# NIGERIAN ELECTRIFICATION PROJECT

RURAL ELECTRIFICATION AGENCY

ENERGY ▿ EMPOWERMENT ▿ EFFICIENCY

## ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT (ESIA)

## OF THE PROPOSED

## 2 MW SOLAR-HYBRID POWER PLANT AND ASSOCIATED INFRASTRUCTURE

## At

## FEDERAL UNIVERSITY OF HEALTH SCIENCES OTUKPO, BENUE STATE - UNDER THE NIGERIA ELECTRIFICATION PROJECT (DESERT TO POWER) PHASE II

## SUBMITTED TO:

## FEDERAL MINISTRY OF ENVIRONMENT, ABUJA

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# ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

**OF THE PROPOSED**

# 2 MW SOLAR-HYBRID POWER PLANT AND ASSOCIATED INFRASTRUCTURE AT FEDERAL UNIVERSITY OF HEALTH SCIENCES OTUKPO, BENUE STATE

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## Table of Contents

**Title Page** ..... Error! Bookmark not defined.
**Table of Contents** ..... Error! Bookmark not defined.
**List of Figures** ..... **x**
**List of Tables** ..... **xi**
**List of Plates** ..... **xiii**
**List of Acronyms, Units And Abbreviations** ..... **xiv**
**Executive Summary** ..... **xvi**

**CHAPTER ONE: INTRODUCTION** ..... **1**
1.1 Background to the Project ..... 1
1.2 Overview of the Project ..... 2
1.3 Project Proponent ..... 2
1.4 Project Location ..... 3
1.5 Rationale and Objectives for the ESIA ..... 5
1.5.1 Rationale for the ESIA ..... 5
1.5.2 Objectives of the ESIA ..... 6
1.6 Scope of the ESIA Study / Terms of Reference ..... 6
1.6.1 Spatial Scope ..... 7
1.6.2 Temporal Scope ..... 7
1.6.3 Thematic Scope ..... 7
1.7 ESIA Methodology ..... 8
1.7.1 Literature Review ..... 8
1.7.2 Reconnaissance Survey ..... 9
1.7.3 Field Investigations ..... 10
1.7.4 Environmental Sampling and Laboratory Analysis ..... 10
1.7.5 Stakeholder Consultation ..... 10
1.7.6 Impact Identification and Assessment ..... 11
1.7.7 Development of Mitigation Measures ..... 12
1.7.8 ESIA Reporting ..... 12
1.8 Policy, Legal and Institutional Framework ..... 12
1.8.1 National Policies, Guidelines and Regulations ..... 13
1.8.2 State Policies, Guidelines and Regulations ..... 14
1.8.3 Local Government Area Bye-laws ..... 14
1.8.4 International Conventions, Agreements, Best Practice Standards and Guidelines ..... 15
1.8.5 Federal Government of Nigeria (FGN) Requirements and Relevant Legislation ..... 16
1.9 REA Environmental, Health and Safety (EHS) Policy ..... 17
1.10 Structure of the Report ..... 18

**CHAPTER TWO: PROJECT JUSTIFICATION** ..... **19**
2.1 Introduction ..... 19
2.2 Justification and Need for the Project ..... 19
2.2.1 National Energy Transition Imperative ..... 20
2.2.2 Economic Justification ..... 20
2.2.3 Diesel Cost Avoidance ..... 20

2.2.4 Institutional Financial Sustainability ..... 21
2.2.5 Environmental and Climate Justification ..... 21
2.2.6 Social and Developmental Justification ..... 22
2.2.7 Strategic Alignment with Rural Electrification Objectives ..... 22
2.3 Value of the Project ..... 23
2.4 Benefits of the Project ..... 23
2.5 Sustainability of the Project ..... 24
2.5.1 Technical Sustainability ..... 24
2.5.2 Social Sustainability ..... 25
2.5.3 Economic Sustainability ..... 26
2.5.4 Environmental Sustainability ..... 26
2.5.5 Solar E-Waste and End-of-Life Management ..... 26
2.6 Project Alternatives ..... 27
2.6.1 Project Site Selection ..... 27
2.6.2 Power Generation Alternatives ..... 28
2.6.3 Solar Power Technology Alternatives ..... 29
2.6.3 Panel Technology Alternatives Considered ..... 31
2.6.4 Solar Battery Alternatives Considered ..... 32
2.7 Project Development Options ..... 32
2.7.1 No Project Option ..... 33
2.7.2 Delayed Project Option ..... 33
2.7.3 Go-Ahead Option ..... 33

**CHAPTER THREE: PROJECT DESCRIPTION ..... 34**
3.1 Introduction ..... 34
3.2 Key Project Components ..... 35
3.2.1 Component 1: Solar PV Farm ..... 37
3.2.2 Component 2: Power station ..... 41
3.2.3 Component 3: Access Roads ..... 44
3.2.4 Component 4: Buildings ..... 44
3.3.5 Component 5: Transmission Line ..... 45
3.2.6 Component 6: Street lights Quantity ..... 46
3.3 Project Phases for Implementation ..... 47
3.3.1 Pre-construction Phase Activities ..... 47
3.3.2 Construction Phase Activities ..... 47
3.3.3 Commissioning Phase Activities ..... 48
3.3.4 Operational Phase Activities ..... 48
3.4 Manpower Requirement ..... 48
3.5 Water Requirement and Supply ..... 49
3.6 Solar PV Network Installation Standards and Codes ..... 50
3.7 Health and Safety ..... 51
3.8 Emergency Shutdown Measures ..... 52
3.9 Waste Management ..... 53
3.9.1 Pre-Construction Phase ..... 53
3.9.2 Construction Phase ..... 54
3.9.3 Operation and Maintenance Phase ..... 54
3.9.4 Decommissioning Phase ..... 55

3.10 Project Schedule ..... 56

**CHAPTER FOUR: DESCRIPTION OF THE EXISTING ENVIRONMENT ..... 57**
4.1 Introduction ..... 57
4.2 Baseline Data Collection ..... 57
4.2.1 Desktop Studies and Literature Review ..... 58
4.2.2 Field Investigations ..... 58
4.3 Regional Physical Environment ..... 65
4.3.1 Climate and Meteorology ..... 65
4.3.3 Geology and Hydrogeology ..... 70
4.4 Project Site Location and Existing Land Use ..... 72
4.4.1 Project Location ..... 72
4.4.2 Existing Land Use ..... 75
4.4.3 Site Accessibility ..... 75
4.4.4 Existing Infrastructure ..... 76
4.4.5 General Site Characteristics ..... 78
4.5 Soil Sampling and Quality ..... 79
4.5.1 Soil Sampling and Field Activities ..... 79
4.5.2 Soil Laboratory Analysis, Interpretation and Discussions ..... 82
4.5.2.1 Physical and General Physicochemical Characteristics ..... 83
4.5.2.2 Exchangeable Cations ..... 87
4.5.2.3 Exchangeable Anions and Nutrient Indicators ..... 89
4.5.2.4 Heavy Metals and Trace Elements ..... 91
4.5.2.5 Organic Contaminants ..... 92
4.5.2.6 Soil Particle-Size Distribution and Textural Characteristics ..... 93
4.5.2.7 Microbiological Characteristics ..... 94
4.5.2.8 Spatial and Vertical Distribution of Soil Quality ..... 95
4.6 Surface Water Sampling and Analysis ..... 97
4.6.1 Surface Water Sampling and Field Activities ..... 97
4.6.2 Surface Water In-Situ Testing and Laboratory Analysis ..... 99
4.6.3 Surface Water Quality ..... 102
4.6.3.1 Comparison of In-Situ and Laboratory Measurements ..... 102
4.6.3.2 Surface Water Physicochemical Characteristics ..... 104
4.6.3.3 Chemical and Major-Ion Characteristics ..... 108
4.6.3.4 Heavy Metals ..... 112
4.6.3.5 Organic Parameters ..... 115
4.6.3.6 Microbiological Characteristics ..... 117
4.6.3.7 Spatial Interpretation of the Sampling Stations ..... 119
4.7 Site-Specific Micro-Climate ..... 121
4.7.1 Temperature and Relative Humidity ..... 121
4.7.2 Results of Air Quality Measurements ..... 125
4.7.2.1 Gaseous Pollutants and Volatile Organics ..... 125
4.7.2.2 Particulate Matter ..... 125
4.7.2.3 Result of Noise Level Measurement ..... 126
4.7.2.4 Air Quality Index (AQI) ..... 127
4.8 Terrestrial Ecology (Flora and Fauna) ..... 128
4.8.1 Vegetation Characteristics ..... 128

4.8.2 Habitat Description ..... 129
4.8.4 Faunal Composition ..... 131
4.8.5 Ecological Condition ..... 131
4.9 Socio-economic and Health Conditions of the Study Area ..... 131
4.9.1 Sampled Population/Socioeconomic Characteristics ..... 132
4.9.2 Respondent's Socio-Economics Characteristics ..... 132
4.9.2.1 Health Status ..... 135
4.9.2.3 Gender-Based Violence and Gender Equality Indicators ..... 137
4.9.2.4 Community/Institutional Utilities and Services Profile ..... 139
4.9.2.5 Traditional Practices and Cultural Heritage ..... 141
4.9.2.6 Community Awareness, Perceived Benefits, and Social Associations ..... 142
4.10 Health, Safety and Environmental (HSE) Baseline Conditions ..... 143
4.11 Summary of Baseline Environmental Conditions ..... 145

**CHAPTER FIVE: POTENTIAL AND ASSOCIATED IMPACTS ..... 147**
5.1 Introduction ..... 147
5.2 Impact Methodology Description ..... 149
5.2.1 Environmental and Social Indicators ..... 150
5.2.2 Impact Identification and Characterization Technique ..... 151
5.2.3 Determination of Impact Significance ..... 153
5.3 Impact Methodology Description ..... 154
5.3.1 Sources of Information ..... 154
5.3.2 Impact Screening ..... 155
5.3.3 Impact Evaluation ..... 155
5.3.4 Mitigation Hierarchy ..... 156
5.4 Impact Severity and Profiling ..... 156
5.4.1 Impact Magnitude ..... 156
5.4.2 Receptor Sensitivity ..... 157
5.4.3 Impact Significance ..... 157
5.5 Project Phases, Associated Activities and Potential Impacts ..... 158
5.5.1 Identified Impacts for the Pre-Construction Phase ..... 158
5.5.1.1 Site Selection ..... 158
5.5.1.2 Site Clearing and Preparation ..... 159
5.5.1.3 Mobilization of Personnel, Equipment and Materials ..... 160
5.5.2 Identified Impacts for the Construction Phase ..... 161
5.5.2.1 Potential Impact on Ambient Air Quality ..... 161
5.5.2.2 Potential Impact on Ambient Noise ..... 161
5.5.2.3 Potential Impact on Soil ..... 162
5.5.2.4 Potential Impact on Surface Water and Drainage ..... 162
5.5.2.5 Potential Impact on Groundwater ..... 162
5.5.2.6 Potential Impact on Flora and Fauna ..... 162
5.5.2.7 Potential Impact on Landscape and Visual Character ..... 163
5.5.2.8 Potential Impact on Employment and Local Economy (Positive Impact) ..... 163
5.5.2.9 Potential Impact on Community Health, Safety and Security ..... 163
5.5.2.10 Potential Impact on Occupational Health and Safety ..... 163
5.5.2.11 Potential Impact of Construction Waste ..... 164

5.5.3 Identified Impacts for the Operation and Maintenance Phase ..... 165
5.5.3.1 Improved Electricity Supply (Positive Impact) ..... 165
5.5.3.2 Reduction in Greenhouse Gas Emissions (Positive Impact) ..... 165
5.5.3.3 Institutional and Socio-economic Benefits (Positive Impact) ..... 165
5.5.3.4 Occupational Health and Safety ..... 166
5.5.3.5 Water Requirement for Panel Cleaning ..... 166
5.5.3.6 Waste Generation ..... 166
5.4.3.7 Visual Impact ..... 167
5.4.3.8 Community Health and Safety ..... 167
5.4.3.9 Electromagnetic Fields (EMF) ..... 167
5.5.4 Identified Impacts for the Decommissioning and Abandonment Phase ..... 168
5.5.4.1 Potential Impact on Air Quality and Noise ..... 168
5.5.4.2 Potential Impact on Soil ..... 168
5.5.4.3 Potential Impact from Waste Generation ..... 168
5.5.4.4 Occupational Health and Safety ..... 169
5.5.4.5 Positive Impact from Material Recovery ..... 169
5.5.5 Summary of Potential Environmental and Social Impacts ..... 169
5.6 Risk Assessment ..... 170
5.6.1 Introduction ..... 170
5.6.2 Risk Assessment Methodology ..... 171
5.6.3 Identified Project Risks ..... 171
5.6.4 Summary of Project Risks ..... 173
5.7 Residual and Cumulative Impacts ..... 173
5.7.1 Environmental Residual Impacts ..... 173
5.7.2 Social Residual Impacts ..... 174
5.7.3 Cumulative Impacts ..... 175

**CHAPTER SIX: MITIGATION MEASURES ..... 178**
6.1 Introduction ..... 178
6.2 Mitigation Objectives and Approach ..... 178
6.3 Mitigation and Enhancement Measures ..... 179
6.3.1 Mitigation Measures for the Pre-Construction Phase ..... 180
6.3.2 Mitigation Measures for the Construction Phase ..... 190
6.3.3 Mitigation Measures for Operations and Maintenance Phase ..... 197
6.3.4 Mitigation Measures for the Decommissioning Phase ..... 206
6.4 Enhancement Measures for Positive Impacts ..... 215

**CHAPTER SEVEN: ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN ..... 216**
7.1 Introduction ..... 216
7.2 Objectives of the ESMP ..... 216
7.3 Environmental and Social Management Measures ..... 217
7.4 Roles, Responsibilities and Accountabilities ..... 248
7.4.1 Roles, Responsibilities and Accountabilities During the Pre-Construction Phase ..... 248
7.4.2 Roles, Responsibilities and Accountabilities During the Construction Phase ..... 250
7.4.3 Roles, Responsibilities and Accountabilities During the Operation Phase 251

7.5 Additional Management Plans ..... 252
7.5.1 Stakeholder Engagement Plan (SEP) ..... 252
7.5.1.1 Grievance Redress Mechanism (GRM) ..... 253
7.5.2 Traffic Management Plan (TMP) ..... 253
7.5.3 Waste Management Plan (WMP) ..... 253
7.5.4 Occupational Health and Safety (OHS) Plan ..... 254
7.5.5 Local Employment Management Plan (LEMP) ..... 254
7.5.6 Erosion Control Management Plan ..... 254
7.5.7 Water Conservation Plan ..... 254
7.5.8 Emergency Preparedness and Response Plan (EPRP) ..... 255
7.5.9 REA Gender-Based Violence (GBV) Action Plan ..... 255
7.5.10 Livelihood Restoration Plan (LRP) ..... 255
7.5.11 Summary of Additional Management Plans ..... 255
7.6 Environmental Monitoring Programme ..... 256
7.7 Training, Awareness and Capacity Building ..... 260
7.8 Implementation Schedule and Reporting ..... 261
7.9 ESMP Costing ..... 261
7.10 Stakeholder Engagement ..... 261
7.10.1 Legal and Administrative Framework Guiding Stakeholder Engagement ..... 262
7.10.2 Objectives of Stakeholder Engagement ..... 262
7.10.3 Stakeholder Identification and Analysis ..... 263
7.10.4 Stakeholder Register ..... 263
7.10.5 Stakeholder Engagement Process ..... 263
7.10.6 Stakeholder Engagement Tools and Communication ..... 264
7.10.7 Principles for Effective Stakeholder Engagement ..... 264
7.10.8 Stakeholder Consultation Methods ..... 264
7.10.9 Summary of Previous Stakeholder Engagement Activities ..... 265

**CHAPTER EIGHT: REMEDIATION PLAN AFTER DECOMMISSIONING/CLOSURE . 267**
8.1 Introduction ..... 267
8.2 Consultation ..... 267
8.3 Decommissioning Activities ..... 267
8.3.1 Management of Decommissioning Activities ..... 268
8.3.2 Decommissioning Planning Requirements ..... 268
8.3.3 Evaluation of Decommissioning Options ..... 269
8.3.4 Risk Assessment and Safety ..... 269
8.3.5 Socio-Economic Considerations ..... 269
8.3.6 Waste Management ..... 269
8.3.7 Used Battery Management ..... 270
8.4 Abandonment Plan ..... 270
8.5 Roles, Responsibilities and Accountabilities for Decommissioning Phase ... 271

**CHAPTER NINE: SUMMARY AND CONCLUSION ..... 281**
9.1 Summary ..... 281
9.2 Conclusion ..... 281

**REFERENCES..... 284**

**APPENDIX I: Socio-Economics Questionaire Sample ..... 287**
**APPENDIX II: Chain of Custody Form..... 289**
**APPENDIX III: Laboratory Analysis Result .....2890**
**APPENDIX IV: Attendance Sheets ..... 294**
**APPENDIX V: Pictorial Evidence of Stakeholder Engagement..... 296**
**APPENDIX VI: Pictorial Evidence of Soil Sampling .....2977**
**APPENDIX VII: Pictorial Evidence of Ambient Air And Noise Level Sampling .... 298**
**APPENDIX VIII: Pictorial Evidence of Water Sampling ..... 299**
**APPENDIX IX: List of Sampling Equipements ..... 300**

