5.3 Traditional Priest
- 5.5.4 Age grade
- 5.5.4 Family heads
- 5.5.5 Other (Specify).....

5.6 What is the nature of land ownership in this community?

- 5.6.1 Personal
- 5.6.2 Family
- 5.6.3 Communal
- 5.6.4 Lease Hold
- 5.6.5 Free Hold
- 5.6.6 Other (specify).....

5.7 Do you own any land in the Community? If yes, what is the size in hectares

- 5.7.1 0 – 1
- 5.7.2 2 – 3
- 5.7.3 4 - 5
- 5.7.4 6 – 7
- 5.7.5 Above 7

5.8 Are there any recreational/leisure facility in this community? If yes, kindly list them

5.9 What benefit do you expect from SPDC in the course of the execution of this project and subsequent operation in the area? Please rank them in order of importance by placing 1 against the most important, 2 against next importance etc.

- 5.9.1 Employment of indigenes
- 5.9.2 Scholarship for indigenes

- 5.9.3 Electricity
- 5.9.4 Primary School
- 5.9.5 Water Project
- 5.9.6 Health Centres
- 5.9.7 Others (specify).....

5.10 What do you think have been the likely negative impact you may have experienced that is associated with SPDC operation in your community?

- 5.10.1 Increased social vices
- 5.10.2 Influx of people
- 5.10.3 Land take
- 5.10.4 Reduced farmland availability
- 5.10.5 Increased cost of living
- 5.10.6 Reduced school enrolment and retention
- 5.10.7 Decline in farm yield
- 5.10.8 Environmental pollution
- 5.10.9 Adulteration of culture
- 5.10.10 Increased motoring accident
- 5.10.11 None
- 5.10.12 Other (specify).....

5.11 What do you think have been the likely positive impacts you may have experienced that is associated with SPDC operation in your community?

- 5.11.1 Increased employment
- 5.11.2 Improved level of education
- 5.11.3 Land compensation
- 5.11.4 Incentive for conceptual engagement
- 5.11.5 Increased sales
- 5.11.6 Provision of social amenities
- 5.11.7 None
- 5.11.8 Other (specify).....

6.0 HOUSING/PHYSICAL ENVIRONMENT

6.1 What type of house do you live in?

- 6.1.1 One room apartment
- 6.1.2 A room and parlour
- 6.1.3 Flat
- 6.1.4 Self contain
- 6.1.5 Duplex
- 6.1.6 Other (specify).....

6.2 How do you own the house you live in?

- 6.2.1 Personal owned
- 6.2.2 Rented
- 6.2.3 Other (specify).....

- 6.3 What structural material is your house made of?
 - 6.3.1 Thatched/mud house
 - 6.3.2 Zinc/mud
 - 6.3.3 Zinc/plank
 - 6.3.4 Zinc/block
 - 6.3.5 Other (specify).....
- 6.4 What in-house facility do you have in your housing type?
 - 6.4.1 Water closet/toilet
 - 6.4.2 Bathroom
 - 6.4.3 Shower
 - 6.4.4 Kitchen
 - 6.4.5 Plumbing fixtures
 - 6.4.6 Other (specify).....
- 6.5 What is your method of sewage disposal?
 - 6.5.1 Open surface privy
 - 6.5.2 Pail (bucket) system
 - 6.5.3 *Shot-put*/Bushes
 - 6.5.4 Other (specify).....
- 6.6 What is your source of water supply?
 - 6.6.1 Stream
 - 6.6.2 Rain water harvest
 - 6.6.3 Water bore hole
 - 6.6.4 Pipe borne water
 - 6.6.5 Hand dug well
 - 6.6.6 Other (specify).....
- 6.7 Except domestic use, what other purpose does this water source serve your household?
 - 6.7.1 Irrigation
 - 6.7.2 Local processing industry (oil palm and cassava processing, etc.)
 - 6.7.3 Economic benefits (e.g. sales)
 - 6.7.4 Other (specify).....
- 6.8 What is your source of cooking fuel?
 - 6.8.1 Firewood
 - 6.8.2 Kerosene
 - 6.8.3 Saw dust
 - 6.8.4 Gas
 - 6.8.5 Electricity stove
 - 6.8.6 Other (specify).....
- 6.9 What is your method of waste disposal?
 - 6.9.1 Dump in pit
 - 6.9.2 Incineration/burning
 - 6.9.3 Dump in nearby bushes

- 6.9.4 Designated place in the community
- 6.9.5 Other (specify).....

- 6.10 What are the common environmental problems in the Neighborhood/Community?
 - 6.10.1 Flooding
 - 6.10.2 Shoreline Erosion
 - 6.10.3 Deforestation
 - 6.10.4 Indiscriminate waste dump
 - 6.10.5 Oil spill
 - 6.10.6 Gas flaring
 - 6.10.7 Noise pollution
 - 6.10.8 Thermal pollution
 - 6.10.9 Others (Specify).....
 - 6.10.10 No idea

- 6.11 What do you think is important to improving quality of life in this community?
 - 6.11.1 Portable water supply
 - 6.11.2 Lucrative employment
 - 6.11.3 Art and culture
 - 6.11.4 Security and safety
 - 6.11.5 Provision and access to amenities and services
 - 6.11.6 Serene natural environment
 - 6.11.7 All of the above
 - 6.11.8 Others (specify).....