# LIST OF FIGURES

Figure 1.1: Map of Nigeria Showing Benue State, and Otukpo LGA ..... 4
Figure 1.2: Institution Main Entrance ..... 5
Figure 1.3: Schematic presentation of the general methodology for the EIA/ESIA ..... 8
Figure 1.4: Federal Ministry of Environment EIA Flowchart ..... 9
Figure 2.1: Photovoltaic power potential of Nigeria ..... 29
Figure 2.2: Typical appearance of mono-crystalline silicon PV panels ..... 31
Figure 2.3: Typical Appearance of Polycrystalline Silicon PV panels ..... 31
Figure 2.4: Typical appearance of Thin-Film CdTe panels ..... 32
Figure 3.1: Simplified electrical configuration diagram ..... 37
Figure 3.2: Example of a Monofacial Si-poly photovoltaic module ..... 38
Figure 3.3: Example of string photovoltaic inverter ..... 39
Figure 3. 4: String Inverter Single Line Diagram ..... 40
Figure 3. 5: Example of Transformer ..... 40
Figure 3. 6: Example of a power station ..... 41
Figure 3.7: Power station Single line Diagram ..... 43
Figure 3.8: Typical Road Cross Section ..... 44
Figure 3.9: Elevation plans of the training Centre ..... 45
Figure 4.1: Monthly Average Temperature for 10-Years Period ..... 66
Figure 4.2: Monthly Average Relative Humidity for 10-Years Period ..... 66
Figure 4.3: Monthly average rainfall for 10-Years Period ..... 67
Figure 4.4: Prevailing Wind Directions in the Study Region ..... 68
Figure 4.5: Sunshine of the study area over the period of Twenty-five years ..... 69
Figure 4.6: Cloud Cover and Visibility Data for the study Region ..... 69
Figure 4.7: Geological and Hydrogeological Map of Benue State ..... 71
Figure 4.8: Air Quality/Noise Level Sampling Location Map for the Study ..... 73
Figure 4.9: Soil Sampling, Sampling Location Map for the Study ..... 74
Figure 4.10: Combined In-Situ Surface Water Results ..... 103
Figure 4.11: Combined Laboratory Physicochemical Results ..... 106
Figure 4.12: Combined Laboratory Chemical Results ..... 110
Figure 4.13: Combined Laboratory Heavy Metal Results ..... 113
Figure 4.14: Combined Laboratory Organics Result ..... 116
Figure 4.15: Combined Laboratory Microbiological Results ..... 118
Figure 4.16: Relative Humidity and Temperature Measured in the Project Area ..... 122
Figure 4.17: Particulate matter concentrations within the project area ..... 125
Figure 4.18: Ambient noise levels within the project area ..... 127
Figure 5.1: Overview of the Impact Assessment Process ..... 148

# LIST OF TABLES

Table 1.1: Summary of ESIA Methodology ..... 12
Table 1.2: National Policies, Guidelines and Regulations Applicable to the Project ..... 13
Table 1.3: Relevant Benue State Institutions ..... 14
Table 1.4: International Conventions, Agreements and Best Practice Standards Applicable to the Project ..... 15
Table 1.5: Relevant Federal Government Legislation Applicable to the Project ..... 16
Table 1.6: Structure of the ESIA Report ..... 18
Table 2.1: Basis for Selection of the Proposed Project Site ..... 28
Table 2.2: Comparison of Power Generation Alternatives ..... 28
Table 2.3: Comparison between CSP and PV Solar Technology ..... 30
Table 2.4: Comparison of PV Panel Technologies ..... 31
Table 2.5: Comparison of Battery Technologies ..... 32
Table 2.6: Comparison of Project Development Options ..... 33
Table 3.1: General Description of the Proposed Project ..... 35
Table 3.2: Main characteristics of the fixed mounting structure ..... 36
Table 3.3: Key Project Characteristics ..... 36
Table 3.4: Photovoltaic module characteristics ..... 38
Table 3.5: Inverter characteristics ..... 39
Table 3.6: Transformer characteristics ..... 41
Table 3.7: Power station characteristics ..... 42
Table 3.8: Estimated Manpower Requirement ..... 49
Table 3.9: Principal Engineering Standards Applicable to the Project ..... 51
Table 3.10: Summary of Anticipated Waste Streams and Management Measures ..... 55
Table 3.11: Tentative Project Implementation Schedule ..... 56
Table 4.1: Field Equipment, Instruments and Materials Used During the Baseline Environmental Survey ..... 63
Table 4.2: Project Site Boundary Coordinates ..... 72
Table 4.3: Soil Sampling Locations, Coordinates and Sample Details ..... 80
Table 4.4: Soil Laboratory Analytical Results ..... 84
Table 4.5: Summary of Soil Physical and General Physicochemical Characteristics ..... 87
Table 4.6: Summary of Exchangeable Cation Characteristics ..... 88
Table 4.7: Summary of Exchangeable Anion Characteristics ..... 90
Table 4.8: Summary of Heavy-Metal Characteristics ..... 92
Table 4.9: Summary of Organic Contaminants ..... 93
Table 4.10: Summary of Soil Textural Characteristics ..... 94
Table 4.11: Summary of Soil Microbiological Characteristics ..... 95
Table 4.12: Overall Soil Quality Assessment ..... 96
Table 4.13: Surface Water Sampling Locations and Sample Details ..... 99
Table 4.14: Surface Water In-Situ Testing ..... 99
Table 4.15: Laboratory Analytical Results for Surface Water Quality ..... 100
Table 4.16: Summary Comparison of In-Situ and Laboratory Measurements ..... 103
Table 4.17: Summary of Surface-Water Physicochemical Characteristics ..... 107
Table 4.18: Summary of Surface-Water Chemical Characteristics ..... 111
Table 4.19: Summary of Surface-Water Heavy Metals ..... 114
Table 4.20: Summary of Surface-Water Organic Parameters ..... 117

Table 4.21: Summary of Surface-Water Microbiological Characteristics ..... 118
Table 4.22: Summary of Overall Surface-Water Quality Assessment ..... 119
Table 4.23: Detection Limits for Air Quality Instruments ..... 121
Table 4.24: Ambient Air Quality Level Around the Project Area ..... 123
Table 4.25: Ambient Noise Levels around the Project Area ..... 126
Table 4.26a: Air Quality Rating Table ..... 127
Table 4.26b: Air Quality Index of the Project Area ..... 127
Table 4.27: Major Habitat Types within the Project Area ..... 129
Table 4.28: Dominant Flora Recorded During the Field Survey ..... 130
Table 4.29: Fauna Observed During the Field Survey ..... 131
Table 4.30: Summary of Health, Safety and Environmental (HSE) Baseline Conditions ..... 144
Table 4.31: Summary of Baseline Environmental Conditions ..... 146
Table 5.1: Examples of Project Activities, Environmental Aspects and Potential Impacts ..... 149
Table 5.2: Environmental and Social Receptors and Impact Indicators ..... 150
Table 5.3: Relationship between Project Activities, Environmental Aspects and Potential Impacts ..... 152
Table 5.4: Summary of Project Activities Considered in the Impact Assessment ..... 155
Table 5.5: Impact Magnitude Criteria ..... 156
Table 5.6: Receptor Sensitivity Criteria ..... 157
Table 5.7: Impact Significance Matrix ..... 157
Table 5.8: Impact Significance Classification ..... 158
Table 5.9: Summary of Potential Impacts during the Pre-Construction Phase ..... 160
Table 5.10: Summary of Potential Impacts during the Construction Phase ..... 164
Table 5.11: Summary of Potential Impacts during the Operation and Maintenance Phase ..... 167
Table 5.12: Summary of Potential Impacts during the Decommissioning Phase ..... 169
Table 5.13: Likelihood Classification ..... 171
Table 5.14: Consequence Classification ..... 171
Table 5.15: Risk Classification Matrix ..... 171
Table 5.16: Summary of Principal Project Risks ..... 173
Table 5.17: Summary of Residual and Cumulative Environmental and Social Impacts ..... 176
Table 6.1: Mitigation Measures for the Pre-Construction Phase ..... 180
Table 6.2: Mitigation Measures for the Construction Phase ..... 190
Table 6.3: Mitigation Measures for Operations and Maintenance Phase ..... 197
Table 6.4: Mitigation Measures for the Decommissioning Phase ..... 206
Table 6.5: Enhancement Measures for Positive Impacts ..... 215
Table 7.1a: Environmental Management Measures for the Pre-Construction Phase of the Proposed Project ..... 219
Table 7.1b: Social Management Measures for the Pre-Construction Phase of the Proposed Project ..... 223
Table 7.2a: Environmental Management Measures for the Construction Phase of the Proposed Project ..... 227
Table 7.2b: Social Management Measures for the Construction Phase of the Proposed Project ..... 232

Table 7.3a: Environmental Management Measures for the Operational Phase of the Proposed Project ..... 238
Table 7.3b: Social Management Measures for the Operational Phase of the Proposed Project ..... 243
Table 7.4: Roles and Responsibilities during the Pre-Construction Phase ..... 248
Table 7.5: Roles and Responsibilities during the Construction Phase ..... 250
Table 7.6: Roles and Responsibilities during Operation Phase ..... 251
Table 7.7: Summary of Additional Management Plans ..... 256
Table 7.8: Environmental and Social Monitoring Programme ..... 257
Table 7.9: Institutional Capacity Strengthening Plan ..... 260
Table 7.10: Summary of ESMP Cost Estimate ..... 261
Table 7.11: Summary of Previous Stakeholder Engagement Activities ..... 266
Table 8.1: Roles, Responsibilities and Accountabilities for Decommissioning Phase.. 271
Table 8.2: Environmental and Social Management Measures for Decommissioning Phase ..... 273

# LIST OF PLATES

Plate 3.1: Proposed Project Site ..... 34
Plate 4.1: Reconnaissance Visit and Site Verification ..... 64
Plate 4.2: Field equipment and instruments used during the baseline environmental investigation at the proposed project site with Federal and State Ministry of Environments officers ..... 64
Plate 4.3: General view of the proposed project site showing secondary vegetation. ..... 75
Plate 4.4: Internal access road to the proposed Solar PV project site. ..... 76
Plate 4.5: External access road into the institution. ..... 76
Plate 4.6: Three-cell reinforced concrete culvert under construction along the project access road. ..... 77
Plate 4.7: Ongoing Administrative Building opposite the Proposed Site. ..... 77
Plate 4.8: Ongoing Lecture Theatre adjacent the Proposed Site. ..... 78
Plate 4.9: Soil Sampling Activities ..... 82
Plate 4.10: Surface Water Sampling and In-Situ Testing Activities ..... 98
Plate 4.11: Air Quality Sampling Activities ..... 124
Plate 4.12: Nosie Level Sampling Activities ..... 124
Plate 4.13: Observed Flora within the Proposed Project Site ..... 130

# LIST OF ACRONYMS, UNITS AND ABBREVIATIONS

| Abbreviation/Acronym | Meaning |
|---|---|
| AC | Alternating Current |
| AEPB | Abuja Environmental Protection Board |
| AfDB | African Development Bank |
| ALARP | As Low As Reasonably Practicable |
| APHA | American Public Health Association |
| APPI | Area of Potential Project Influence |
| ASTM | American Society for Testing and Materials |
| AQ | Air Quality |
| BESS | Battery Energy Storage System |
| BOD | Biochemical Oxygen Demand |
| CBO | Community-Based Organization |
| CFU | Colony Forming Unit |
| CLO | Community Liaison Officer |
| CO | Carbon Monoxide |
| $CO_2$ | Carbon Dioxide |
| COD | Chemical Oxygen Demand |
| CR | Critically Endangered |
| dB(A) | A-weighted Decibel |
| DC | Direct Current |
| DO | Dissolved Oxygen |
| EEP | Energizing Education Programme |
| EHS | Environment, Health and Safety |
| EIA | Environmental Impact Assessment |
| EMP | Environmental Management Plan |
| EMS | Environmental Management System |
| EPC | Engineering, Procurement and Construction |
| ESIA | Environmental and Social Impact Assessment |
| ESMP | Environmental and Social Management Plan |
| FMEnv | Federal Ministry of Environment |
| FUHSO | Federal University of Health Sciences Otukpo |
| GBV | Gender-Based Violence |
| GIS | Geographic Information System |
| GPS | Global Positioning System |
| GRM | Grievance Redress Mechanism |
| GRC | Grievance Redress Committee |
| GW | Groundwater |
| HSE | Health, Safety and Environment |
| $H_2S$ | Hydrogen Sulphide |
| IFC | International Finance Corporation |
| ISO | International Organization for Standardization |
| ISS | Integrated Safeguards System |
| ITCZ | Inter-Tropical Convergence Zone |
| IUCN | International Union for Conservation of Nature |
| KII | Key Informant Interview |

| Abbreviation/Acronym | Meaning |
|---|---|
| km | Kilometre |
| kV | Kilovolt |
| kVA | Kilovolt-Ampere |
| kWh | Kilowatt-hour |
| LTI | Lost Time Injury |
| m | Metre |
| $m^2$ | Square Metre |
| $m^3$ | Cubic Metre |
| mg/L | Milligram per Litre |
| mm | Millimetre |
| MW | Megawatt |
| MWh | Megawatt-hour |
| N | Nitrogen |
| NAAQS | Nigerian Ambient Air Quality Standards |
| NDC | Nationally Determined Contribution |
| NEP | Nigeria Electrification Programme |
| NESREA | National Environmental Standards and Regulations Enforcement Agency |
| NGO | Non-Governmental Organization |
| $NH_3$ | Ammonia |
| $NO_2$ | Nitrogen Dioxide |
| NOUN | National Open University of Nigeria |
| NTU | Nephelometric Turbidity Unit |
| OHS | Occupational Health and Safety |
| PPE | Personal Protective Equipment |
| PV | Photovoltaic |
| QA/QC | Quality Assurance/Quality Control |
| REA | Rural Electrification Agency |
| REMP | Renewable Energy Master Plan |
| SEA | Sexual Exploitation and Abuse |
| SEP | Stakeholder Engagement Plan |
| SH | Sexual Harassment |
| $SO_2$ | Sulphur Dioxide |
| SW | Surface Water |
| TDS | Total Dissolved Solids |
| THB | Total Heterotrophic Bacteria |
| TOR | Terms of Reference |
| TSP | Total Suspended Particulates |
| TSS | Total Suspended Solids |
| UPS | Uninterruptible Power Supply |
| WHO | World Health Organization |
| WMP | Waste Management Plan |

# EXECUTIVE SUMMARY

## ES 1 INTRODUCTION

The Federal Government of Nigeria, through the Rural Electrification Agency (REA), is implementing the Nigeria Electrification Project Phase II (NEP II) – Desert to Power (DTP II) Programme to improve access to reliable, sustainable and clean electricity in selected federal institutions. The programme supports renewable energy deployment, strengthens energy security, reduces dependence on fossil fuels and promotes sustainable socioeconomic development through solar photovoltaic (PV) technology.

As part of the programme, the Federal University of Health Sciences, Otukpo (FUHSO), Benue State, has been selected as one of the beneficiary institutions for the development of a 2 MW Solar Photovoltaic (PV) Hybrid Power Project and associated infrastructure. The proposed project will provide a dedicated renewable energy source to improve electricity reliability within the University and support teaching, learning, research, healthcare services and administrative activities, while significantly reducing dependence on diesel-powered electricity generation and associated greenhouse gas emissions. In accordance with the Environmental Impact Assessment (EIA) Act CAP E12, Laws of the Federation of Nigeria (LFN) 2004, an Environmental and Social Impact Assessment (ESIA) was undertaken to identify potential environmental and social impacts throughout the project life cycle and to develop appropriate mitigation and management measures. The ESIA also provides the basis for an Environmental and Social Management Plan (ESMP) to support environmentally sustainable and socially responsible project implementation.

The ESIA study involved desktop reviews, field investigations, laboratory analyses, stakeholder consultations and environmental baseline surveys covering the physical, biological and socio-economic characteristics of the proposed project area. The assessment indicates that the proposed project is environmentally feasible and socially acceptable, provided the recommended mitigation measures, monitoring requirements and management plans are effectively implemented throughout the project life cycle.

### *Legal and Administrative Framework*

The Environmental and Social Impact Assessment was undertaken in compliance with applicable Federal Government legislation, environmental regulations, international environmental safeguards and relevant institutional policies governing environmental protection, occupational health and safety, renewable energy development and sustainable infrastructure projects.

The principal national legal and regulatory instruments applicable to the proposed project include:

- ✓ **Environmental Impact Assessment (EIA) Act CAP E12 LFN 2004** – Provides the statutory basis for environmental assessment of projects likely to have significant environmental impacts and mandates approval from the Federal Ministry of Environment (FMEnv).
- ✓ **Land Use Act CAP L5 LFN 2004** – Governs land acquisition, land tenure, and land rights in Nigeria.

- ✓ **National Environmental Standards and Regulations Enforcement Agency (NESREA) Act, 2007 and Sectoral Regulations** – Establishes NESREA as the environmental regulatory authority responsible for enforcing environmental standards and compliance.
- ✓ **Electricity Act, 2023** – The principal legislation governing the generation, transmission, distribution, and supply of electricity in Nigeria. It promotes a competitive electricity market, encourages private sector participation, supports renewable energy development, and requires electricity projects to comply with environmental and regulatory requirements, including obtaining relevant permits and implementing mitigation measures.
- ✓ **Climate Change Act, 2021** – Provides the legal framework for achieving low greenhouse gas emissions and climate-resilient development in Nigeria.
- ✓ **Employees' Compensation Act, 2010** – Provides the legal framework for compensation in cases of workplace injury, disease, disability, or death.
- ✓ **Electric Power Sector Reform Act, 2005** – Established the framework for reforming Nigeria's electricity industry and restructuring the power sector.
- ✓ **Public Health Act CAP 103 LFN 1995** – Provides measures for the protection of public health.
- ✓ **Natural Resources Conservation Act CAP 349 LFN 1990** – Provides for the conservation and sustainable management of natural resources and biodiversity.
- ✓ **Penal Code Act CAP 53 LFN 2008** – Provides legal provisions applicable to offences and enforcement.
- ✓ **National Policy on the Environment (2016)** – Establishes Nigeria's environmental management principles and sustainable development objectives.
- ✓ **National Energy Policy (2013)** – Promotes energy security, diversification of energy sources, and increased integration of renewable energy.
- ✓ **Nigeria's Nationally Determined Contributions (NDCs) under the Paris Agreement (Updated 2021)** – Commits Nigeria to reducing greenhouse gas emissions by 20% unconditionally and 47% conditionally by 2030 relative to the business-as-usual scenario, while promoting renewable energy and climate resilience.
- ✓ **Roadmap for Power Sector Reform (2010)** – Provides strategic direction for reforms within Nigeria's electricity sector.
- ✓ **EIA Sectoral Guidelines for the Power Sector (2013)** – Provides sector-specific guidance for environmental assessment of power generation, transmission, distribution, and renewable energy projects.
- ✓ **FMEnv EIA Procedural Guidelines (2017, Updated 2021)** – Defines procedures for ESIA preparation, review, public disclosure, and approval in Nigeria.
- ✓ **Guidelines on Environmental Audit (2010)** – Provides the framework for environmental compliance monitoring and auditing.
- ✓ **FMEnv Abandonment and Decommissioning Guidelines (1995, Updated Framework 2017)** – Provides guidance on facility closure, decommissioning, and site restoration.

- ✓ **Otukpo Local Government Area administrative requirements** – Provide local administrative requirements applicable to development projects within the project area.
- ✓ **African Development Bank (AfDB) Integrated Safeguards System (ISS, 2023)** – Provides a comprehensive framework for environmental and social risk management through ten Operational Safeguards (OS1–OS10), covering environmental assessment, involuntary resettlement, biodiversity, pollution prevention, labour, stakeholder engagement, and other sustainability issues. This ESIA has been prepared in accordance with the applicable requirements of the 2023 ISS.
- ✓ **IFC Performance Standards on Environmental and Social Sustainability (2012)** – International benchmark for managing environmental and social risks in development projects.
- ✓ **United Nations Framework Convention on Climate Change (UNFCCC, 1992)** – International treaty aimed at stabilizing greenhouse gas concentrations and addressing climate change.
- ✓ **Paris Agreement (2015)** – Global agreement under the UNFCCC to limit global temperature rise and strengthen climate resilience.
- ✓ **International Labour Organization (ILO) Conventions** – International labour standards covering occupational safety and health, workers' rights, equality, and decent work.
- ✓ **International Union for Conservation of Nature (IUCN) Guidelines (1996)** – International guidelines supporting biodiversity conservation and sustainable natural resource management.

In addition to the national legal requirements, the ESIA has been structured to align project planning and implementation with applicable lender safeguard expectations, including risk identification, mitigation hierarchy, stakeholder engagement, grievance management, labour and working conditions, pollution prevention, biodiversity considerations, community health and safety, and monitoring commitments.

## ES 2 PROJECT JUSTIFICATION

### *Need for the Project and Benefits*

The proposed project is intended to provide reliable, affordable and environmentally sustainable electricity to the Federal University of Health Sciences, Otukpo through the deployment of a dedicated 2 MW Solar Photovoltaic Hybrid Power System. Reliable electricity is fundamental to the University's academic, administrative, healthcare, research and community service functions, particularly given its specialized mandate in medical and health sciences education.

The project is expected to:

- provide reliable and uninterrupted electricity supply to the University;
- improve teaching, learning, research and innovation;
- strengthen healthcare delivery within the University's medical facilities;
- reduce dependence on diesel generators and associated operating costs;
- reduce greenhouse gas emissions and air pollution;

- contribute to Nigeria's renewable energy and climate change commitments;
- improve campus safety through reliable lighting and essential services;
- stimulate employment and local economic activities during project implementation;
- improve institutional productivity and operational efficiency;
- enhance energy security and long-term sustainability of University operations.

**Project Value**

The proposed project forms part of the Rural Electrification Agency's Nigeria Electrification Project (NEP II) – Desert to Power Programme funded by the Federal Government of Nigeria in collaboration with its development partners. The project comprises the engineering, procurement, construction, installation, testing, commissioning and subsequent operation and maintenance of a 2 MW Solar Photovoltaic Hybrid Power System and Associated Infrastructure within the Federal University of Health Sciences, Otukpo. The Engineering, Procurement and Construction (EPC) Contractor will be competitively selected by the Rural Electrification Agency in accordance with applicable procurement procedures, while long-term operation and maintenance will be undertaken by qualified personnel to ensure sustainability throughout the project lifespan.

**Project Sustainability**

***Technical Sustainability***

The project will be implemented using proven solar photovoltaic technology and internationally accepted engineering standards. Construction, installation, commissioning and operation will be undertaken by qualified and experienced personnel under the supervision of the Rural Electrification Agency and relevant University authorities. Preventive maintenance programmes, routine inspections and equipment replacement schedules will ensure reliable long-term performance.

***Economic Sustainability***

The project will significantly reduce the University's expenditure on diesel fuel, generator maintenance and grid electricity consumption where applicable. Reduced operating costs will enable greater investment in teaching, research, healthcare services and infrastructure development while ensuring long-term financial sustainability.

***Environmental Sustainability***

The use of solar photovoltaic technology will substantially reduce greenhouse gas emissions, atmospheric pollutants and fossil fuel consumption associated with conventional electricity generation. The implementation of the Environmental and Social Management Plan (ESMP), environmental monitoring programme and recommended mitigation measures will further ensure that project activities remain environmentally sustainable throughout their life cycle.

***Social Sustainability***

The ESIA incorporated stakeholder consultations with relevant government agencies, University representatives and host community stakeholders. The concerns and recommendations raised during consultations have been incorporated into project planning. Continuous stakeholder engagement, implementation of the Stakeholder Engagement Plan (SEP), Grievance Redress Mechanism (GRM), Occupational Health and Safety Plan and community liaison activities will support the project's long-term social sustainability.

***Project Alternatives***

Several alternatives were evaluated during project planning, including alternative energy technologies, project layout options, photovoltaic module technologies, inverter configurations, battery storage systems and the "No Project" alternative. The selected option comprising a 2 MW Solar Photovoltaic Hybrid System was considered the most technically feasible, environmentally acceptable and economically viable alternative capable of meeting the University's present and future electricity demand while minimizing adverse environmental impacts.

***No Project Option***

The "No Project" alternative would result in continued dependence on unreliable electricity supply and diesel-powered generators, leading to increased operating costs, higher greenhouse gas emissions, reduced research productivity and constraints on healthcare delivery, academic activities and institutional development. The option would also undermine the objectives of the Nigeria Electrification Project and the Federal Government's commitment to renewable energy development and climate change mitigation. Accordingly, the "No Project" option was considered undesirable and rejected in favour of implementing the proposed 2 MW Solar Photovoltaic Hybrid Power Project.

## ES 3 PROJECT DESCRIPTION

**Project Overview**

The proposed project involves the development of a 2 MW Solar Photovoltaic (PV) Hybrid Power Project and associated infrastructure within the Permanent Site of the Federal University of Health Sciences, Otukpo (FUHSO), Benue State, Nigeria. It forms part of the Nigeria Electrification Project Phase II (NEP II) – Desert to Power (DTP II) Programme implemented by the Rural Electrification Agency (REA) to improve electricity access in selected federal tertiary institutions through renewable energy technologies. The facility will provide reliable and sustainable electricity for the University's academic, administrative, healthcare and research activities, reduce dependence on fossil-fuel-powered generation and support national renewable energy and climate change objectives. The development will occupy approximately 10 hectares (100,235.02 m²) within the University's Permanent Site in Otobi, Otukpo Local Government Area, Benue State, approximately 19 km from the University's operational campus. The site is presently characterized by undeveloped land comprising secondary vegetation, cultivated farmland and scattered institutional infrastructure under construction.

**Project Objectives**

The principal objective of the proposed project is to provide a sustainable and reliable electricity supply capable of supporting the present and future energy requirements of the Federal University of Health Sciences, Otukpo.

The specific objectives include:

- Provision of reliable and uninterrupted electricity supply for academic, research and healthcare activities.
- Reduction in dependence on diesel-powered generators and associated operational costs.
- Promotion of renewable energy utilization and energy efficiency.
- Reduction of greenhouse gas emissions and atmospheric pollution.
- Improvement of institutional productivity, healthcare delivery and learning environment.
- Enhancement of long-term energy security and infrastructure resilience.

**Project Location**
The proposed project is located within the Permanent Site of the Federal University of Health Sciences, Otukpo (FUHSO), Benue State, Nigeria. The Permanent Campus is situated along the Otukpo–Igumale Road within the Otobi axis of Otukpo Local Government Area and occupies land legally owned by the University. The project site lies approximately 19 km from the University's currently operational campus and is accessed through the Otukpo–Igumale Road, which is presently undergoing reconstruction by the Federal Government. The improved road network is expected to significantly enhance accessibility during both construction and operational phases. The proposed project footprint occupies approximately 100,235.02 m² (10 hectares) of relatively level terrain suitable for solar photovoltaic development.

**Existing Site Conditions**
At the time of the ESIA, the Permanent Campus was still under development. Existing infrastructure consisted primarily of institutional buildings at various stages of construction, including the Administrative Building, College of Medicine, College of Science, student hostels, staff quarters and associated civil infrastructure. The proposed project site itself remained largely undeveloped and was occupied predominantly by secondary Guinea Savannah vegetation comprising grasses, shrubs, scattered trees and cultivated crops. No residential settlements, commercial developments or permanent human habitation were observed within the proposed project footprint. The site is characterized by gently undulating topography with well-drained lateritic soils suitable for civil construction. No evidence of active erosion, flooding or unstable ground conditions was observed within the proposed development area.

**Major Project Components**
The principal components of the proposed development include:

- Approximately 2 MW Solar Photovoltaic (PV) Array.
- PV mounting structures and foundations.
- Hybrid inverter systems.
- Battery Energy Storage System (BESS).
- Power conditioning equipment.
- Transformers and switchgear.
- Distribution and control panels.
- Underground and overhead electrical cabling.
- Internal access roads and hardstand areas.
- Security fencing and controlled access gates.
- Drainage infrastructure.
- Operation and maintenance facilities.
- Security and lighting systems.
- Earthing and lightning protection systems.
- Supervisory Control and Data Acquisition (SCADA) and remote monitoring systems.

**Project Activities**
Project implementation will comprise pre-construction, construction, operation and maintenance, and decommissioning phases. These phases provide the framework for identifying project activities, assessing potential environmental and social impacts, and assigning mitigation and monitoring responsibilities throughout the project life cycle.

**(a) Pre-Construction Phase**

This phase will include:

- Detailed engineering design.
- Land survey and setting out.
- Site preparation.
- Contractor mobilization.
- Delivery of construction equipment and materials.
- Environmental and social management planning.
- Health, Safety, Security and Environmental (HSSE) mobilization.
- Stakeholder engagement.

**(b) Construction Phase**

Major construction activities will include:

- Site clearing and vegetation removal within the project footprint.
- Earthworks and grading.
- Foundation excavation.
- Installation of mounting structures.
- Installation of solar PV modules.
- Battery storage installation.
- Installation of transformers, switchgear and electrical equipment.
- Construction of internal access roads and drainage facilities.
- Cable trenching and electrical interconnections.
- Testing and commissioning.

Construction activities are expected to generate temporary environmental impacts including dust emissions, noise generation, vegetation disturbance, construction waste generation and increased vehicle movements. These impacts are considered temporary and manageable through implementation of the Environmental and Social Management Plan (ESMP).

**(c) Operational Phase**

Following commissioning, the solar PV facility will operate continuously to supply electricity to the University. Operational activities will include:

- Routine equipment inspection.
- Preventive maintenance.
- Cleaning of photovoltaic panels.
- Battery monitoring and maintenance.
- Electrical system testing.
- Vegetation management.
- Environmental monitoring.
- Occupational health and safety management.
- Security surveillance.

Operational environmental impacts are expected to be minimal and largely associated with routine maintenance activities.

**(d) Maintenance Phase**

Routine maintenance activities will include:

- Replacement of defective photovoltaic modules.
- Inverter servicing.
- Battery replacement when required.
- Inspection of electrical connections.
- Drainage maintenance.
- Vegetation control.

- Inspection of fencing and security facilities.
- Environmental monitoring.

Maintenance activities will be undertaken periodically throughout the operational life of the project.

**(e) Decommissioning Phase**

At the end of the project's operational life, decommissioning activities will involve:

- Shutdown of electrical systems.
- Removal of photovoltaic modules.
- Removal of batteries and associated electrical equipment.
- Dismantling of mounting structures.
- Recovery and recycling of reusable materials.
- Disposal of non-recyclable wastes through licensed waste contractors.
- Restoration and stabilization of disturbed land.

A detailed Decommissioning and Site Restoration Plan will be implemented to ensure that environmental impacts associated with project closure are minimized and that the site is restored to an environmentally stable condition.

**Expected Project Benefits**

The proposed project is expected to deliver significant environmental, social and economic benefits, including:

- Reliable electricity supply for the University.
- Improved teaching, learning and research.
- Enhanced healthcare service delivery.
- Reduced dependence on fossil fuels.
- Reduction in greenhouse gas emissions.
- Improved energy efficiency.
- Employment opportunities during construction.
- Capacity development through technology transfer.
- Improved institutional productivity.
- Contribution to Nigeria's renewable energy targets and sustainable development objectives.

**Project Implementation Schedule**

The project will be implemented in accordance with the approved Engineering, Procurement and Construction (EPC) programme developed by the Rural Electrification Agency and the appointed contractor. The implementation schedule will comprise detailed engineering, procurement, construction, commissioning, operation, maintenance and eventual decommissioning phases, with environmental and social management activities integrated throughout the project life cycle.

## ES 4 DESCRIPTION OF THE EXISTING ENVIRONMENT

A comprehensive baseline environmental study was undertaken to establish the prevailing physical, biological and environmental conditions of the proposed project area prior to project implementation. The study comprised desktop reviews, reconnaissance surveys, field measurements, laboratory analyses and stakeholder interactions, and provides the environmental baseline against which potential project impacts have been assessed. The baseline investigations covered climate and meteorology, geology and hydrogeology, topography, soils, surface water quality, ambient air quality, ambient noise, terrestrial ecology,

existing land use, drainage characteristics, infrastructure and Health, Safety, Security and Environmental (HSSE) conditions. Environmental samples were collected using standardized procedures and analysed at an accredited environmental laboratory in accordance with applicable national and international analytical standards.

**Climate and Meteorology**

The proposed project area lies within the Southern Guinea Savannah ecological zone of Nigeria and experiences a tropical wet-and-dry (Aw) climate characterized by distinct rainy and dry seasons. The rainy season generally extends from April to October, while the dry season occurs between November and March, influenced by the seasonal movement of the Inter-Tropical Discontinuity (ITD). Meteorological conditions were established using climatic data obtained from the Nigerian Meteorological Agency (NiMet). The region experiences relatively high temperatures throughout the year, moderate to high relative humidity during the rainy season, adequate annual rainfall, light to moderate prevailing winds and high sunshine duration, all of which are favourable for solar photovoltaic electricity generation.

**Geology and Hydrogeology**

The proposed project area is situated within the Lower Benue Trough, part of the larger Benue Trough sedimentary basin of Nigeria. The geology is dominated by Cretaceous sedimentary formations comprising sandstones, shales, siltstones and mudstones that have undergone extensive tropical weathering to produce lateritic residual soils. Hydrogeologically, groundwater occurrence within the area is associated with weathered and fractured sedimentary formations. Although two boreholes had previously been constructed within the University's Permanent Campus, neither was operational during the field investigation because they depended on generator-powered pumping systems. Consequently, groundwater sampling was not undertaken as part of the baseline study.

The geological conditions are considered favourable for the proposed Solar PV development, with no evidence of major geological hazards, unstable landforms or significant engineering constraints within the project footprint.

**Topography, Soils and Drainage**

The proposed project occupies approximately 10 hectares (100,235.02 m²) of gently undulating terrain within the Permanent Site of the Federal University of Health Sciences, Otukpo. The site is characterized by relatively level topography and well-drained lateritic soils suitable for the construction of solar photovoltaic infrastructure. Baseline soil investigations involved the collection of topsoil (0–15 cm) and subsoil (15–30 cm) samples from representative sampling locations distributed across the project area, including control samples collected outside the project influence area. Laboratory analyses indicated that the soils are generally slightly acidic to near neutral, non-saline, moderately conductive, and exhibit natural variations in nutrient concentrations associated with vegetation and agricultural activities. Heavy metal concentrations were substantially below applicable guideline values, while petroleum hydrocarbons (BTEX) and oil and grease were not detected. Overall, the soil quality is considered suitable for the proposed development and no evidence of widespread contamination was identified. The project area is naturally well drained. Surface runoff is conveyed through an existing reinforced concrete triple-cell culvert located along the access road into a natural drainage channel situated behind the proposed project site. While localized waterlogging was observed within portions of the downstream drainage corridor during the

field survey, the proposed development area occupies relatively elevated ground and remained dry throughout the investigation.