- 6.12 Which of these infrastructure facilities do you have in your community?
Please tick as appropriate.
 - 6.12.1 Health centre
 - 6.12.2 Water bore-hole
 - 6.12.3 Primary school
 - 6.12.4 Secondary school
 - 6.12.5 Tertiary/technical institution
 - 6.12.6 Tarred road(s)
 - 6.12.7 Electricity
 - 6.12.8 Cassava processing plant
 - 6.12.9 Market stall
 - 6.12.10 Police station
 - 6.12.11 Other (specify).....

- 7.0 FISHERY, FOREST AND WILDLIFE
 - 7.1 Are you engaged in fishing activities? If yes, where do you usually fish?
 - 7.1.1 Rivers within a few nautical miles from the village
 - 7.1.2 Open sea fishing
 - 7.1.3 Fish pond
 - 7.2 What type of fishing craft do you use?

- 7.2.1 Non-motorized dug-out canoe
- 7.2.2 Non-motorized plank canoe
- 7.2.3 Motorized dug-out canoe
- 7.2.4 Trawler
- 7.2.5 Other (specify).....
- 7.3 What type of fishing gear do you use?
 - 7.3.1 Hand picking
 - 7.3.2 Hook and line
 - 7.3.3 Scoop net
 - 7.3.4 Cast net Set net
 - 7.3.5 Drift net
 - 7.3.6 Purse seine net
 - 7.3.7 Traps
 - 7.3.8 Crayfish net
 - 7.3.9 Trawl net
 - 7.3.10 Other (specify)
- 7.4 Please list the types of fish you normally catch?
 - 7.4.1
 - 7.4.2
 - 7.4.3
 - 7.4.4
 - 7.4.5
 - 7.4.6
 - 7.4.7
 - 7.4.8
 - 7.4.9
 - 7.4.10
- 7.5 How much do you realize from fish sales in a month?
 - 7.5.1 N0.0 – N250.00
 - 7.5.2 N250.00 – 500.00
 - 7.5.3 N501.00 – 750.00
 - 7.5.4 N751.00 – 1,000.00
 - 7.5.5 N1001.00 – 1,500.00
 - 7.5.6 N1, 501.00 – 1,750.00
 - 7.5.7 N1, 751.00 – N2, 000.00
 - 7.5.8 Above N2, 000.00
- 7.6 How would you describe fish yield in the last five years?
 - 7.6.1 It has increased steadily
 - 7.6.2 It has increased rapidly
 - 7.6.3 It has declined steadily
 - 7.6.4 It has declined rapidly
 - 7.6.5 It is the same or stable
- 7.7 If declining what do you think is responsible? (Record answer verbatim)
 - 7.7.1

- 7.7.2
- 7.7.3
- 7.8 Are you involved in forest resource exploitation in this community? If yes, what type of forest exploitation are you engaged in?
 - 7.8.1 Gathering of firewood
 - 7.8.2 Hunting
 - 7.8.3 Logging
 - 7.8.4 Snail gathering
 - 7.8.5 Non timber forest product gathering (herbs, roots, etc.)
 - 7.8.6 Other (specify).....
- 7.9 Please list the type of timber found in this area.
 - 7.9.1
 - 7.9.2
 - 7.9.3
 - 7.9.4
 - 7.9.5
 - 7.9.6
 - 7.9.7
 - 7.9.8
 - 7.9.9
- 7.10 What are the indigenous ways used in the community to conserve and protect the land, forest and water-bodies?
 - 7.10.1 Traditional injunctions/taboo
 - 7.10.2 Sanctions
 - 7.10.3 Fallow system
 - 7.10.4 Other (specify).....
- 7.11 Please list the type of wild animal and birds you normally see or catch in this area.
 - 7.11.1
 - 7.11.2
 - 7.11.3
 - 7.11.4
 - 7.11.5
 - 7.11.6
 - 7.11.7
 - 7.11.8
 - 7.11.9
 - 7.11.10.....
- 7.12 What are your expectations from the operation of SPDC in your community?
 - 7.12.1
 - 7.12.2
 - 7.12.3

Thank You!

APPENDIX 5:

FME_{env} TECHNICAL COMMENTS AND SPDC's RESPONSES ON THE EIA DRAFT REPORT OF THE PROPOSED OTUMARA AGS PROJECT

| S/N | FME _{env} COMMENTS | SPDC's RESPONSES |
|-----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | Executive Summary | |
| 1 | Include the following laws Delta State Ecology Law,2006 Bendel State Forestry Law Cap 59, 1976 Delta State Waste Management Law, 2004 Delta State Revenue Edict, 1997 Delta State Internal Revenue Consolidation Law, 2009 | Included in ES 1.4 page xxi |
| 2 | Include Endangered species Act | Included in ES 1.4 page xxi |
| 3 | Vegetation There are two vegetation types in the area: Fresh water swamp and Marsh/Mangrove and not four as indicated in the report. Herbs and grasses are indicators of disturbance | Included in ES vegetation page xxxii and chapter 4, page 66: Four basic categories: the Salt Marsh, Mangrove Swamp, Phoenix swamp, and Fresh water swamp forest were observed according to Terminologies used are as defined in the Coastal and Marine Ecological Classification (CMEC) Standard (2012) |
| 4 | Land cover changes at Otumara | |
| 5 | Issue of salt water should be addressed by SPDC. It is necessary to restore the place back to it's original status | The issue of salt water intrusion has been addressed in the EMP of chapter 7 |
| 6 | The report points out that there was underground water pollution, this boils down to SPDC providing sources of potable drinking water as soon as they commence business in the area | There exists a Project Global Memorandum of understanding (PGMoU) were the communities have provided with funds to embark on projects such as water treatment plants that will improve their livelihood |
| 7 | The report indicated that there was extensive mangrove forest vegetation between Otumara and Saghara. The mangrove species should be identified and documented | Mangrove plants <i>Rhizophora racemosa</i> , <i>Rhizophora harrisonii</i> , and <i>Rhizophora mangle</i> have been identified page xxxii |
| 8 | Associated and Potential Environmental Impact Include the following: Loss of land and vegetation, under potential and major negative impact Waste disposal and water pollution under moderate rated impact | It has been included in page xxxv |
| 9 | The project schedule was not mentioned in the ES | It has been included in page xxvi |
| 10 | The broad objective of putting of flares in Otumara field by 2009 | This date has been overtaken by events. Date has been removed. Page xxi |
| 11 | Generally, the waters are slightly acidic to slightly alkaline....What waters are we talking about 'TSS should have been conducted to know | Surface waters sampled in Otumara field. Page xxix |

| S/N | FME _{env} COMMENTS | SPDC's RESPONSES |
|-----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | the pollution status of the water body | |
| 12 | Change decree to Act throughout the text | It has been done |
| 13 | Please include impacts both negative and positive on plants/wildlife | The impacts on plants/wildlife is limited to the pipeline right of way(RoW) and the 11hactares to be acquired for the field logistic base.The impacts were not ranked as significant |
| 14 | Literacy rate of 73.9% can't be considered low | This has been rewritten based on the new study (2012/2013)-page xxxiv 'About 67% of the sampled population have post primary education and 10% have some forms of tertiary education' |
| 15 | List of fishes found in the area should be updated from aquatic studies and biological/scientific names used. What is scale fish | List of fishes have been updated based on the new study (2012/2013) The term scale fish does not exist in new study |
| 16 | The maintenance scheduled for the process facilities is not included in the executive summary | This has been included in page xxxvii and xxxviii |
| Chapter 1 | | |
| 17 | Map of Nigeria showing Delta state and Otumara AGS | Included in Fig1.1 page 3 |
| 18 | Map of Delta State showing Otumara AGS | Included in Fig1.2 page 4 |
| 19 | Include Delta State Environmental Laws indicated in Executive summary | Included in pages 6 and 7 |
| 20 | No map of Nigeria showing Delta State | Included in Fig1.1 page 3 |
| 21 | Federal Ministry of Environment Guideline on Oil and Gas | Included in page 5 |
| 22 | National Environment Regulations, Pollution Abatement Industries and Facilities Generating Waste Regulation | Included in page 5 |
| 23 | Flares out in 2008/2011 | Not included in new study(2012/2013) |
| 24 | You talk about rerouting from Saghara back to Otumara. What happens to the former route and Projects | Rerouting of pipelines from Saghara to Otumara will utilize only existing RoW. Saghara flow station will be mothballed and preserved (see chapter 2 and 3) |
| 25 | Brown field over 34 years. When was the last integrity test done? | In 2012 |
| 26 | Warri South West bye –laws of the Operation area | Not available |
| Chapter 2 | | |
| 29 | Shall improve the living standards of the rural communities. This is a brown field of over 34 years. What is the present standard of living of Otumara Community and how will this project improve on their living condition | The key objective of the project is to eliminate routine gas flaring and by implication reduce emissions into the atmosphere, thereby improving local atmospheric quality as well as reducing global warming potential Extension of electric power supply to the host communities, coupled with the community development activities associated with the project contained |

| S/N | FME _{env} COMMENTS | SPDC's RESPONSES |
|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | | in the PGMoU will boost the overall infrastructural status of the host |
| 30 | Flare out date | Not included in new study(2012/2013) |
| 31 | The level of gas flaring going on at Otumara flow station and the level of upgrade that will be achieved by the upgrade should be indicated to give the true value of the project | Re-routing of the pipelines from Saghara flowstation to Otumara flowstation and the mothballing of the Saghara flow station will eliminate gas flaring at Saghara flowstation. Otumara and Saghara flowstations are situated close to one another and share the same communities. Absence of emissions from Saghara will impact positively on Otumara. Both Otumara AGS and Saghara AGS projects are closely linked |
| Chapter 3 | | |
| 32 | Is the 3ha of land to be acquired outside the already existing RoW | It is no longer 3ha but 11ha and it is outside SPDC RoW. Page 4 and 11 |
| 33 | The statement in page 11-3 that ' the likely spill during the project execution will be engine oil, diesel and petrol, in very small quantities' should be expunged because this cannot be ascertained now | This statement no longer exists in the new EIA report (2012/13) |
| 34 | Has the Project commenced, the last statement in this section of the report says the 'first gas is expected from the node by mid 2009'. The activity scheduled is not properly described. This is necessary so that stakeholders will be abreast with issues relating to the Project | As at 2009 the project had not commenced |
| 35 | What does re-routing of Otumara well 17T, 36L, 40T and 43S involve | These wells located in Otumara field flow to Saghara flowstation, however, will involve flowing these wells from Saghara flowstation to Otumara flowstation through existing pipeline RoW (page 4) |
| 36 | The Design Criteria should be specific and not descriptive. It should have figures instead of description | This has been rewritten-page 5-10 |
| 37 | How often is the integrity status of the cathodic protection of the pipe going to be monitored | Quarterly –page 9 |
| 38 | 'The pipeline, flush water effluent shall be transported to Forcados Terminal for segregation and disposal in accordance with existing regulations.The water from hydrotesting shall be managed in line with existing statutory regulations' | This has been rewritten |
| 39 | Is there a plan to construct a wastewater pipe conveying this water to Forcados? Which regulations are referred to | In SPDCs new waste management system hydrotest water will transported to Forcados Terminal via series of pipelines |
| 40 | Realistically there should be a waste treatment plant on site to treat effluent and other confirmatory analysis discharge same into ocean | Oily water discharges shall be controlled to less than 20ppm oil in water by oil/water separators, interceptors and saver pit systems-page25 |
| 41 | There is no project schedule | Project schedule included-page 17 |