**Surface Water Quality**

No surface water body exists within the proposed project footprint or the University's Permanent Campus. Consequently, representative baseline surface water quality was established using the Aloma River in Akwete-Akpa Community, approximately 3.2 km from the proposed project site. Water samples were collected at upstream, midstream and downstream locations for in-situ measurements and laboratory analyses. Because the Aloma River is outside the immediate project footprint, the results should be interpreted as representative of the wider drainage environment rather than as direct evidence of existing water quality within the project site. The baseline results showed generally acceptable physicochemical conditions, including near-neutral pH, low salinity, low dissolved solids and relatively low organic pollution. Elevated concentrations of nitrate, nitrite, chromium, copper, iron and microbiological indicators were recorded at some sampling locations, suggesting existing influences from surrounding agricultural activities and natural environmental processes rather than the proposed project. No petroleum hydrocarbons (BTEX), oil or grease contamination was detected. The analytical results provide baseline conditions against which future project-related changes in surface water quality can be evaluated where hydrological connectivity is relevant.

**Ambient Air Quality and Noise Environment**

Ambient air quality and environmental noise monitoring were conducted at representative locations within the proposed project area using calibrated field instruments. The measured concentrations of gaseous pollutants and particulate matter indicated generally good ambient air quality with no evidence of significant industrial or commercial pollution sources within the project area. The observed air quality reflects the predominantly rural character of the site, with occasional influences from vehicular traffic along the access road and ongoing construction activities within the Permanent Campus. Similarly, ambient noise levels were generally low and remained within applicable Federal Ministry of Environment guideline values for institutional environments. Existing noise sources consisted mainly of construction equipment operating within portions of the Permanent Campus, occasional vehicular movement and natural environmental sounds. Construction of the proposed Solar PV project is expected to generate temporary increases in noise levels; however, these impacts are considered localized and manageable through the implementation of appropriate mitigation measures.

**Terrestrial Ecology**

The terrestrial ecology of the proposed project area is characteristic of a secondary Guinea Savannah ecosystem that has experienced previous anthropogenic disturbance associated with farming and ongoing institutional development. Vegetation within the project footprint comprises a mixture of grasses, shrubs, scattered trees and cultivated crops. Common plant species recorded during the field survey included oil palm (*Elaeis guineensis*), teak (*Tectona grandis*), cassava (*Manihot esculenta*), yam (*Dioscorea* spp.), banana (*Musa paradisiaca*) and elephant grass (*Pennisetum purpureum*), together with other secondary vegetation species typical of the region. No mammals or reptiles were observed during the field investigation. However, the presence of common bird species and insects was confirmed through direct observation and characteristic calls from the surrounding vegetation. No endangered species, critical habitats, protected areas or ecologically sensitive features were identified within the proposed project footprint.

**Existing Land Use and Infrastructure**

The proposed project site is located within the Permanent Campus of the Federal University of Health Sciences, Otukpo, which is currently under development. Existing infrastructure within the campus includes the Administrative Building, Staff Quarters, Male Hostel, College of Medicine and College of Science buildings, all of which were at different stages of construction during the baseline survey. The proposed project area itself is largely undeveloped and presently supports secondary vegetation and small cultivated plots. No residential settlements, commercial developments or permanent human habitation occur within the project footprint. Access to the project site is provided through the Otukpo–Igumale Road, which is currently undergoing reconstruction by the Federal Government and includes new drainage infrastructure designed to improve year-round accessibility.

**Health, Safety, Security and Environmental (HSSE) Baseline**

The baseline HSSE assessment indicated that the proposed project area presents generally low environmental and occupational health risks under existing conditions. Nevertheless, the wider project region has experienced security challenges associated with insurgency and banditry, which have reportedly affected ongoing construction activities within the University's Permanent Campus. Consequently, all ESIA field investigations were conducted under enhanced security arrangements, with military and police personnel accompanying the field team throughout the site reconnaissance, environmental sampling and ecological surveys. Appropriate Health, Safety and Environment (HSE) procedures, including the use of personal protective equipment, safe field practices, equipment calibration and quality assurance protocols, were implemented throughout the investigation.

**Summary of Baseline Environmental Conditions**

Overall, the baseline environmental investigations indicate that the proposed project site possesses favourable environmental characteristics for the implementation of the proposed 2 MW Solar Photovoltaic Hybrid Power Project. The site is characterized by gently undulating terrain, competent lateritic soils, adequate drainage, acceptable ambient air quality and noise conditions, low ecological sensitivity and the absence of significant environmental constraints. No environmentally sensitive habitats, protected species or permanent settlements were identified within the proposed development area. Although localized security concerns exist within the wider region, these can be effectively managed through appropriate contractor security protocols and HSSE management measures. The baseline data generated during the ESIA provide a robust reference for evaluating the environmental and social impacts of the proposed development and for designing appropriate mitigation, monitoring and environmental management measures to ensure environmentally sustainable project implementation.

## ES 5 POTENTIAL ENVIRONMENTAL AND SOCIAL IMPACTS

The Environmental and Social Impact Assessment (ESIA) identified and evaluated the potential environmental and social impacts associated with the proposed 2 MW Solar Photovoltaic (PV) Power Project throughout its pre-construction, construction, operation, maintenance and decommissioning phases. The assessment considered the nature, magnitude, duration, reversibility and significance of each impact, together with the sensitivity of the receiving environment and the effectiveness of proposed mitigation measures. Overall, the proposed project is expected to generate substantial long-term positive environmental, social and economic benefits through improved electricity supply, reduced greenhouse gas emissions, enhanced institutional productivity and improved learning and healthcare services. Most adverse impacts identified are expected to be temporary, localized and reversible, and can be

effectively managed through the implementation of appropriate mitigation measures and the Environmental and Social Management Plan (ESMP).

**Positive Impacts**

The proposed project is expected to generate numerous beneficial impacts during both construction and operational phases, including:

- Improved access to reliable and sustainable electricity for the Federal University of Health Sciences, Otukpo.
- Enhanced teaching, learning, research and healthcare delivery.
- Increased reliability of critical medical and laboratory equipment.
- Reduced dependence on diesel-powered generators.
- Reduction in greenhouse gas emissions and fossil fuel consumption.
- Improved ambient air quality through reduced generator emissions.
- Employment opportunities for skilled and unskilled labour during construction.
- Increased demand for local goods and services.
- Capacity building and technology transfer in renewable energy.
- Improved campus security through reliable electricity for lighting and surveillance.
- Contribution to Nigeria's renewable energy, climate change and sustainable development objectives.

**Potential Adverse Impacts**

**a. Pre-Construction Phase**

Potential impacts during the pre-construction phase include:

- Temporary vegetation clearance within the project footprint.
- Minor disturbance of cultivated plots.
- Increased movement of personnel and equipment.
- Occupational health and safety risks associated with survey and site preparation activities.
- Community expectations regarding employment opportunities.

These impacts are expected to be of low significance and readily manageable.

**b. Construction Phase**

Potential impacts during construction include:

**Physical Environment**

- Temporary deterioration of ambient air quality due to dust generation.
- Temporary increase in environmental noise levels.
- Soil disturbance arising from excavation and earthworks.
- Localized soil compaction from construction equipment.
- Generation of construction wastes.
- Increased risk of accidental spills of fuels and lubricants.
- Increased surface runoff and localized erosion if exposed soils are not properly managed.

**Water Resources**

- Increased sediment transport into nearby drainage channels during rainfall events.
- Potential contamination of runoff from accidental spillages.
- Increased suspended solids in drainage water.

**Biological Environment**

- Removal of secondary vegetation within the project footprint.

- Temporary disturbance of birds and other small fauna.
- Loss of common plant species within the construction area.

No impacts on critical habitats, endangered species or protected ecosystems are anticipated.

**Socio-Economic Environment**

- Temporary restriction of access to portions of the construction site.
- Increased traffic movement.
- Temporary community disturbance associated with construction activities.
- Occupational health and safety risks to workers.
- Security concerns associated with movement of personnel and equipment.

**c. Operational Phase**

Potential operational impacts include:

- Minor noise generated by electrical equipment and transformers.
- Routine maintenance waste generation.
- Battery replacement and management.
- Generation of end-of-life photovoltaic components over the project lifespan.
- Occupational hazards during maintenance activities.
- Electrical safety risks.

Conversely, the operational phase will generate substantial positive environmental benefits through clean energy production and reduced atmospheric emissions.

**d. Decommissioning Phase**

Potential impacts during decommissioning include:

- Generation of demolition wastes.
- Temporary dust and noise generation.
- Removal of electrical equipment.
- Transportation of dismantled materials.
- Occupational health and safety risks.
- Temporary soil disturbance.

Most project materials, including photovoltaic modules, metals and electrical components, are recyclable and will be managed in accordance with applicable environmental regulations.

**Overall Impact Evaluation**

Following implementation of the proposed mitigation measures, most adverse environmental and social impacts are expected to reduce from **moderate** or **minor** significance to **minor** or **negligible** significance. No significant irreversible environmental impacts were identified during the assessment. This conclusion is based on the temporary and localized nature of the principal construction impacts, the low ecological sensitivity of the project footprint, the absence of permanent settlements within the site, and the availability of practical mitigation and monitoring measures to manage residual risks.

## ES 6 MITIGATION MEASURES

Appropriate mitigation measures have been developed to eliminate, minimize or compensate for identified environmental and social impacts throughout the project life cycle.
The principal mitigation measures include:

**Physical Environment**

- Restrict vegetation clearance to approved construction areas.

- Minimize exposed soil surfaces.
- Implement erosion and sediment control measures.
- Maintain existing drainage pathways.
- Regular watering of exposed surfaces to suppress dust.
- Proper maintenance of construction equipment to minimize exhaust emissions.
- Routine housekeeping throughout the project site.

**Water Resources**

- Prevent fuel, oil and chemical spillages.
- Store fuels and lubricants within bunded areas.
- Implement spill prevention and emergency response procedures.
- Dispose of wastewater through approved methods.
- Maintain adequate buffer distances from drainage channels.

**Biological Environment**

- Limit vegetation removal to the approved project footprint.
- Avoid unnecessary disturbance to surrounding vegetation.
- Prohibit hunting, trapping or collection of wildlife by project personnel.
- Restore disturbed areas following construction.

**Waste Management**

- Implement a comprehensive Waste Management Plan.
- Segregate wastes at source.
- Recycle reusable materials where practicable.
- Dispose of hazardous wastes through licensed waste contractors.
- Maintain proper waste storage facilities.

**Occupational Health and Safety**

- Implement a comprehensive Health, Safety and Environment (HSE) Plan.
- Provide appropriate Personal Protective Equipment (PPE).
- Conduct routine HSE training.
- Maintain first aid facilities.
- Develop emergency preparedness and response procedures.
- Enforce safe working practices throughout construction and operation.

**Community Health, Safety and Security**

- Maintain effective communication with surrounding communities.
- Implement traffic management measures.
- Employ trained security personnel.
- Coordinate security arrangements with relevant government security agencies where necessary.
- Maintain a functional Grievance Redress Mechanism (GRM).

**Environmental Monitoring**

Environmental monitoring will include routine monitoring of:

- Ambient air quality.
- Environmental noise.
- Soil quality.
- Surface water quality where applicable.
- Vegetation restoration.
- Waste management.

- Occupational health and safety performance.
- Community health and safety.
- Compliance with the Environmental and Social Management Plan (ESMP).

After implementation of the mitigation and monitoring measures, residual impacts are expected to remain localized, short-term for construction-related activities, and manageable within applicable regulatory limits. Any exceedance identified through monitoring will trigger corrective actions, additional controls, and follow-up reporting by the responsible implementing party.

## ES 7 ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN (ESMP)

The Environmental and Social Management Plan (ESMP) sets out the mitigation measures, monitoring requirements, institutional responsibilities, reporting procedures and corrective actions needed to implement the proposed 2 MW Solar Photovoltaic (PV) Power Project and associated infrastructure at the Federal University of Health Sciences, Otukpo (FUHSO) in an environmentally sustainable and socially responsible manner. The ESMP applies across the pre-construction, construction, operation, maintenance and decommissioning phases and supports compliance with applicable environmental legislation, occupational health and safety requirements, Rural Electrification Agency (REA) project requirements and international good industry practice.

### Objectives of the ESMP

The principal objectives of the Environmental and Social Management Plan are to:

- Ensure compliance with applicable national environmental legislation and regulatory requirements.
- Prevent, minimize or adequately manage adverse environmental and social impacts associated with project implementation.
- Protect public health, worker safety and the surrounding environment.
- Promote efficient utilization of natural resources and good environmental stewardship.
- Establish clear institutional responsibilities for environmental management.
- Provide a framework for environmental monitoring, reporting and continuous improvement.
- Facilitate effective stakeholder engagement and grievance management throughout project implementation.

### Institutional Responsibilities

Implementation of the ESMP will involve collaboration among several institutions and project stakeholders. The Rural Electrification Agency (REA), as Project Proponent, will provide overall oversight of ESMP implementation and ensure compliance with applicable environmental and social safeguard requirements. The Engineering, Procurement and Construction (EPC) Contractor will be responsible for implementing all environmental, occupational health, safety and social mitigation measures during project construction. The Contractor will prepare and implement detailed site-specific management plans consistent with the approved ESMP. The Federal University of Health Sciences, Otukpo (FUHSO) will provide institutional support during project implementation and subsequently oversee environmental and safety management during project operation. The Federal Ministry of Environment (FMEnv), relevant regulatory agencies and Benue State environmental authorities will undertake regulatory oversight, compliance inspections and environmental audits where necessary.

### Environmental Monitoring Programme

A comprehensive environmental monitoring programme has been developed to evaluate the effectiveness of mitigation measures and ensure compliance throughout project implementation.

The monitoring programme includes periodic assessment of:

- Ambient air quality.
- Environmental noise levels.
- Soil quality.
- Surface water quality where applicable.
- Drainage performance and erosion control.
- Vegetation restoration.
- Construction waste management.
- Hazardous material management.
- Occupational health and safety performance.
- Community health and safety.
- Security management.
- Compliance with environmental permit conditions.

Monitoring results will be documented, reviewed periodically and used to improve environmental performance where necessary.

**Occupational Health, Safety and Security**

A comprehensive Occupational Health, Safety and Security Management Plan will be implemented throughout the project life cycle.

The programme will include:

- Provision and mandatory use of appropriate Personal Protective Equipment (PPE).
- Routine toolbox meetings and HSE training.
- Hazard identification and risk assessment.
- Permit-to-work procedures.
- Emergency preparedness and response planning.
- Incident reporting and investigation.
- Fire prevention and emergency response equipment.
- First aid facilities and trained first aid personnel.
- Traffic and vehicle safety management.
- Contractor safety supervision.

Considering the prevailing regional security situation observed during the baseline survey, appropriate security management measures shall also be implemented throughout project execution, including coordination with relevant government security agencies where necessary.

**Waste Management**

A comprehensive Waste Management Plan will be implemented during all phases of the project.

Waste management measures will include:

- Waste minimization at source.
- Segregation of hazardous and non-hazardous wastes.
- Recycling and reuse of suitable materials.
- Appropriate storage of hazardous materials.
- Disposal through approved and licensed waste management contractors.
- Proper documentation of waste generation and disposal.

Special attention will be given to the management of batteries, electrical components and end-of-life photovoltaic equipment in accordance with applicable environmental regulations.

**Stakeholder Engagement and Grievance Redress**

Stakeholder engagement will continue throughout project implementation to ensure effective communication between the Project Proponent, the University, regulatory agencies and other relevant stakeholders. A Grievance Redress Mechanism (GRM) will be maintained throughout the project to provide transparent procedures for receiving, documenting, investigating and resolving complaints arising from project activities.

**Summary of ESMP Cost Estimate**

| S/N | ESMP Activity | Estimated Cost (USD) |
|---|---|---|
| **1** | Pre-Construction Environmental Management Measures | 9,000 |
| **2** | Pre-Construction Social Management Measures | 13,000 |
| **3** | Construction Environmental Management Measures | 29,000 |
| **4** | Construction Social Management Measures | 29,000 |
| **5** | Operational Environmental Management Measures (Annual) | 16,500 |
| **6** | Operational Social Management Measures (Annual) | 17,000 |
| **7** | Additional Management Plans | 25,500 |
| **8** | Environmental and Social Monitoring Programme | 25,200 |
| **9** | Training, Awareness and Capacity Building | 14,000 |
| **Total Initial ESMP Implementation Cost** *(excluding annual operational costs)* | | **144,700** |
| **Annual Operational ESMP Cost** | | **33,500 per annum** |

**Environmental Reporting and Compliance**

Environmental performance reports will be prepared periodically throughout construction and operation.

The reports will include:

- Environmental monitoring results.
- HSE performance statistics.
- Incident reports.
- Waste management records.
- Corrective actions implemented.
- Compliance status with environmental permit conditions.
- Stakeholder engagement activities.
- Grievance records and resolutions.

Regular environmental inspections and internal audits will also be undertaken to ensure continual compliance and improvement.

## ES 8 DECOMMISSIONING AND SITE REHABILITATION

Although the proposed Solar Photovoltaic Project is expected to operate for several decades with routine maintenance and equipment replacement, eventual decommissioning has been considered as part of the project life cycle. At the end of its operational life, the project will be decommissioned in accordance with applicable environmental regulations and international good industry practice.

The principal decommissioning activities will include:

- Safe shutdown of electrical systems.
- Removal of photovoltaic modules.
- Dismantling of mounting structures.
- Removal of transformers, batteries and electrical equipment.

- Recovery of reusable materials.
- Recycling of recyclable components.
- Environmentally sound disposal of hazardous wastes.
- Restoration of disturbed areas.
- Reinstatement of natural drainage patterns where necessary.

Before project closure, a detailed Decommissioning Plan will be prepared to define shutdown procedures, roles and responsibilities, waste segregation and recycling requirements, hazardous waste handling, worker health and safety measures, site restoration standards, monitoring requirements and reporting procedures.

## ES 9 SUMMARY AND CONCLUSION

The Environmental and Social Impact Assessment undertaken for the proposed 2 MW Solar Photovoltaic (PV) Hybrid Power Project and associated infrastructure at the Federal University of Health Sciences, Otukpo (FUHSO), Benue State, has demonstrated that the project is environmentally feasible, technically viable and socially beneficial. Baseline investigations confirmed that the proposed development site is characterized by gently undulating terrain, well-drained lateritic soils, acceptable ambient environmental quality and relatively low ecological sensitivity. No environmentally sensitive habitats, protected species, major geological constraints or permanent settlements were identified within the proposed project footprint. The baseline investigations also established representative environmental conditions for soils, ambient air quality, environmental noise, surface water quality and terrestrial ecology, which will serve as reference conditions for future environmental monitoring.

The assessment identified several positive impacts associated with the project, including improved electricity supply, enhanced teaching and research, improved healthcare delivery, reduced dependence on fossil fuels, lower greenhouse gas emissions, employment generation and increased institutional productivity. Potential adverse impacts were found to be largely temporary, localized and associated primarily with construction activities. These impacts can be effectively avoided, minimized or managed through the implementation of the recommended mitigation measures and the Environmental and Social Management Plan (ESMP). The ESMP provides a comprehensive framework for environmental management, occupational health and safety, environmental monitoring, waste management, stakeholder engagement and regulatory compliance throughout the project life cycle. With effective implementation of these measures, the residual environmental and social impacts are expected to be minor to negligible and within acceptable regulatory limits.

Accordingly, the proposed 2 MW Solar Photovoltaic (PV) Hybrid Power Project and associated infrastructure at the Federal University of Health Sciences, Otukpo is considered environmentally acceptable and socially desirable. It is therefore recommended for approval and implementation, subject to full compliance with the mitigation measures, Environmental and Social Management Plan (ESMP), stakeholder engagement commitments, grievance redress procedures, monitoring requirements, applicable statutory approvals and relevant environmental and social safeguard policies contained in this ESIA.

# CHAPTER ONE
# INTRODUCTION

## 1.1 Background to the Project

The Government of the Federal Republic of Nigeria has identified access to reliable, affordable, and sustainable electricity as a critical enabler of economic development, social inclusion, educational advancement, and environmental sustainability. Despite significant investments in the country's electricity sector, many public institutions continue to experience inadequate and unreliable power supply arising from grid instability, increasing electricity demand, ageing transmission and distribution infrastructure, and the high operating costs associated with fossil fuel-based backup generation. These challenges are also felt within tertiary educational institutions, where uninterrupted electricity supply is essential for teaching, research, digital learning, laboratory operations, administrative functions, healthcare services, security systems, and other critical campus activities.

Recognizing these challenges, the Federal Government of Nigeria, through the Rural Electrification Agency (REA), has continued to implement strategic renewable energy programmes aimed at expanding access to clean and reliable electricity across underserved communities and public institutions. Key REA initiatives include the Nigeria Electrification Project (NEP), which is designed to reduce the national energy access deficit; the Energizing Education Programme (EEP), which targets reliable electricity supply for tertiary institutions; and the Desert to Power Phase II Programme, which seeks to accelerate renewable energy deployment by harnessing Nigeria's abundant solar resources. These programmes support the development of institutional solar photovoltaic (PV) projects that improve electricity reliability, reduce dependence on fossil fuels, lower greenhouse gas emissions and strengthen national energy security.

The Nigeria Electrification Project forms part of the African Development Bank's broader support to Nigeria's power sector and has provided a foundation for subsequent renewable energy interventions. In this context, the Desert to Power Programme represents a major renewable energy initiative aimed at expanding electricity access, stimulating economic activity and strengthening climate resilience through solar energy deployment.

As part of this initiative, REA proposes the development of a **2 MW Solar Photovoltaic (PV) Hybrid Power Project and associated infrastructure** at the Federal University of Health Sciences, Otukpo (FUHSO), Benue State. The proposed project will comprise a ground-mounted solar photovoltaic array, battery energy storage system, inverter stations, transformer and switchgear facilities, monitoring and control systems, underground electrical cabling, perimeter security infrastructure and ancillary facilities required for the safe generation, storage and distribution of electricity. The facility will be interconnected with the campus electrical distribution network to provide a reliable, renewable and environmentally sustainable source of electricity for the University.

The proposed project will occupy approximately 10 hectares (100,235.02 m²) within the University's Permanent Campus, which is currently under development and located approximately 19 km from the University's presently operational campus. The proposed development comprises a ground-mounted solar photovoltaic power plant, battery energy storage systems (BESS), inverters, transformers, switchgear, internal distribution network, access roads, drainage infrastructure, security facilities and other ancillary works required for efficient project operation.

The objectives of this component are to:

- Improve the reliability and sustainability of electricity supply to the Federal University of Health Sciences, Otukpo.
- Support teaching, learning, research, healthcare delivery and administrative activities through uninterrupted power supply.
- Reduce dependence on diesel-powered generators and associated operating costs.
- Promote renewable energy development and improve energy efficiency within the University.
- Contribute to the Federal Government's renewable energy, climate change mitigation and sustainable development objectives.

In accordance with the Environmental Impact Assessment (EIA) Act, Cap E12, Laws of the Federation of Nigeria, 2004, and other applicable environmental regulations, the proposed project requires an Environmental and Social Impact Assessment (ESIA) prior to implementation. This ESIA has therefore been undertaken to establish the existing environmental and social conditions within the project area, assess the potential environmental and social impacts associated with the proposed development, and recommend appropriate mitigation, monitoring and management measures for environmentally sustainable project implementation.

## 1.2 Overview of the Project

The proposed project consists of the construction, installation, operation and maintenance of a 2 MW Solar Photovoltaic (PV) Hybrid Power Project and Associated Infrastructure at the Federal University of Health Sciences, Otukpo (FUHSO), Benue State. The project forms part of the Nigeria Electrification Project (NEP II) – Desert to Power (DTP II) Programme being implemented by the Rural Electrification Agency (REA) with funding support from the African Development Bank (AfDB).

The proposed development will comprise the following major components:

- Ground-mounted Solar Photovoltaic (PV) Arrays;
- Battery Energy Storage System (BESS);
- Power Conversion System (Inverters);
- Transformers and Switchgear;
- Internal Electrical Distribution Network;
- Supervisory Control and Monitoring System;
- Internal Access Roads;
- Stormwater Drainage System;
- Security Fence and Access Control Facilities;
- Operations and Maintenance Facilities; and
- Other associated civil, structural and electrical infrastructure.

The project is expected to provide dedicated and reliable electricity to the University's Permanent Campus, including academic buildings, research laboratories, administrative offices, healthcare facilities, student hostels, staff quarters, water supply systems, security infrastructure and street lighting.

## 1.3 Project Proponent

The Rural Electrification Agency is a Federal Government agency established to promote, coordinate and facilitate rural electrification and improve electricity access across Nigeria through grid extension, mini-grid systems and standalone renewable energy solutions. The

Agency plays a leading role in implementing national programmes aimed at expanding electricity access to underserved communities, public institutions and productive sectors of the economy. Under the Nigeria Electrification Project (NEP II) – Desert to Power (DTP II) Programme, the REA is responsible for:

- Project planning and implementation;
- Procurement and contract administration;
- Environmental and social safeguards compliance;
- Stakeholder coordination;
- Monitoring and evaluation; and
- Overall project supervision.

The Agency is also responsible for ensuring that the project complies with applicable Federal Government environmental regulations, funding agency safeguard requirements, and the REA Environmental, Health and Safety (EHS) Policy throughout the project lifecycle.

## 1.4 Project Location

The proposed 2 MW Solar Photovoltaic (PV) Hybrid Power Project and associated infrastructure is located within the Permanent Site of the Federal University of Health Sciences, Otukpo (FUHSO), Otukpo Local Government Area (LGA), Benue State, Nigeria.

The project site is situated within the University's Permanent Campus, approximately 19 km from the University's currently operational campus in Otukpo town. The proposed development occupies approximately 10 hectares (100,235.02 m²) of land wholly owned by the University and designated for institutional development. The coordinates fall within:

**POINT A:** Latitude 7.0668010; Longitude 8.0976078
**POINT B:** Latitude 7.0633362; Longitude 8.0981894
**POINT C:** Latitude 7.0667979; Longitude 8.0976282
**POINT D:** Latitude 7.0663816; Longitude 8.1003373

**National and Regional Context**

Benue State, North-Central Nigeria. Benue State is situated within the Middle Belt region of Nigeria and shares boundaries with Nasarawa State to the north, Taraba State to the east, Cross River State to the south, Enugu State to the southwest, Ebonyi State to the south, Kogi State to the west, and the Republic of Cameroon along its southeastern border.

Otukpo is one of the major urban centres in southern Benue State and serves as the administrative headquarters of Otukpo Local Government Area. The town lies along the strategic A3 Federal Highway, which connects Makurdi, Otukpo and Enugu, thereby providing an important transportation corridor linking North-Central Nigeria with the southeastern part of the country.

*See Figure 1.1 for Map of Nigeria Showing Benue State, and Otukpo LGA.*
*See Figure 1.2 for Institution Main Entrance*

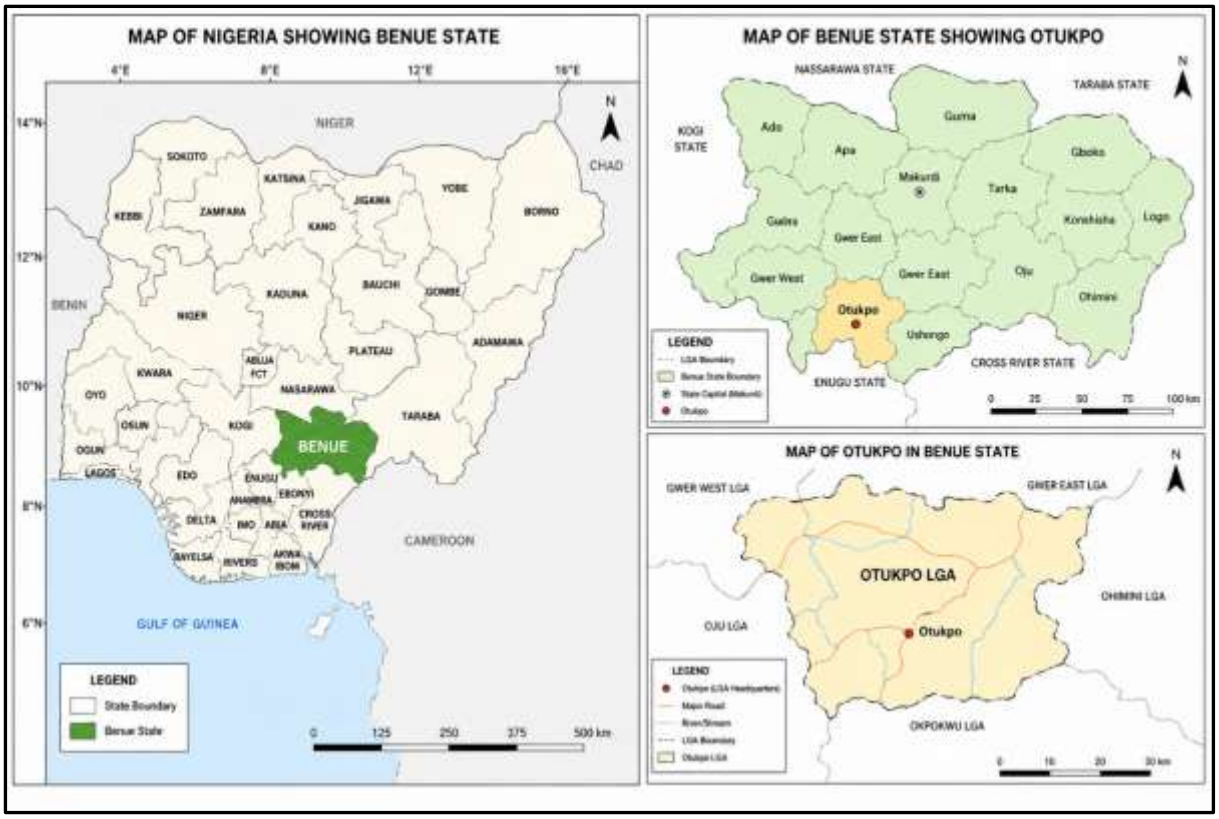



**Figure 1.1: Map of Nigeria Showing Benue State, and Otukpo LGA**

**Campus Layout & Key Zones**

The Permanent Campus is accessed via the Otukpo–Igumale Road, a major arterial road that links Otukpo with neighbouring communities and provides direct access to the project area. Internal access roads and drainage infrastructure are currently under construction as part of the University's ongoing campus development.

The proposed project area is characterized by gently undulating topography, well-drained lateritic soils and secondary Guinea Savannah vegetation comprising grasses, shrubs, scattered trees and cultivated crops. The site occupies relatively elevated terrain compared with the adjacent natural drainage corridor located behind the proposed development area, making it suitable for the construction and long-term operation of the proposed solar photovoltaic facility.




**Figure 1.2: Institution Main Entrance**
**Source**: *Bolben Ltd. Fieldwork Survey, 2026.*

## 1.5 Rationale and Objectives for the ESIA

### 1.5.1 Rationale for the ESIA

The proposed 2 MW Solar Photovoltaic (PV) Hybrid Power Project and associated infrastructure falls within the category of renewable energy developments requiring environmental assessment under the provisions of the Environmental Impact Assessment Act, Cap E12, Laws of the Federation of Nigeria, 2004. The Act requires public and private projects that are likely to have significant environmental effects to undergo environmental assessment before implementation. In addition, the project must comply with the Federal Ministry of Environment EIA Procedural Guidelines, relevant National Environmental Standards and Regulations Enforcement Agency regulations, the Climate Change Act and the African Development Bank Integrated Safeguards System.

The ESIA provides the basis for integrating environmental and social considerations into project planning, design, construction, operation, maintenance and decommissioning. For the proposed 2 MW Solar Photovoltaic (PV) Hybrid Power Project at FUHSO, the ESIA identifies potential environmental and social risks, evaluates their significance and establishes practical measures for mitigation, monitoring and management throughout the project life cycle.

Specifically, the ESIA was undertaken to:

- Establish the existing physical, biological and socio-economic baseline conditions within the project area;
- Identify and evaluate the potential environmental and social impacts associated with the proposed project;
- Develop practical measures for avoiding, minimizing or mitigating adverse impacts while enhancing positive impacts;
- Ensure compliance with applicable Federal, State and Local Government environmental requirements;
- Facilitate informed decision-making during project planning and implementation;

- Promote environmentally sustainable development and good international industry practice; and
- Develop an Environmental and Social Management Plan (ESMP) for implementation throughout the project lifecycle.

### 1.5.2 Objectives of the ESIA

The overall objective of this ESIA is to ensure that the proposed project is implemented in an environmentally sustainable and socially responsible manner by identifying potential impacts at an early stage and incorporating appropriate mitigation and management measures into project implementation. The study also provides the environmental information required by regulatory authorities and other stakeholders for informed decision-making.

To achieve this overall objective, the specific objectives of the ESIA are to:

- Describe the proposed project and its associated activities;
- Characterize the existing environmental and social conditions of the project area;
- Identify environmentally and socially sensitive receptors that may be affected by project implementation;
- Predict and evaluate the potential environmental and social impacts during the construction, operation and decommissioning phases;
- Assess project alternatives, where applicable;
- Recommend appropriate mitigation and enhancement measures;
- Develop an Environmental and Social Management Plan (ESMP);
- Establish environmental monitoring requirements and performance indicators;
- Facilitate stakeholder consultation and incorporate stakeholder concerns into project planning; and
- Ensure compliance with applicable environmental legislation, regulatory requirements and funding agency safeguard requirements.

## 1.6 Scope of the ESIA Study / Terms of Reference

**The scope of the ESIA study covers the following:**

- Review of applicable local and international laws, regulations, standards, and industry codes that apply to the proposed Project.
- Description of all activities that will be carried out during project development and implementation.
- Desktop review of relevant documents on the Project and the environment where it will be located, including the NEP Environmental and Social Management Framework (ESMF), among others.
- Field data collection covering the biophysical and socio-economic components of the Project's Area of Influence.
- Consultations with relevant stakeholders, including government institutions, project-affected persons and FUHSO management representatives. Details of stakeholder consultations are documented in the stakeholder engagement "*Chapter 4"* of this report.
- Laboratory analysis of field samples, impact identification and evaluation, and development of appropriate mitigation measures and an Environmental Management Plan.
- Perimeter survey of the project site, including the preparation of survey maps.
- Report preparation and disclosure.

For ease of presentation, the scope of the study is discussed under the following components:

- Spatial Scope;
- Temporal Scope; and
- Thematic Scope.