| S/N | FME _{env} COMMENTS | SPDC's RESPONSES |
|-----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 42 | Design criteria-Regulatory considerations spoke of EGASPIN, Minerals Act, nothing on FME _{env} on Oil and Gas Sectoral Guidelines, was this report for FME _{env} considerations | This section has been re-written in new document to include FME _{env} considerations-page 5 |
| 43 | Acquisition of land opposite Otumara flowstation for the compressor out treatment facilities. 2km fresh acquisition for RoW. What exactly is the acquisition and for what | The additional land take is 11ha and it is for the Field logistic Base(FLB)-page 11 |
| 44 | Power generation 'exact load shall be determined after FEED'. This amounts to placing the cart before the horse. Information from FEED is expected to be captured in the EIA report for obvious reasons of possible change in Design concept | This section on power generation has been re-written-page 6 and 7 |
| 45 | The water for flushing, where will it end up | Forcados Terminal |
| 46 | Project schedule, None existent but first gas from node expected in mid 2009. What is the status now | Quarter 4, 2014 |
| Chapter 4 | | |
| 47 | Sampling map absent | Sampling map included |
| 48 | Values of soils in south western Nigeria | Table does not exist in new EIA (2012/2013)report |
| 49 | Soil heavy metal values are not within regulatory limits | Table 4.3.2 shows soil heavy metals all below regulatory limits in the new(2012/2013) report-page 29 |
| 50 | Ni, Cr and Pb were not mentioned among the parameters not within the regulatory limit in the report | There levels in the soil were determined in the new report |
| 51 | The statement ' the relative higher concentration of Zn, Fe, and Cu in the sediment are reflective of the characteristics of the soils of Otumara Field ' what is the cause? THC was also observed to be high in some sampling stations | Table 4.3.2 shows soil heavy metals and TPH levels all below regulatory limits and intervention values in the new(2012/2013) report-page 29 |
| 52 | In this report, it was stated that the area is endowed with high species diversity and on sediment physicochemistry that the low level of nitrogen concentration in the water system may have accounted for the low level of aquatic invertebrates. Water do you think has contributed to this? | In the new EIA (2012/2013) report aquatic zooplankton composition and density was evident in both seasons though dry season levels were slightly greater than wet season levels. Variations in zooplankton density with stations were also observed and attributed to variation in nutrient levels. Nitrogen is an important element for protein formation and thus a limiting nutrient in aquatic systems- page 58 |
| 53 | The presence of soil hydrocarbon degraders indicates hydrocarbon content in the environment and also the presence of enteric bacteria is as a result of faecal contamination | In the current EIA report the %HUB and HUF were less than 1% of the THB and TF of the soil samples suggesting very low concentrations THC and TPH in the soils. Faecal coliforms were also occurred in low levels-page35 and 36 |

| S/N | FME _{env} COMMENTS | SPDC's RESPONSES |
|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 54 | Data from a most recent study should have been used to discuss the bacterial composition of Otumara water instead of that of 1999. The season it was obtained was not stated whether dry or wet | A new EIA report (2012/2013) was conducted involving fresh sampling in August 2012 for wet season and in January 2013 for dry season |
| 55 | The heavy metal values for the ground water studies are above acceptable limits | Most of the heavy metals fell below regulatory limits, except for Fe, Pb and V which were slightly higher than the set limits especially during the dry season-page 88 |
| 56 | The work done on common names of animals is commendable. However, more work should be done on common names of plants side by side with their botanical names for non- botanists and the public to easily identify with. Moreover plants are more easily identified within the communities by their common names | This has been done in Table 4.7.5 page 75 |
| 57 | All the existing baseline data for Otumara area used in this report are more than five years old and has therefore lapsed considering the length of time from the date of revalidation | A new EIA report (2012/2013) was conducted involving fresh sampling in August 2012 for wet season and in January 2013 for dry season. |
| 58 | The report needs to reflect on the prevailing physical, chemical and biological parameters instead of the secondary data that was presented | A new EIA report (2012/2013) was conducted involving fresh sampling in August 2012 for wet season and in January 2013 for dry season. |
| 59 | Sampling map and spatial boundary for the study is not stated | It has been included |
| 60 | Consultation with representatives of host communities-Please name the host communities | Ugboegungun, Ugborodo and Deghele |
| 61 | There is no consistency in reporting the prevailing wind direction. The use of South westerlies, South Easterlies, North Easterlies and North Westerlies should be properly looked into | What we have in the new report is North Easterly and South Westerly |
| 62 | Concentration of pollutants at Otumara field. How relevant is this study done in 2002 | A new EIA report (2012/2013) was conducted involving fresh sampling in August 2012 for wet season and in January 2013 for dry season. |
| 63 | FME _{env} should be used as source throughout the text not FEPA | This has been effected in the new (2012/2013) report |
| 64 | Indicate the density per meter square of plant species that were recorded | This is a function of vegetation type. Four types were observed: Low and intertidal salt marsh(2500 – 3000 plants per ha) High Salt Marsh/ <i>Paspalum</i> Marsh (35 – 50 trees per ha) Mangrove Swamp(35 – 50 trees per ha) Fresh Water Swamp Vegetation (Typical swamp tree species present here are <i>Fleroya ledermanii</i> (1,000 trees pa ha), <i>Alstonia boonei</i> (148 trees pa |

| S/N | FME _{env} COMMENTS | SPDC's RESPONSES |
|-----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | | ha), <i>Ceiba pentandra</i> (50 trees pa ha) and <i>Anthocleista djalonenensis</i> (80 trees pa ha) Phoenix Swamp Forest (120 trees per ha), |
| 65 | The moluscs (phylum: mollusca) did not reflect in this report. This group of animals is in this zone in their terrestrial/aquatic form. The moluscs (phylum: mollusca) did not reflect in this report. This group of animals are common in this zone in their terrestrial/aquatic form | This has been captured in in the new report pages 59-59 section on macroinvertebrates (hydrobiology studies) |
| Chapter 5 | | |
| 66 | Impacts of dredging activities at pipeline river crossing is omitted in this section of the report | Impacts of dredging activities have been captured in Table 5.2 |
| 67 | Under mobilization of equipment/personnel, the following rating should be moderate and not minor as stated in the report | In the new report, apart from loss of vegetation which was rated low as an impact during mobilization other impacts were rated high to medium(moderate) in Table 5.5 page10 |
| 68 | The impact on air pollution resulting from emission of exhausts fumes/noxious gases and on surface water pollution from water craft oil leakages | These impacts have been captured in Table 5.5 |
| 69 | Under pipeline excavation and trenching, the impact on aquatic life in river crossing and surface water pollution should be included | These impacts have been captured in Table 5.5 |
| 70 | The dredging activity for the project should also be included in this section, and its impact on the various environmental components, so that mitigation measures are proffered for its activity | These impacts have been captured in Table 5.5 |
| 71 | Under the Piggig operation, the rating for the impact on contamination of surface water and soil from pig washout should be moderate and not minor as stated in the report. | In the new report the rating is high (Table 5.5) |
| 72 | Impacts during construction operation and decommissioning should include wastes that are likely to be generated | These impacts have been captured in Table 5.5 |
| 73 | Reduction in negative effects of flares on the environment was not captured | This is captured in the Saghara EIA. It is not within the scope of the Otumara EIA, though both projects are closely linked. |
| 74 | Pipeline Route Survey-The impact should include exposure and vandalization by human beings | This is the survey of the proposed pipeline route. In this case existing pipeline route will be used. |
| Chapter 6 | | |
| 75 | The following should be included in the mitigation measures | They are all included in Table 6.1 |

| S/N | FME _{env} COMMENTS | SPDC's RESPONSES |
|-------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | <ul style="list-style-type: none"> • Surface water pollution, waste disposal, aquatic ecology during dredging, excavation and trenching • Disruption of aquatic life during transportation of equipment and personnel • Fire/safety concern in project activity | |
| 76 | No mitigation measure was proffered for alteration to local topography resulting in flooding and water pooling, this the Ministry believes is necessary because of the nature of the environment in which the project is to be carried out | This has been included in Table 6.1 |
| 77 | The various impacts identified and the preferred mitigation measures should be tabulated | This has been included in Table 6.1 |
| Chapter 7 | | |
| 78 | There is no specific statement on how to treat the generated wastes | Included in section 7.9 |
| 79 | <p>Justify the use of data of 2006 and 2002 for the report</p> <ul style="list-style-type: none"> • The spatial boundary of study not stated • EMP action party missing • Trenching/Excavation impact at river crossing not stated • Impact on stringing and welding • Impact of possible fire outbreak • It is possible to determine the quantity of mangrove to be affected and to re-plant same | <p>A new report using data obtained from 2012 and 2013 was used Spatial boundary was a radius of 2km from flowstation EMP action party included in Table 7.1</p> <p>Trenching/Excavation included in Table 7.1</p> <p>Impact on stringing and welding included in Table 7.1 Impact of possible fire outbreak included in Table 7.1</p> |
| 80 | SPDC is the only party responsible for implementation and monitoring. This should be revised to accommodate Regulators, particularly during land mark events in the construction/operation phases | Regulators included in Table 7.1 |
| Executive Summary | | |
| 1 | <p>Include the following laws</p> <p>Delta State Ecology Law,2006</p> <p>Bendel State Forestry Law Cap 59, 1976</p> | Included in ES 1.4 page xxi |