### 1.6.1 Spatial Scope

The spatial scope defines the geographical extent of the study area and includes the proposed project footprint as well as areas that may be directly or indirectly influenced by project activities. It covers all environmental receptors within the project's Area of Influence (AoI) that could potentially experience environmental or social changes during project implementation.
The spatial scope of this ESIA therefore covers:

- The proposed 10-hectare project footprint within the Permanent Site of the Federal University of Health Sciences, Otukpo;
- Areas likely to be directly or indirectly affected by project activities (Area of Influence);
- Existing access roads and associated infrastructure;
- The downstream drainage corridor receiving runoff from the project area;
- Akwete-Akpa Community, identified as the nearest community within the project's Area of Influence; and
- The representative surface water sampling location (Aloma River) used for baseline water quality assessment.

### 1.6.2 Temporal Scope

The temporal scope defines the period over which potential environmental and social impacts associated with the proposed project were assessed. The assessment considers both the existing baseline conditions and the likely impacts that may occur throughout the entire lifecycle of the project. Accordingly, the temporal scope covers the following project phases:

- Pre-construction phase;
- Construction phase;
- Operation and maintenance phase; and
- Decommissioning phase.

The baseline environmental investigations undertaken during the field survey represent the prevailing environmental conditions at the time of the study. These conditions provide the reference point for assessing potential project-related changes during construction, operation, maintenance and decommissioning, and for evaluating the effectiveness of the mitigation and monitoring measures presented in subsequent chapters.

### 1.6.3 Thematic Scope

The thematic scope identifies the environmental and social issues considered during the ESIA. The assessment covered all relevant environmental, biological, social, health and safety components necessary for evaluating the potential impacts of the proposed project and developing appropriate management measures.
The thematic scope of the study includes:

- Project description and project alternatives;
- Physical environment (climate, geology, topography, soils, drainage, ambient air quality and noise);
- Biological environment (flora and fauna);
- Surface water quality;
- Environmental quality assessment;
- Occupational Health, Safety and Environment (HSE);
- Stakeholder consultation and public participation;
- Environmental and social impact assessment;
- Mitigation and enhancement measures;
- Environmental and Social Management Plan (ESMP);
- Environmental monitoring programme;

- Emergency preparedness and response considerations; and
- Institutional arrangements for environmental and social management.

## 1.7 ESIA Methodology

The Environmental and Social Impact Assessment (ESIA) for the proposed 2 MW Solar Photovoltaic (PV) Hybrid Power Project and associated infrastructure was undertaken in accordance with the approved Terms of Reference, the Environmental Impact Assessment Act, Cap E12, Laws of the Federation of Nigeria, 2004, the Federal Ministry of Environment Procedural Guidelines, the REA Environmental, Health and Safety Policy, and other relevant national and international safeguard requirements. The study combined desktop review, reconnaissance survey, field investigation, environmental sampling, laboratory analysis, stakeholder consultation and impact assessment to establish baseline conditions and evaluate potential project impacts.

### 1.7.1 Literature Review

Relevant project documents and published information relating to the proposed project and the project environment were reviewed to provide background information and guide the field investigations. The review included:

- Project design information;
- Approved Terms of Reference (ToR);
- Existing maps and satellite imagery;
- Relevant environmental legislation, regulations and guidelines;
- Previous environmental studies;
- Published geological, hydrological and ecological information; and
- Applicable international environmental safeguard requirements.

The information obtained from the desktop review formed the basis for planning the field investigations and impact assessment.

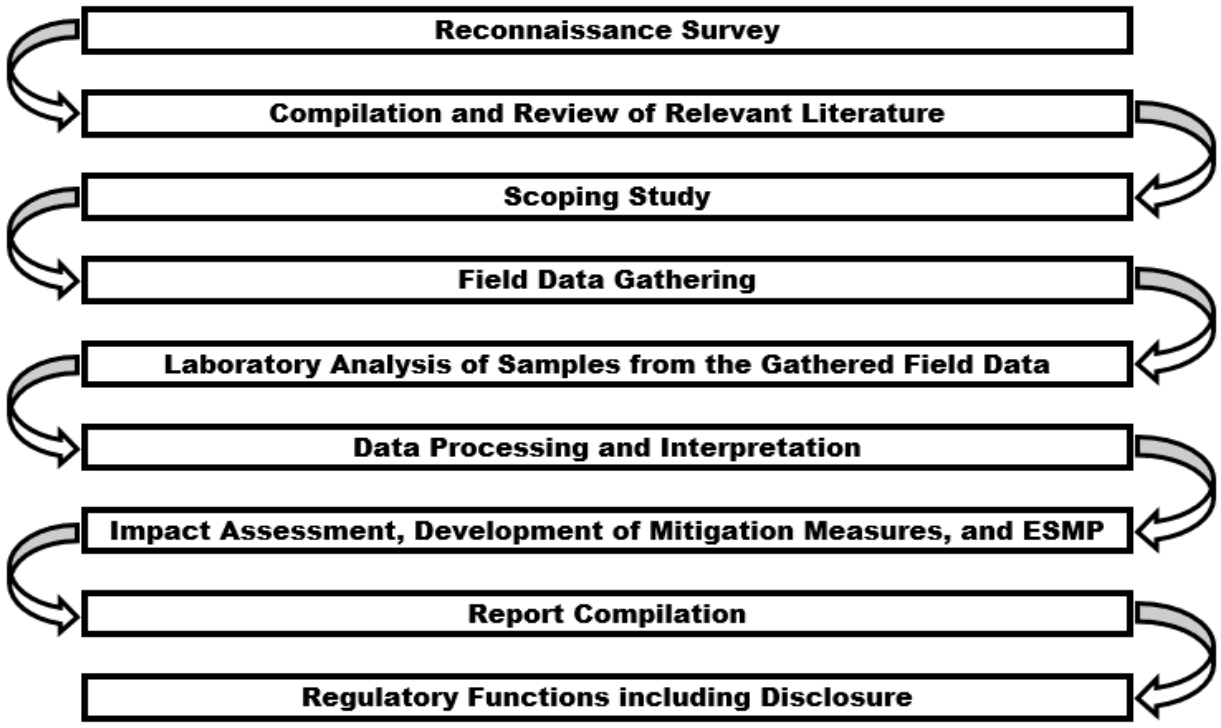



**Figure 1.3: Schematic presentation of the general methodology for the EIA/ESIA**
*(**Source**: Bolben Energy and Environmental Services Ltd.)*

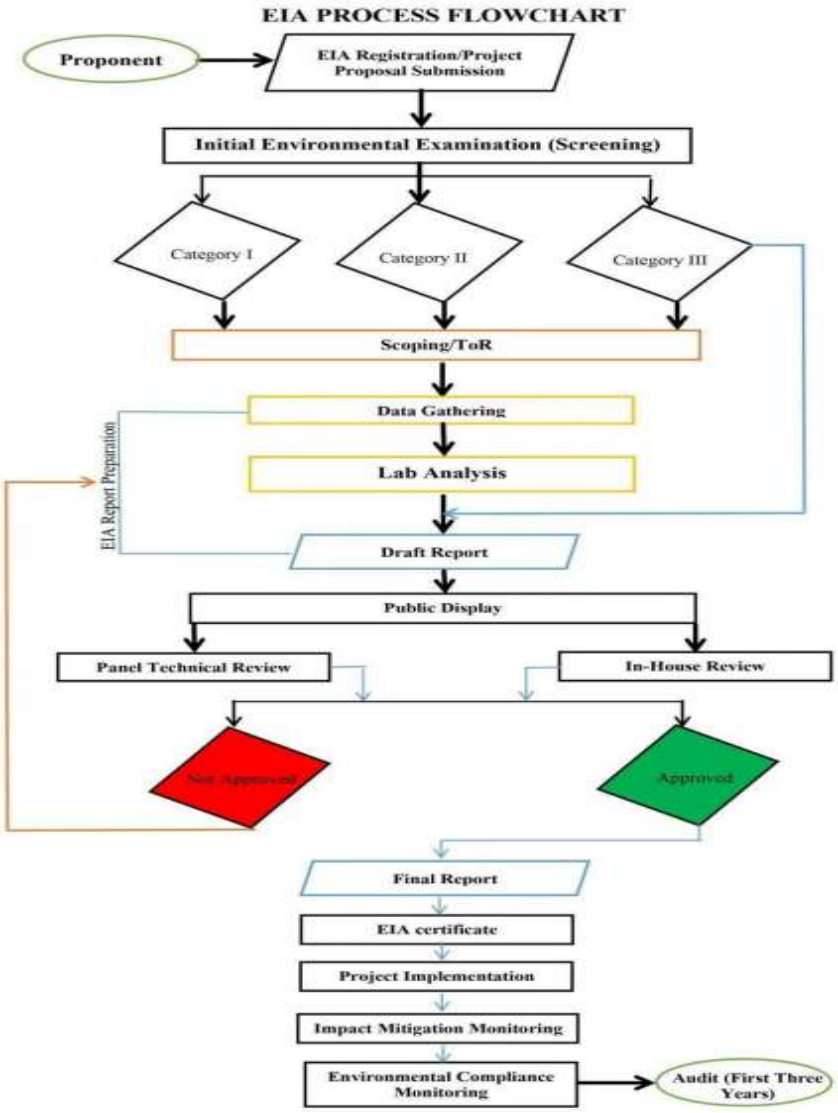



**Figure 1.4: Federal Ministry of Environment EIA Flowchart**

***Source**: Environmental Assessment Department, Federal Ministry of Environment*

### 1.7.2 Reconnaissance Survey

A reconnaissance survey of the proposed project area was undertaken to familiarize the study team with the project environment and verify the proposed project location. The survey also provided an opportunity to identify environmentally sensitive receptors and confirm suitable locations for environmental sampling.

During the reconnaissance survey, the following activities were undertaken:

- Verification of the project location;
- Confirmation of project boundary coordinates;
- Assessment of existing land use;
- Identification of drainage characteristics;
- Assessment of accessibility;
- Identification of environmentally sensitive features; and
- Photographic documentation of the project area.

### 1.7.3 Field Investigations

Baseline environmental investigations were conducted to establish the existing environmental conditions within the proposed project area. The field programme comprised physical, biological and environmental assessments using standard field procedures and internationally accepted sampling protocols.

The investigations included:

- Soil quality assessment;
- Surface water quality assessment;
- Ambient air quality monitoring;
- Ambient noise level monitoring;
- Terrestrial ecological survey (flora and fauna);
- Drainage assessment;
- Existing environmental condition assessment; and
- Health, Safety and Environmental (HSE) assessment.

Environmental sampling locations were selected to provide representative coverage of the project area and its Area of Influence.

### 1.7.4 Environmental Sampling and Laboratory Analysis

Environmental samples were collected using standard field procedures and appropriate Quality Assurance and Quality Control (QA/QC) protocols. All equipment used during the field investigations were calibrated prior to use, while samples were properly labelled, preserved and transported to an accredited environmental laboratory for detailed analyses.

The investigations included:

- Topsoil and subsoil sampling;
- Surface water sampling;
- Ambient air quality monitoring;
- Ambient noise measurements; and
- Field observations and photographic documentation.

Laboratory analyses included the determination of:

- Physicochemical parameters;
- Heavy metals;
- Microbiological parameters (where applicable); and
- Other relevant environmental quality indicators.

### 1.7.5 Stakeholder Consultation

Stakeholder consultation constituted an integral component of the ESIA process and was undertaken in accordance with the requirements of the Environmental Impact Assessment (EIA) Act, the Federal Ministry of Environment (FMEnv) Procedural Guidelines, and the Rural Electrification Agency (REA) Environmental, Health and Safety (EHS) Policy. The consultation process was designed to ensure that relevant stakeholders were adequately informed about the proposed project, provided the opportunity to express their views and concerns, and actively participated in the environmental assessment process.

The stakeholder engagement programme comprised two principal consultations, namely:

- **Reconnaissance Visit and Site Verification Meeting** with the management of the Federal University of Health Sciences, Otukpo (FUHSO), representatives of the Federal Ministry of Environment (FMEnv), Benue State environmental authorities and the ESIA Consultant Team; and

- **Host Community Stakeholder Engagement** with the leadership and members of **Akwete-Akpa Community**, which is the nearest host community to the project.

The consultations were undertaken to achieve the following objectives:

- Introduce the proposed project and the ESIA study to relevant stakeholders;
- Obtain institutional, environmental and socio-economic information relating to the project area;
- Verify the proposed project site and environmental baseline conditions;
- Identify stakeholders' concerns, expectations and recommendations;
- Facilitate public participation throughout the ESIA process;
- Obtain permission for baseline investigations and environmental sampling; and
- Promote transparency and effective communication among all stakeholders.

The consultation programme involved representatives of the following institutions and stakeholder groups:

- Rural Electrification Agency (REA);
- Federal Ministry of Environment (FMEnv);
- Benue State Ministry of Environment;
- Benue State Ministry of Water Resources, Environment and Climate Change;
- Management of the Federal University of Health Sciences, Otukpo (FUHSO);
- Traditional institutions and community leadership;
- Akwete-Akpa Community representatives;
- Youth and women representatives;
- Community members; and
- The ESIA Consultant Team.

During the consultation meetings, stakeholders were briefed on the proposed project, its objectives, anticipated benefits, the ESIA process and the planned baseline environmental investigations. Discussions also provided an opportunity for participants to seek clarification, express their expectations and provide information relevant to the environmental and social assessment. In addition, permission was granted for the consultant team to undertake the baseline investigations, including socio-economic surveys and representative surface water sampling within Akwete-Akpa Community. The concerns, observations and recommendations obtained during the stakeholder consultations were documented and have been incorporated into the baseline environmental assessment, impact evaluation, development of mitigation measures and preparation of the Environmental and Social Management Plan (ESMP). The detailed stakeholder consultation process, attendance records, issues raised and responses are presented in the Stakeholder Engagement Chapter of this report.

### 1.7.6 Impact Identification and Assessment

Potential environmental and social impacts associated with the proposed project were identified by comparing project activities with the existing baseline environmental conditions established during the field investigations.

The assessment considered:

- Nature of the impact;
- Magnitude;
- Spatial extent;
- Duration;
- Frequency;
- Reversibility;

- Likelihood of occurrence; and
- Sensitivity of affected receptors.

The significance of each identified impact was subsequently evaluated to determine appropriate mitigation measures.

### 1.7.7 Development of Mitigation Measures

Mitigation measures were developed in accordance with the mitigation hierarchy to eliminate, minimize, restore or compensate for adverse environmental and social impacts associated with the proposed project. The recommended mitigation measures provide the basis for the preparation of the Environmental and Social Management Plan (ESMP).

### 1.7.8 ESIA Reporting

The findings of the desktop review, field investigations, laboratory analyses, stakeholder consultations and impact assessment were integrated into this Environmental and Social Impact Assessment Report.

The report presents:

- Description of the proposed project;
- Existing environmental baseline conditions;
- Assessment of potential environmental and social impacts;
- Recommended mitigation measures;
- Environmental and Social Management Plan (ESMP);
- Environmental monitoring programme; and
- Conclusions and recommendations.

**Table 1.1: Summary of ESIA Methodology**

| Activity | Methodology | Expected Output |
|---|---|---|
| Literature Review | Review of project documents, maps, legislation and published literature | Background information and study planning |
| Reconnaissance Survey | Site inspection and verification | Confirmation of project location and sampling points |
| Field Investigations | Environmental sampling and field observations | Baseline environmental data |
| Laboratory Analysis | Physicochemical, microbiological and heavy metal analyses | Environmental quality data |
| Stakeholder Consultation | Meetings and consultations with stakeholders | Stakeholder concerns and inputs |
| Impact Assessment | Impact identification and significance evaluation | Predicted environmental and social impacts |
| Mitigation Planning | Development of mitigation measures | Environmental and Social Management Plan (ESMP) |
| ESIA Reporting | Compilation and interpretation of findings | Environmental and Social Impact Assessment Report |

## 1.8 Policy, Legal and Institutional Framework

The implementation of the proposed 2 MW Solar Photovoltaic (PV) Hybrid Power Project and Associated Infrastructure is governed by a number of international conventions, national policies, environmental laws, regulations, standards and institutional requirements relating to environmental protection, renewable energy development, occupational health and safety,

pollution prevention and sustainable development. These instruments provide the legal and administrative framework for environmental assessment, project planning, implementation, monitoring and environmental compliance throughout the project lifecycle. The proposed project has therefore been planned and assessed in accordance with the applicable statutory requirements of the Federal Republic of Nigeria, relevant Benue State environmental regulations, and internationally accepted environmental safeguard principles. The principal policy, legal and institutional instruments applicable to the project are discussed under the following sub-sections.

### 1.8.1 National Policies, Guidelines and Regulations

In addition to statutory legislation, several national policies, environmental guidelines and sector-specific regulations provide administrative guidance for environmental protection, pollution control, renewable energy development and sustainable infrastructure projects. These instruments complement the legal framework and guide project planning, implementation and environmental compliance. The principal national policies and regulations applicable to the proposed project are presented in Table 1.2.