| S/N | FME _{env} COMMENTS | SPDC's RESPONSES |
|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | Delta State Waste Management Law, 2004 Delta State Revenue Edict, 1997 Delta State Internal Revenue Consolidation Law, 2009 | |
| 2 | Include Endangered species Act | Included in ES 1.4 page xxi |
| 3 | Vegetation There are two vegetation types in the area: Fresh water swamp and Marsh/Mangrove and not four as indicated in the report. Herbs and grasses are indicators of disturbance | Included in ES vegetation page xxxii and chapter 4, page 66: Four basic categories: the Salt Marsh, Mangrove Swamp, Phoenix swamp, and Fresh water swamp forest were observed according to Terminologies used are as defined in the Coastal and Marine Ecological Classification (CMEC) Standard (2012) |
| 4 | Land cover changes at Otumara | |
| 5 | Issue of salt water should be addressed by SPDC. It is necessary to restore the place back to it's original status | The issue of salt water intrusion has been addressed in the EMP of chapter 7 |
| 6 | The report points out that there was underground water pollution, this boils down to SPDC providing sources of potable drinking water as soon as they commence business in the area | There exists a Project Global Memorandum of understanding (PGMoU) where the communities have provided with funds to embark on projects such as water treatment plants that will improve their livelihood |
| 7 | The report indicated that there was extensive mangrove forest vegetation between Otumara and Saghara. The mangrove species should be identified and documented | Mangrove plants <i>Rhizophora racemosa</i> , <i>Rhizophora harrisonii</i> , and <i>Rhizophora mangle</i> have been identified page xxxii |
| 8 | Associated and Potential Environmental Impact Include the following: Loss of land and vegetation, under potential and major negative impact Waste disposal and water pollution under moderate rated impact | It has been included in page xxxv |
| 9 | The project schedule was not mentioned in the ES | It has been included in page xxvi |
| 10 | The broad objective of putting of flares in Otumara field by 2009 | This date has been overtaken by events. Date has been removed. Page xxi |

| S/N | FME _{env} COMMENTS | SPDC's RESPONSES |
|-----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 11 | Generally, the waters are slightly acidic to slightly alkaline...What waters are we talking about 'TSS should have been conducted to know the pollution status of the water body | Surface waters sampled in Otumara field. Page xxix |
| 12 | Change decree to Act throughout the text | It has been done |
| 13 | Please include impacts both negative and positive on plants/wildlife | The impacts on plants/wildlife is limited to the pipeline right of way(RoW) and the 11hactares to be acquired for the field logistic base.The impacts were not ranked as significant |
| 14 | Literacy rate of 73.9% can't be considered low | This has been rewritten based on the new study (2012/2013)-page xxxiv 'About 67% of the sampled population have post primary education and 10% have some forms of tertiary education' |
| 15 | List of fishes found in the area should be updated from aquatic studies and biological/scientific names used. What is scale fish | List of fishes have been updated based on the new study (2012/2013) The term scale fish does not exist in new study |
| 16 | The maintenance scheduled for the process facilities is not included in the executive summary | This has been included in page xxxvii and xxxviii |
| Chapter 1 | | |
| 17 | Map of Nigeria showing Delta state and Otumara AGS | Included in Fig1.1 page 3 |
| 18 | Map of Delta State showing Otumara AGS | Included in Fig1.2 page 4 |
| 19 | Include Delta State Environmental Laws indicated in Executive summary | Included in pages 6 and 7 |
| 20 | No map of Nigeria showing Delta State | Included in Fig1.1 page 3 |
| 21 | Federal Ministry of Environment Guideline on Oil and Gas | Included in page 5 |
| 22 | National Environment Regulations, Pollution Abatement Industries and Facilities Generating Waste Regulation | Included in page 5 |
| 23 | Flares out in 2008/2011 | Not included in new study(2012/2013) |
| 24 | You talk about rerouting from Saghara back to Otumara. What happens to the former route and Projects | Rerouting of pipelines from Saghara to Otumara will utilize only existing RoW. Saghara flow station will be mothballed and preserved |

| S/N | FME _{env} COMMENTS | SPDC's RESPONSES |
|-----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | | (see chapter 2 and 3) |
| 25 | Brown field over 34 years. When was the last integrity test done? | In 2012 |
| 26 | Warri South West bye –laws of the Operation area | Not available |
| Chapter 2 | | |
| 29 | Shall improve the living standards of the rural communities. This is a brown field of over 34 years. What is the present standard of living of Otumara Community and how will this project improve on their living condition | The key objective of the project is to eliminate routine gas flaring and by implication reduce emissions into the atmosphere, thereby improving local atmospheric quality as well as reducing global warming potential Extension of electric power supply to the host communities, coupled with the community development activities associated with the project contained in the PGMoU will boost the overall infrastructural status of the host |
| 30 | Flare out date | Not included in new study(2012/2013) |
| 31 | The level of gas flaring going on at Otumara flow station and the level of upgrade that will be achieved by the upgrade should be indicated to give the true value of the project | Re-routing of the pipelines from Saghara flowstation to Otumara flowstation and the mothballing of the Saghara flow station will eliminate gas flaring at Saghara flowstation. Otumara and Saghara flowstations are situated close to one another and share the same communities. Absence of emissions from Saghara will impact positively on Otumara. Both Otumara AGS and Saghara AGS projects are closely linked |
| Chapter 3 | | |
| 32 | Is the 3ha of land to be acquired outside the already existing RoW | It is no longer 3ha but 11ha and it is outside SPDC RoW. Page 4 and 11 |
| 33 | The statement in page 11-3 that ‘ the likely spill during the project execution will be engine oil, diesel and petrol, in very small quantities’ should be expunged because this cannot be ascertained now | This statement no longer exists in the new EIA report (2012/13) |

| S/N | FMEnv COMMENTS | SPDC's RESPONSES |
|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 34 | Has the Project commenced, the last statement in this section of the report says the 'first gas is expected from the node by mid 2009'. The activity scheduled is not properly described. This is necessary so that stakeholders will be abreast with issues relating to the Project | As at 2009 the project had not commenced |
| 35 | What does re-routing of Otumara well 17T, 36L, 40T and 43S involve | These wells located in Otumara field flow to Saghara flowstation, however, will involve flowing these wells from Saghara flowstation to Otumara flowstation through existing pipeline RoW (page 4) |
| 36 | The Design Criteria should be specific and not descriptive. It should have figures instead of description | This has been rewritten-page 5-10 |
| 37 | How often is the integrity status of the cathodic protection of the pipe going to be monitored | Quarterly –page 9 |
| 38 | 'The pipeline, flush water effluent shall be transported to Forcados Terminal for segregation and disposal in accordance with existing regulations.The water from hydrotesting shall be managed in line with existing statutory regulations' | This has been rewritten |
| 39 | Is there a plan to construct a wastewater pipe conveying this water to Forcados? Which regulations are referred to | In SPDCs new waste management system hydrotest water will be transported to Forcados Terminal via series of pipelines |
| 40 | Realistically there should be a waste treatment plant on site to treat effluent and other confirmatory analysis discharge same into ocean | Oily water discharges shall be controlled to less than 20ppm oil in water by oil/water separators, interceptors and saver pit systems-page25 |
| 41 | There is no project schedule | Project schedule included-page 17 |
| 42 | Design criteria-Regulatory considerations spoke of EGASPIN, Minerals Act, nothing on FMEnv on Oil and Gas Sectoral Guidelines, was this report for FMEnv considerations | This section has been re-written in new document to include FMEnv considerations-page 5 |
| 43 | Acquisition of land opposite Otumara flowstation for the compressor out treatment facilities. 2km fresh acquisition for | The additional land take is 11ha and it is for the Field logistic Base(FLB)-page 11 |

| S/N | FME _{env} COMMENTS | SPDC's RESPONSES |
|-----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | RoW. What exactly is the acquisition and for what | |
| 44 | Power generation 'exact load shall be determined after FEED'. This amounts to placing the cart before the horse. Information from FEED is expected to be captured in the EIA report for obvious reasons of possible change in Design concept | This section on power generation has been re-written-page 6 and 7 |
| 45 | The water for flushing, where will it end up | Forcados Terminal |
| 46 | Project schedule, None existent but first gas from node expected in mid 2009. What is the status now | Quarter 4, 2014 |
| Chapter 4 | | |
| 47 | Sampling map absent | Sampling map included |
| 48 | Values of soils in south western Nigeria | Table does not exist in new EIA (2012/2013)report |
| 49 | Soil heavy metal values are not within regulatory limits | Table 4.3.2 shows soil heavy metals all below regulatory limits in the new(2012/2013) report-page 29 |
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| 51 | The statement ' the relative higher concentration of Zn, Fe, and Cu in the sediment are reflective of the characteristics of the soils of Otumara Field ' what is the cause? THC was also observed to be high in some sampling stations | Table 4.3.2 shows soil heavy metals and TPH levels all below regulatory limits and intervention values in the new(2012/2013) report-page 29 |
| 52 | In this report, it was stated that the area is endowed with high species diversity and on sediment physicochemistry that the low level of nitrogen concentration in the water system may have accounted for the low level of aquatic invertebrates. Water do you think has contributed to this? | In the new EIA (2012/2013) report aquatic zooplankton composition and density was evident in both seasons though dry season levels were slightly greater than wet season levels. Variations in zooplankton density with stations were also observed and attributed to variation in nutrient levels. Nitrogen is an important element for protein formation and thus a limiting nutrient in aquatic systems- page 58 |
| 53 | The presence of soil hydrocarbon degraders indicates hydrocarbon | In the current EIA report the %HUB and HUF were less than 1% of |

| S/N | FME _{env} COMMENTS | SPDC's RESPONSES |
|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | content in the environment and also the presence of enteric bacteria is as a result of faecal contamination | the THB and TF of the soil samples suggesting very low concentrations THC and TPH in the soils. Faecal coliforms were also occurred in low levels-page35 and 36 |
| 54 | Data from a most recent study should have been used to discuss the bacterial composition of Otumara water instead of that of 1999. The season it was obtained was not stated whether dry or wet | A new EIA report (2012/2013) was conducted involving fresh sampling in August 2012 for wet season and in January 2013 for dry season |
| 55 | The heavy metal values for the ground water studies are above acceptable limits | Most of the heavy metals fell below regulatory limits, except for Fe, Pb and V which were slightly higher than the set limits especially during the dry season-page 88 |
| 56 | The work done on common names of animals is commendable. However, more work should be done on common names of plants side by side with their botanical names for non- botanists and the public to easily identify with. Moreover plants are more easily identified within the communities by their common names | This has been done in Table 4.7.5 page 75 |
| 57 | All the existing baseline data for Otumara area used in this report are more than five years old and has therefore lapsed considering the length of time from the date of revalidation | A new EIA report (2012/2013) was conducted involving fresh sampling in August 2012 for wet season and in January 2013 for dry season. |
| 58 | The report needs to reflect on the prevailing physical, chemical and biological parameters instead of the secondary data that was presented | A new EIA report (2012/2013) was conducted involving fresh sampling in August 2012 for wet season and in January 2013 for dry season. |
| 59 | Sampling map and spatial boundary for the study is not stated | It has been included |
| 60 | Consultation with representatives of host communities-Please name the host communities | Ugboegungun, Ugborodo and Deghele |
| 61 | There is no consistency in reporting the prevailing wind direction. The use of South westerlies, South Easterlies, North Easterlies and North Westerlies should be properly looked into | What we have in the new report is North Easterly and South Westerly |
| 62 | Concentration of pollutants at Otumara field. How relevant is this | A new EIA report (2012/2013) was conducted involving fresh |