**Table 1.2: National Policies, Guidelines and Regulations Applicable to the Project**

| Policy/Guideline/Institution | Description | Relevance to the Project |
|---|---|---|
| National Policy on the Environment (Revised 2016) | Provides the national framework for environmental protection and sustainable development. | Guides environmental planning and management throughout the project lifecycle. |
| National Renewable Energy and Energy Efficiency Policy (NREEEP) | Promotes renewable energy development and energy efficiency across Nigeria. | Supports the deployment of solar photovoltaic systems such as the proposed project. |
| Federal Ministry of Environment (FMEnv) EIA Procedural Guidelines | Provides procedures for conducting Environmental Impact Assessments in Nigeria. | Guides the preparation, review and approval of this ESIA. |
| National Environmental (Construction Sector) Regulations, 2011 | Establishes environmental standards for construction activities. | Applicable during site preparation and construction works. |
| National Environmental (Noise Standards and Control) Regulations, 2009 | Regulates environmental noise generation. | Applicable to construction and operational noise management. |
| National Environmental (Air Quality Control) Regulations, 2014 | Establishes standards for ambient air quality and emissions. | Guides air quality management during project implementation. |
| National Environmental (Surface and Groundwater Quality Control) Regulations, 2011 | Regulates protection of water resources from pollution. | Relevant to stormwater management and prevention of water contamination. |
| National Environmental (Soil Erosion and Flood Control) Regulations, 2011 | Provides measures for erosion prevention and land protection. | Applicable to drainage design, site grading and erosion control measures. |

| Policy/Guideline/Institution | Description | Relevance to the Project |
|---|---|---|
| National Environmental (Sanitation and Waste Control) Regulations | Regulates waste management and environmental sanitation. | Guides management of construction and operational wastes. |
| Federal Ministry of Power | Responsible for national electricity policy and sector oversight. | Provides policy direction for electricity infrastructure development. |
| Rural Electrification Agency (REA) | Implements rural electrification and renewable energy programmes in Nigeria. | Project implementing agency responsible for project execution and safeguards compliance. |

### 1.8.2 State Policies, Guidelines and Regulations

At the State level, the implementation of the proposed project is subject to the environmental policies, institutional requirements and administrative procedures of the Benue State Government. These institutions complement the responsibilities of the Federal regulatory agencies through environmental monitoring, compliance oversight and coordination of environmental management activities within the State. The principal State institutions relevant to the proposed project are presented in Table 1.3.

**Table 1.3: Relevant Benue State Institutions**

| Institution | Responsibility | Relevance to the Project |
|---|---|---|
| Benue State Ministry of Environment and Climate Change | Environmental policy implementation and environmental management within the State. | Provides oversight and collaborates with FMEnv on environmental matters. |
| Benue State Ministry of Water Resources, Environment and Climate Change | Management of water resources and environmental protection. | Participated in the ESIA field investigations and stakeholder consultations; relevant to water resources and environmental compliance. |
| Benue State Physical Planning Authorities | Physical development planning and development control. | Relevant where development approvals are required. |

### 1.8.3 Local Government Area Bye-laws

The proposed project is located within Otukpo Local Government Area (LGA). The Local Government Authority plays an important role in promoting environmental sanitation, public health, community development and local environmental management. Although environmental regulation is primarily undertaken by Federal and State agencies, compliance with applicable Local Government administrative requirements and bye-laws remains important during project implementation.

Relevant Local Government responsibilities include:

- Environmental sanitation;
- Public health and hygiene;
- Solid waste management;
- Community liaison and conflict resolution;

- Development control (where applicable); and
- Support for environmental awareness and community participation.

The Project Proponent will maintain effective collaboration with the Otukpo Local Government Council and relevant community institutions throughout project implementation to ensure compliance with applicable local administrative requirements and promote good community relations.

### 1.8.4 International Conventions, Agreements, Best Practice Standards and Guidelines

Nigeria is a signatory to several international environmental conventions, treaties and agreements aimed at promoting environmental protection, biodiversity conservation, climate change mitigation and sustainable development. Although these conventions are implemented through national legislation and policies, they provide important guiding principles for environmental planning and management. In addition to these conventions, internationally recognized environmental and social safeguard standards provide guidance for the planning and implementation of infrastructure projects, particularly those financed by multilateral development institutions. The principal international conventions and standards applicable to the proposed project are presented in Table 1.4.

**Table 1.4: International Conventions, Agreements and Best Practice Standards Applicable to the Project**

| Convention/Agreement/Guideline | Objective | Relevance to the Project |
|---|---|---|
| United Nations Framework Convention on Climate Change (UNFCCC), 1992 | Promote global action to reduce greenhouse gas emissions and address climate change. | The project promotes renewable energy and contributes to climate change mitigation by reducing reliance on fossil fuel-based electricity generation. |
| Paris Agreement (2015) | Strengthen the global response to climate change and support low-carbon development. | The proposed solar PV project supports Nigeria's commitment to reducing greenhouse gas emissions and increasing renewable energy generation. |
| Convention on Biological Diversity (CBD), 1992 | Conserve biological diversity and promote sustainable use of biological resources. | The ESIA assesses potential impacts on flora, fauna and habitats and recommends measures for biodiversity conservation. |
| African Convention on the Conservation of Nature and Natural Resources | Promote sustainable management of Africa's natural resources. | Supports environmentally sustainable project planning and implementation. |
| United Nations Sustainable Development Goals (SDGs), 2015 | Promote sustainable global development. | The project directly contributes to SDG 7 (Affordable and Clean Energy), SDG 9 (Industry, Innovation and |

| Convention/Agreement/Guideline | Objective | Relevance to the Project |
|---|---|---|
| | | Infrastructure), SDG 13 (Climate Action) and SDG 15 (Life on Land). |
| IFC Environmental, Health and Safety (EHS) Guidelines | International Good Industry Practice (GIIP) for environmental, health and safety management. | Provides guidance for occupational health and safety, pollution prevention and environmental management during project implementation. |
| African Development Bank (AfDB) Integrated Safeguards System (ISS) | Environmental and social safeguard requirements for AfDB-supported projects. | Provides the environmental and social safeguard framework applicable to the proposed project. |

### 1.8.5 Federal Government of Nigeria (FGN) Requirements and Relevant Legislation

The Federal Government of Nigeria has enacted several laws and regulations to ensure that development projects are planned, implemented and operated in an environmentally sustainable manner. These legal instruments provide the statutory basis for environmental protection, pollution prevention, occupational health and safety, land administration, renewable energy development and environmental impact assessment. Compliance with these legislations is mandatory throughout the planning, construction, operation and decommissioning phases of the proposed project. The principal Federal legislation applicable to the proposed project is presented in Table 1.5.

**Table 1.5: Relevant Federal Government Legislation Applicable to the Project**

| Legislation | Description | Relevance to the Project |
|---|---|---|
| Environmental Impact Assessment (EIA) Act, Cap E12, LFN 2004 | Provides the legal framework for conducting Environmental Impact Assessments for projects likely to have significant environmental impacts. | Forms the statutory basis for undertaking this ESIA prior to project implementation. |
| Electricity Act, 2023 | Regulates the generation, transmission, distribution and supply of electricity in Nigeria and promotes renewable energy development. | Provides the legal framework for the implementation and operation of the proposed solar PV project. |
| National Environmental Standards and Regulations Enforcement Agency (NESREA) Act, 2007 | Establishes NESREA as the national agency responsible for environmental compliance and enforcement. | Provides environmental regulatory oversight and enforcement throughout project implementation. |
| Land Use Act, Cap L5, LFN 2004 | Governs land ownership, administration and land acquisition in Nigeria. | The project will be implemented on land legally allocated to FUHSO by the Government. |

| Legislation | Description | Relevance to the Project |
|---|---|---|
| Labour Act, Cap L1, LFN 2004 | Regulates employment conditions, workers' welfare and labour relations. | Applicable to employment and welfare of construction and operational personnel. |
| Employees' Compensation Act, 2010 | Provides compensation for occupational injuries, diseases and workplace accidents. | Applicable to occupational health and employee welfare during project implementation. |
| Factories Act, Cap F1, LFN 2004 | Provides requirements for occupational health and safety in workplaces. | Applicable during construction, installation and operation of the proposed facility. |
| National Water Resources Act, Cap N43, LFN 2004 | Regulates the protection and sustainable management of Nigeria's water resources. | Relevant to stormwater management and protection of nearby water resources. |

## 1.9 REA Environmental, Health and Safety (EHS) Policy

The Rural Electrification Agency (REA) is committed to implementing electrification projects in a manner that safeguards the environment, protects human health and safety, and promotes sustainable development. The Agency's Environmental, Health and Safety (EHS) Policy provides the framework for integrating environmental and social considerations into project planning, design, construction, operation and decommissioning, while ensuring compliance with applicable national legislation and international good industry practice. The implementation of the proposed 2 MW Solar Photovoltaic (PV) Hybrid Power Project and Associated Infrastructure shall therefore be guided by the principles of the REA EHS Policy. The policy seeks to ensure that all project activities are undertaken in a manner that prevents pollution, protects environmental resources, minimizes occupational hazards and promotes the health, safety and well-being of workers, host communities and other stakeholders.

The key objectives of the REA EHS Policy include:

- Compliance with all applicable environmental, health and safety legislation, regulations and standards;
- Prevention and minimization of environmental pollution;
- Protection of biodiversity and natural resources;
- Promotion of safe and healthy working conditions;
- Prevention of occupational injuries, illnesses and accidents;
- Efficient utilization of energy, water and other natural resources;
- Effective waste management through the application of the waste management hierarchy;
- Promotion of stakeholder participation and effective communication;
- Continuous environmental monitoring and performance improvement; and
- Integration of environmental, social, health and safety considerations into all phases of project implementation.

To achieve these objectives, the Project Proponent and Contractors shall develop and implement appropriate Environmental, Health and Safety Management Plans, emergency preparedness procedures, incident reporting mechanisms, environmental monitoring programmes and occupational health and safety measures throughout the life cycle of the proposed project.

## 1.10 Structure of the Report

This Environmental and Social Impact Assessment (ESIA) Report has been prepared in accordance with the approved Terms of Reference (ToR) and the Federal Ministry of Environment (FMEnv) Procedural Guidelines for Environmental Impact Assessment. The report is structured to provide a systematic description of the proposed project, the existing environmental conditions, the potential environmental and social impacts, and the measures required to ensure environmentally sustainable project implementation.

The report is organized into the following chapters:

**Table 1.6: Structure of the ESIA Report**

| Chapter | Title | Content |
|---|---|---|
| **Chapter One** | Introduction | Introduces the project, outlines the objectives and scope of the ESIA, describes the study methodology, and presents the applicable policy, legal and institutional framework. |
| **Chapter Two** | Project Justification | Presents the need, justification, benefits, sustainability considerations and alternatives considered for the proposed project. |
| **Chapter Three** | Project Description | Describes the proposed project, its components, implementation activities, technical requirements and operational characteristics. |
| **Chapter Four** | Description of the Existing Environment | Describes the baseline physical, biological and socio-economic conditions of the project area, including stakeholder consultation outcomes. |
| **Chapter Five** | Potential and Associated Impacts | Assesses the potential environmental and social impacts associated with the proposed project and evaluates their significance. |
| **Chapter Six** | Mitigation Measures | Presents measures to avoid, minimize, mitigate or enhance the identified environmental and social impacts. |
| **Chapter Seven** | Environmental and Social Management Plan (ESMP) | Describes the environmental and social management measures, monitoring programme, implementation arrangements and other management plans required for effective project implementation. |
| **Chapter Eight** | Remediation Plan after Decommissioning/Closure | Presents the proposed decommissioning strategy, site restoration measures and post-closure management requirements. |
| **Chapter Nine** | Summary and Conclusion | Summarizes the findings of the ESIA and presents the overall conclusions and recommendations for project implementation. |
| The appendices accompanying this report contain supporting information, including stakeholder consultation records, laboratory analytical results, field data sheets, attendance registers, Terms of Reference, and other relevant documentation used in preparing the ESIA. | | |

# CHAPTER TWO
# PROJECT JUSTIFICATION

## 2.1 Introduction

This chapter presents the justification for the proposed 2-Megawatt (MW) Solar Photovoltaic (PV) Hybrid Power Project and Associated Infrastructure at the Permanent Site of the Federal University of Health Sciences, Otukpo (FUHSO), Benue State. The project is being implemented by the Rural Electrification Agency (REA) under the Nigeria Electrification Project Phase II (NEP II) – Desert to Power Phase II (DTP II) Programme, with financing support from the African Development Bank. The proposed project is intended to provide dedicated, reliable and sustainable electricity to support the University's academic, administrative, research, healthcare and residential activities. It will also reduce dependence on diesel-powered generators, improve institutional energy security and support the Federal Government's transition towards cleaner and more efficient electricity generation.

The chapter discusses:

- The justification and need for the project;
- The strategic and financial value of the project;
- Anticipated environmental, social and economic benefits;
- Technical, environmental, economic and social sustainability;
- Alternative project sites and technologies considered; and
- The implications of the No Project, Delayed Project and Go-Ahead options.

The assessment of alternatives considers the environmental, technical, financial and operational implications of the available options in order to identify the most suitable development approach for the proposed project. The structure follows the approved report outline and draws on the project-justification approach used for comparable REA university electrification projects.

## 2.2 Justification and Need for the Project

Reliable electricity is essential to the effective operation of a specialized tertiary institution such as the Federal University of Health Sciences, Otukpo. Academic instruction, biomedical research, laboratory analysis, healthcare training, information and communication technology, water supply, security systems, student accommodation and administrative services all require a stable and continuous electricity supply. The FUHSO Permanent Campus is currently under development and is expected to become the University's principal academic and administrative campus. At the time of the ESIA field investigation, the campus had no connection to the national electricity grid, while the available boreholes could only operate when powered by generators. The absence of a reliable electricity source would therefore limit the commissioning and effective use of the buildings and supporting infrastructure presently under construction.

The proposed 2 MW solar-hybrid facility is justified by the need to:

- Provide a dedicated and reliable electricity supply to the Permanent Campus;
- Support the commissioning and operation of academic, medical, research and administrative facilities;
- Reduce dependence on diesel-powered generators;
- Lower long-term electricity generation and maintenance costs;
- Reduce greenhouse gas emissions, air pollution and generator noise;
- Improve campus security through reliable lighting and surveillance infrastructure;

- Support digital learning, medical training and research activities;
- Promote institutional energy security and operational resilience; and
- Advance the renewable-energy objectives of the Federal Government and the Rural Electrification Agency.

### 2.2.1 National Energy Transition Imperative

The proposed project supports the Federal Government's objective of increasing the contribution of renewable energy to Nigeria's electricity mix and improving access to reliable electricity through decentralized power systems. Solar photovoltaic technology provides an appropriate solution for public institutions that require dependable electricity but are constrained by unavailable or unreliable grid supply.

The project contributes to the national energy transition by:

- Increasing renewable-energy generation capacity;
- Reducing dependence on fossil-fuel-based self-generation;
- Supporting decentralized and off-grid electricity access;
- Improving energy efficiency within a public institution;
- Strengthening the resilience of critical educational and healthcare infrastructure; and
- Supporting the transition towards lower-carbon development.

The proposed development is also consistent with the objectives of the Nigeria Electrification Project and the Desert to Power Programme, which seek to expand access to clean electricity by harnessing the available solar-energy potential in beneficiary locations.

### 2.2.2 Economic Justification

Electricity generated through diesel-powered generators is associated with high and recurring expenditure on fuel, lubricants, servicing, spare parts and equipment replacement. These costs are further affected by fuel-price fluctuations, transportation expenses, exchange-rate pressures and the declining efficiency of generators over time. A solar-hybrid power system requires substantial initial investment but has comparatively low operating costs because solar radiation is freely available and photovoltaic modules contain few moving parts. The proposed project will therefore provide a more predictable and sustainable electricity cost over its operational life.

The principal economic justifications include:

- Reduction in recurring expenditure on diesel fuel;
- Reduction in generator servicing and replacement costs;
- Lower exposure to fluctuations in fuel prices;
- Improved productivity through reduced electricity interruptions;
- Reduced damage to laboratory, ICT and medical equipment caused by unstable power supply;
- More efficient use of University financial resources; and
- Increased opportunities for local procurement, employment and service provision during project implementation.

### 2.2.3 Diesel Cost Avoidance

Without the proposed project, the University would need to rely substantially on diesel-powered generators to operate facilities at the Permanent Campus. For a campus containing academic buildings, laboratories, hostels, staff quarters, water-supply systems, healthcare facilities, security installations and street lighting, this would require considerable fuel

consumption. The proposed solar-hybrid system will reduce the operating hours of diesel generators and limit their use mainly to exceptional circumstances, emergency support or periods of major maintenance where required. Avoided diesel expenditure will include:

- Fuel procurement;
- Transportation and storage of diesel;
- Lubricants and consumables;
- Routine servicing;
- Repairs and replacement of generator components;
- Management of waste oil and contaminated materials; and
- Costs associated with generator downtime.

The actual financial savings will depend on the final campus electricity load profile particularly given the limited availability of power grid in the school area (*yet to be connected to the national grid*), generator efficiency, prevailing diesel prices and the proportion of electricity supplied by the solar photovoltaic and battery systems.

### 2.2.4 Institutional Financial Sustainability

Reliable electricity will improve the University's ability to use its facilities efficiently and deliver its academic, medical and research mandate. Reduced expenditure on diesel generation will allow a greater proportion of institutional resources to be directed towards teaching, laboratory development, healthcare training, research, maintenance and student services.

Long-term financial sustainability will depend on:

- Effective operation and preventive maintenance;
- Appropriate metering and energy-management systems;
- Budgetary provision for equipment replacement;
- Training of University technical personnel;
- Proper management of battery and inverter replacement cycles;
- Monitoring of electricity demand and system performance; and
- Clear arrangements between REA, the University and the appointed operation and maintenance contractor.

Where a cost-recovery or service-charge arrangement is adopted, it should be developed in consultation with the University and should be transparent, affordable and adequate to support routine operation, maintenance and future replacement of major components.