| S/N | FMEnv COMMENTS | SPDC's RESPONSES |
|-----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | study done in 2002 | sampling in August 2012 for wet season and in January 2013 for dry season. |
| 63 | FMEnv should be used as source throughout the text not FEPA | This has been effected in the new (2012/2013) report |
| 64 | Indicate the density per meter square of plant species that were recorded | <p>This is a function of vegetation type. Four types were observed:</p> <p>Low and intertidal salt marsh(2500 – 3000 plants per ha)</p> <p>High Salt Marsh/<i>Paspalum</i> Marsh (35 – 50 trees per ha)</p> <p>Mangrove Swamp(35 – 50 trees per ha)</p> <p>Fresh Water Swamp Vegetation (Typical swamp tree species present here are <i>Fleroya ledermanii</i> (1,000 trees pa ha), <i>Alstonia boonei</i> (148 trees pa ha), <i>Ceiba pentandra</i> (50 trees pa ha) and <i>Anthocleista djalonensis</i> (80 trees pa ha)</p> <p>Phoenix Swamp Forest (120 trees per ha),</p> |
| 65 | The moluscs (phylum: mollusca) did not reflect in this report. This group of animals is in this zone in their terrestrial/aquatic form. The moluscs (phylum: mollusca) did not reflect in this report. This group of animals are common in this zone in their terrestrial/aquatic form | This has been captured in in the new report pages 59-59 section on macroinvertebrates (hydrobiology studies) |
| Chapter 5 | | |
| 66 | Impacts of dredging activities at pipeline river crossing is omitted in this section of the report | Impacts of dredging activities have been captured in Table 5.2 |
| 67 | Under mobilization of equipment/personnel, the following rating should be moderate and not minor as stated in the report | In the new report, apart from loss of vegetation which was rated low as an impact during mobilization other impacts were rated high to medium(moderate) in Table 5.5 page10 |

| S/N | FME _{env} COMMENTS | SPDC's RESPONSES |
|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|
| 68 | The impact on air pollution resulting from emission of exhausts fumes/noxious gases and on surface water pollution from water craft oil leakages | These impacts have been captured in Table 5.5 |
| 69 | Under pipeline excavation and trenching, the impact on aquatic life in river crossing and surface water pollution should be included | These impacts have been captured in Table 5.5 |
| 70 | The dredging activity for the project should also be included in this section, and its impact on the various environmental components, so that mitigation measures are proffered for its activity | These impacts have been captured in Table 5.5 |
| 71 | Under the Pigging operation, the rating for the impact on contamination of surface water and soil from pig washout should be moderate and not minor as stated in the report. | In the new report the rating is high (Table 5.5) |
| 72 | Impacts during construction operation and decommissioning should include wastes that are likely to be generated | These impacts have been captured in Table 5.5 |
| 73 | Reduction in negative effects of flares on the environment was not captured | This is captured in the Saghara EIA. It is not within the scope of the Otumara EIA, though both projects are closely linked. |
| 74 | Pipeline Route Survey-The impact should include exposure and vandalization by human beings | This is the survey of the proposed pipeline route. In this case existing pipeline route will be used. |
| Chapter 6 | | |
| 75 | The following should be included in the mitigation measures <ul style="list-style-type: none"> • Surface water pollution, waste disposal, aquatic ecology during dredging, excavation and trenching • Disruption of aquatic life during transportation of equipment and personnel • Fire/safety concern in project activity | They are all included in Table 6.1 |
| 76 | No mitigation measure was proffered for alteration to local topography resulting in flooding and water pooling, this the Ministry believes is necessary because of the nature of the | This has been included in Table 6.1 |

| S/N | FME _{env} COMMENTS | SPDC's RESPONSES |
|-----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | environment in which the project is to be carried out | |
| 77 | The various impacts identified and the preferred mitigation measures should be tabulated | This has been included in Table 6.1 |
| Chapter 7 | | |
| 78 | There is no specific statement on how to treat the generated wastes | Included in section 7.9 |
| 79 | <p>Justify the use of data of 2006 and 2002 for the report</p> <ul style="list-style-type: none"> • The spatial boundary of study not stated • EMP action party missing • Trenching/Excavation impact at river crossing not stated • Impact on stringing and welding • Impact of possible fire outbreak • It is possible to determine the quantity of mangrove to be affected and to re-plant same | <p>A new report using data obtained from 2012 and 2013 was used</p> <p>Spatial boundary was a radius of 2km from flowstation</p> <p>EMP action party included in Table 7.1</p> <p>Trenching/Excavation included in Table 7.1</p> <p>Impact on stringing and welding included in Table 7.1</p> <p>Impact of possible fire outbreak included in Table 7.1</p> |
| 80 | SPDC is the only party responsible for implementation and monitoring. This should be revised to accommodate Regulators, particularly during land mark events in the construction/operation phases | Regulators included in Table 7.1 |