### 2.2.5 Environmental and Climate Justification

Solar photovoltaic generation produces electricity without the routine combustion of fossil fuels. Its operation therefore avoids most of the greenhouse gas emissions, exhaust gases, particulate matter, noise and waste oil associated with diesel-powered generation.

The environmental and climate benefits include:

- Reduction in carbon dioxide emissions;
- Reduction in nitrogen oxides, sulphur oxides and particulate emissions;
- Reduction in generator-related noise;
- Reduced handling and storage of diesel fuel;
- Lower risk of fuel and lubricant spills;
- Reduced generation of waste oil, filters and contaminated materials; and
- Contribution to Nigeria's climate-change mitigation and renewable-energy objectives.

The project will nevertheless require careful environmental management during construction and operation, particularly in relation to vegetation clearance, erosion control, stormwater drainage, battery safety, electrical and electronic waste, accidental spills and end-of-life equipment management.

### 2.2.6 Social and Developmental Justification

The proposed project will support the University's role in medical education, health-sciences training, research and healthcare manpower development. A reliable electricity supply will improve the functionality of teaching laboratories, ICT facilities, administrative systems, water-supply infrastructure, student accommodation and campus security installations.

The anticipated social and developmental benefits include:

- Improved teaching and learning conditions;
- Enhanced laboratory and research capacity;
- Reliable operation of medical and scientific equipment;
- Improved access to digital learning resources;
- Improved water supply and sanitation services;
- Better campus illumination and security;
- Employment opportunities during construction and operation;
- Skills development and transfer of renewable-energy knowledge;
- Increased demand for local goods and services; and
- Improved institutional capacity to deliver health-sciences education and research.

The project is not expected to cause physical displacement because the proposed site lies within University-owned land designated for institutional development.

### 2.2.7 Strategic Alignment with Rural Electrification Objectives

The Rural Electrification Agency is responsible for expanding access to reliable electricity through grid extension, mini-grid, standalone and other decentralized energy solutions. The proposed FUHSO project is consistent with this mandate because it will provide dedicated electricity to a public institution whose Permanent Campus presently lacks a dependable power supply.

The project aligns with REA's objectives by:

- Extending electricity access to an inadequately served public institution;
- Promoting renewable and decentralized power generation;
- Supporting productive and institutional use of electricity;
- Reducing reliance on fossil-fuel-based self-generation;
- Demonstrating the application of solar-hybrid technology in tertiary education;
- Improving environmental and social outcomes through clean-energy investment; and
- Supporting the wider objectives of the Nigeria Electrification Project and Desert to Power Programme.

Overall, the project is considered necessary to enable the effective use and future expansion of the FUHSO Permanent Campus. It provides a technically appropriate and environmentally preferable response to the University's electricity requirements while delivering long-term institutional, economic, environmental and social benefits.

## 2.3 Value of the Project

The project is co-financed by the African Development Bank and the funding covers Engineering, Procurement, and Construction (EPC) as well as Operations & Maintenance (O&M) contracts. These contracts will be awarded to competitively selected EPC contractors who will build, operate, and maintain the power plants at each site. While the project is primarily for institutional consumption, non-monetary value is realized through:

- Reduced operating expenditures;
- Reallocation of savings to academic development;
- Potential energy research commercialization;
- Contribution to the Nigeria's NDC commitment to cut carbon emission by 20% by the year 2030, under the Paris Agreement;
- Avoided GHG emissions and improved environmental performance; and
- Reduced generator maintenance expenditure.

## 2.4 Benefits of the Project

The proposed project is expected to generate substantial direct and indirect benefits during its construction and operational phases. These benefits will primarily accrue to FUHSO, its students and staff, while also supporting local economic activity and national renewable-energy objectives.

The potential benefits include:

**a. Academic and Research Benefits**

- Reliable electricity for teaching and learning activities;
- Improved operation of laboratories and research equipment;
- Reduced interruption of practical and clinical training;
- Improved access to digital learning platforms and online resources;
- Enhanced capacity for medical and health-sciences research; and
- Improved preservation and handling of temperature-sensitive laboratory materials.

**b. Institutional and Operational Benefits**

- Reliable electricity for administrative and support services;
- Improved operation of water-supply and sanitation systems;
- Reduced equipment downtime;
- Better planning of academic and institutional activities;
- Reduced dependence on emergency generators; and
- Improved use of facilities under construction at the Permanent Campus.

**c. Environmental Benefits**

- Reduced consumption of diesel fuel;
- Reduced carbon dioxide and other combustion emissions;
- Reduced noise from generator operation;
- Reduced generation of waste oil and contaminated maintenance materials;
- Reduced risk of diesel spills; and
- Increased use of renewable energy.

**d. Health, Safety and Security Benefits**

- Improved campus illumination;
- Reliable power for security and surveillance systems;
- Improved operation of healthcare and emergency-response equipment;
- Reduced exposure to generator exhaust and noise;

- Improved working and residential conditions; and
- Safer movement within the campus during periods of low natural light.

**e. Economic Benefits**

- Savings on diesel procurement;
- Reduced generator maintenance expenditure;
- Employment opportunities during construction;
- Opportunities for local contractors and suppliers;
- Skills acquisition and technical capacity development; and
- Increased economic activity associated with the development of the Permanent Campus.

**f. National and Strategic Benefits**

- Contribution to Nigeria's renewable-energy objectives;
- Support for the Energy Transition Plan;
- Contribution to greenhouse gas emission reduction;
- Demonstration of decentralized solar-hybrid electricity in a public institution;
- Advancement of the objectives of the Nigeria Electrification Project; and
- Strengthening of collaboration among REA, FUHSO, AfDB and relevant government institutions.

The benefits associated with comparable REA university solar projects include improved academic activity, reduced fossil-fuel use, lower electricity costs, employment creation, increased local procurement and support for Nigeria's climate commitments.

## 2.5 Sustainability of the Project

The long-term success of the proposed project will depend on the continued technical performance of the solar-hybrid system, adequate funding for operation and maintenance, effective environmental management and sustained institutional and stakeholder support.
Project sustainability is considered under the following headings:

- Technical sustainability;
- Social sustainability;
- Economic sustainability; and
- Environmental sustainability.

### 2.5.1 Technical Sustainability

Technical sustainability refers to the ability of the project to operate safely, efficiently, and reliably over its intended lifespan (at least 25 years). For the proposed 2 MW solar hybrid plant project at FUHSO, the technical sustainability is embedded in the project's procurement structure (ensuring certified equipment/materials are used), engineering oversight, operational framework, and capacity development strategy led by the Rural Electrification Agency (REA). The project will be designed, constructed and commissioned by a suitably qualified Engineering, Procurement and Construction (EPC) contractor selected by REA through an approved competitive procurement process.

An EPC Framework shall be developed and the selection process will follow pre-established technical, financial, and performance criteria consistent with national procurement standards and international best practices. Under this framework:

- REA's qualified engineers will provide oversight during design and construction;
- The EPC contractor will assume full responsibility for detailed engineering design;

- All equipment procurement will comply with approved technical specifications and international standards (e.g., IEC-certified components);
- Installation will adhere to quality assurance and quality control (QA/QC) protocols;
- Testing and commissioning will follow structured acceptance procedures;
- Performance guarantees will be contractually binding.

This structured EPC approach shall ensure that system design is optimized, construction quality is verified, and long-term performance risks are minimized. Additionally, technical sustainability is reinforced by requiring the EPC contractor to:

- Conduct detailed site-specific engineering studies;
- Prepare structural, electrical, and protection system designs;
- Undertake geo-technical assessments to ensure stable mounting foundations;
- Provide grid interconnection studies;
- Develop protection coordination and earthing designs.
- Develop comprehensive Operation Manuals and Maintenance Manuals; Equipment datasheets; Protection and control schematics; Emergency response procedures; Preventive maintenance schedules etc;
- Ensure that all installations undergo Factory Acceptance Tests (FAT) and Site Acceptance Tests (SAT) prior to commissioning as well as conducting Performance Ratio Verification and system output validation before handover.

**Equipment Quality Assurance, OEM Standards and Regulatory Compliance**
Technical sustainability is strengthened using equipment from reputable Original Equipment Manufacturers (OEMs) with proven performance, warranties, spare parts availability, and technical support to ensure long-term reliability and reduce the risk of failure. All major components, including solar PV modules, inverters, batteries, transformers, switchgear, and protection devices, shall comply with relevant international standards and Nigerian regulatory requirements. Equipment shall be certified by the Standards Organisation of Nigeria (SON) and meet Mandatory Conformity Assessment Programme (MANCAP) requirements, where applicable. Electrical installations shall also be inspected and certified by the Nigerian Electricity Management Services Agency (NEMSA) prior to commissioning to ensure compliance with national safety standards. Installation, testing, commissioning, and maintenance shall be carried out by qualified and certified personnel in accordance with NEMSA requirements and industry best practices to ensure safe and reliable operation.

### 2.5.2 Social Sustainability

Social sustainability requires continued support from the University community, host community, regulatory authorities and other relevant stakeholders.
Measures supporting social sustainability include:

- Early and continuous stakeholder engagement;
- Disclosure of relevant project information;
- Implementation of a Stakeholder Engagement Plan;
- Operation of an accessible Grievance Redress Mechanism;
- Transparent communication on construction activities;
- Consideration of local employment opportunities;
- Protection of workers and surrounding communities;
- Prevention of gender-based violence, harassment and discrimination;
- Maintenance of campus access and security; and

- Timely resolution of complaints.

Stakeholder consultations undertaken during the ESIA established an initial basis for cooperation among FUHSO management, environmental regulators and Akwete-Akpa Community. Continued engagement will be required throughout construction, operation and decommissioning.

### 2.5.3 Economic Sustainability

Economic sustainability will depend on the ability of the project to meet the University's electricity needs while generating sufficient savings or revenue to support routine operation, maintenance and future component replacement.

Measures supporting economic sustainability include:

- Reduction in diesel and generator-maintenance expenditure;
- Provision of annual operation and maintenance budgets;
- Accurate metering of electricity generation and consumption;
- Energy-efficiency and demand-management measures;
- Establishment of a maintenance reserve;
- Financial planning for battery and inverter replacement;
- Appropriate contractual arrangements for O&M services; and
- Periodic review of project operating costs and performance.

Any service-charge or cost-recovery mechanism adopted for campus users should be developed through consultation and should balance affordability with the need to maintain the facility.

The project will also contribute indirectly to the University's financial sustainability by reducing electricity-related interruptions, protecting sensitive equipment and improving the productivity of academic and administrative services.

### 2.5.4 Environmental Sustainability

The principal environmental advantage of the project is the use of solar energy, which produces electricity without routine fuel combustion. Environmental sustainability will, however, require effective management of construction impacts and operational materials throughout the project lifecycle.

The principal measures include:

- Implementation of the approved ESMP;
- Restriction of vegetation clearance to the approved footprint;
- Conservation and reuse of suitable topsoil;
- Erosion and sediment control;
- Maintenance of natural drainage patterns;
- Pollution and spill prevention;
- Controlled storage of fuels and chemicals;
- Proper management of general and hazardous waste;
- Safe operation and monitoring of the battery system;
- Periodic environmental monitoring;
- Restoration of disturbed areas; and
- Responsible recycling or disposal of end-of-life equipment.

### 2.5.5 Solar E-Waste and End-of-Life Management

Solar modules, batteries, inverters, cables, transformers and control equipment will eventually require replacement or disposal. These materials shall be managed in accordance with applicable environmental regulations and the waste-management hierarchy.

End-of-life management shall include:

- Maintenance of an equipment and waste inventory;
- Manufacturer take-back arrangements where available;
- Reuse of serviceable components;
- Recycling through approved facilities;
- Use of licensed hazardous and electronic-waste contractors;
- Secure temporary storage;
- Documentation of collection and disposal; and
- Prohibition of uncontrolled dumping, burning or dismantling.

Provision for replacement and end-of-life management should be incorporated into the project's financial and operational planning from the commencement of operations.

## 2.6 Project Alternatives

The consideration of alternatives is an integral component of the Environmental and Social Impact Assessment (ESIA) process. It provides an opportunity to evaluate feasible options and demonstrate that the selected project design represents the most appropriate solution from technical, environmental, economic and social perspectives. For the proposed 2 MW Solar Photovoltaic (PV) Hybrid Power Project and Associated Infrastructure at the Federal University of Health Sciences, Otukpo (FUHSO), the assessment of alternatives focused primarily on the power generation technology and associated system components. This approach was adopted because the proposed project site is located entirely within the University's Permanent Campus, where sufficient land has already been designated for future institutional development. Consequently, alternative locations were not actively pursued, as no technical, environmental or land-use constraints were identified that would necessitate relocation of the proposed development.

### 2.6.1 Project Site Selection

The proposed Solar PV facility will be developed on approximately 10 hectares (100,235.02 $m^2$) of land within the Permanent Site of the Federal University of Health Sciences, Otukpo. The selected site forms part of the University's master-planned campus and is entirely owned by the University. Field investigations confirmed that the proposed location consists of relatively level, undeveloped land covered predominantly by secondary Guinea Savannah vegetation with no permanent buildings, residential structures or existing institutional facilities within the immediate project footprint. At the time of the ESIA study, the surrounding campus infrastructure was still under construction and none of the nearby buildings had been commissioned or occupied.

The selected site was considered suitable for the proposed development because it:

- is located entirely within University-owned land;
- provides sufficient space for the proposed 2 MW Solar PV facility and associated infrastructure;
- does not require land acquisition or involuntary resettlement;
- does not affect existing academic or residential facilities;
- is easily accessible through the internal campus road network;
- is located close to the planned electricity demand centres within the Permanent Campus; and
- possesses favourable topographic and environmental characteristics for utility-scale solar development.

Considering these factors, the proposed location was considered appropriate for the project and no alternative site assessment was considered necessary.

**Table 2.1: Basis for Selection of the Proposed Project Site**

| Selection Criterion | Assessment |
|---|---|
| **Land ownership** | Located entirely within FUHSO Permanent Campus. |
| **Land availability** | Approximately 10 ha of undeveloped land available for the project. |
| **Existing structures** | No completed buildings or occupied facilities within the project footprint. |
| **Resettlement requirement** | No land acquisition or physical displacement required. |
| **Accessibility** | Easily accessible through the campus access road. |
| **Topography** | Generally, level to gently undulating terrain suitable for solar PV installation. |
| **Environmental sensitivity** | No environmentally sensitive features identified within the proposed footprint. |
| **Overall suitability** | Suitable for the proposed development. |

### 2.6.2 Power Generation Alternatives

The principal objective of the proposed project is to provide reliable, sustainable and cost-effective electricity to the Permanent Campus of the Federal University of Health Sciences, Otukpo. In achieving this objective, three electricity supply options were considered, namely continued reliance on diesel generators, dependence on the national electricity grid and the installation of a solar photovoltaic hybrid power system. Continued dependence on diesel generators would require substantial expenditure on fuel, maintenance and equipment replacement while contributing to greenhouse gas emissions, air pollution and noise generation. Similarly, sole dependence on the national grid would not provide the level of reliability required for a specialized medical university because of the well-recognized challenges associated with grid instability and intermittent power supply. The proposed Solar PV Hybrid System combines solar photovoltaic generation with battery energy storage to provide reliable electricity throughout the day and night while significantly reducing dependence on fossil-fuel-based electricity generation. The system also aligns with the objectives of the Nigeria Electrification Project (NEP II) and the Rural Electrification Agency's commitment to expanding the use of renewable energy technologies within public institutions. Accordingly, the Solar PV Hybrid System represents the most appropriate power supply option for the proposed development.

**Table 2.2: Comparison of Power Generation Alternatives**

| Alternative | Advantages | Limitations | Decision |
|---|---|---|---|
| **Diesel Generation** | Proven technology and independent power supply. | High fuel and maintenance costs, air emissions, noise and greenhouse gas emissions. | Not Preferred |
| **National Grid Supply** | No on-site generation infrastructure required. | Subject to grid instability and unreliable electricity supply. | Not Preferred |
| **Solar PV Hybrid System** | Renewable energy source, reliable electricity supply, low operating cost and reduced environmental impacts. | Higher initial capital investment. | **Preferred Option** |

### 2.6.3 Solar Power Technology Alternatives

Solar power generation is currently one of the fastest growing areas in renewable energy. Beyond panel production, it does not emit any significant GHGs. Compared to alternative renewable generation technologies such as wind turbines or biofuel generators, Solar energy is produced by converting the sun's radiation – a process void of any smoke, gas, or other chemical by-product, which makes this technology to meet the clean development mechanism of the Kyoto Protocol. This is the main driving force behind all green energy technology, as nations attempt to meet climate change obligations in curbing emissions. The use of solar energy for the proposed power plant in FUHSO Benue will significantly avoid the generation of GHG emissions associated with fossil-fuelled power plants. Thus, the proposed Project will help contribute to Nigeria's NDC on climate change. In addition, the relatively high solar irradiation within the Benue State region (as indicated in Figure 2.1) will be able to support the proposed power plant.

The solar technologies considered for the proposed power plant in FUHSO Benue are:

- Concentrated Solar Power (CSP) Systems
- Photovoltaic (PV) Solar Panels

However, the preferred option for the proposed power plant is the use of PV Solar Panel since it is highly flexible and requires low installation and maintenance cost in comparison to CSP technology. Water requirement for PV system is also low when compared to CSP system. The comparison between CPS and PV Solar technologies considered for the Project is summarized in Table 2.3.

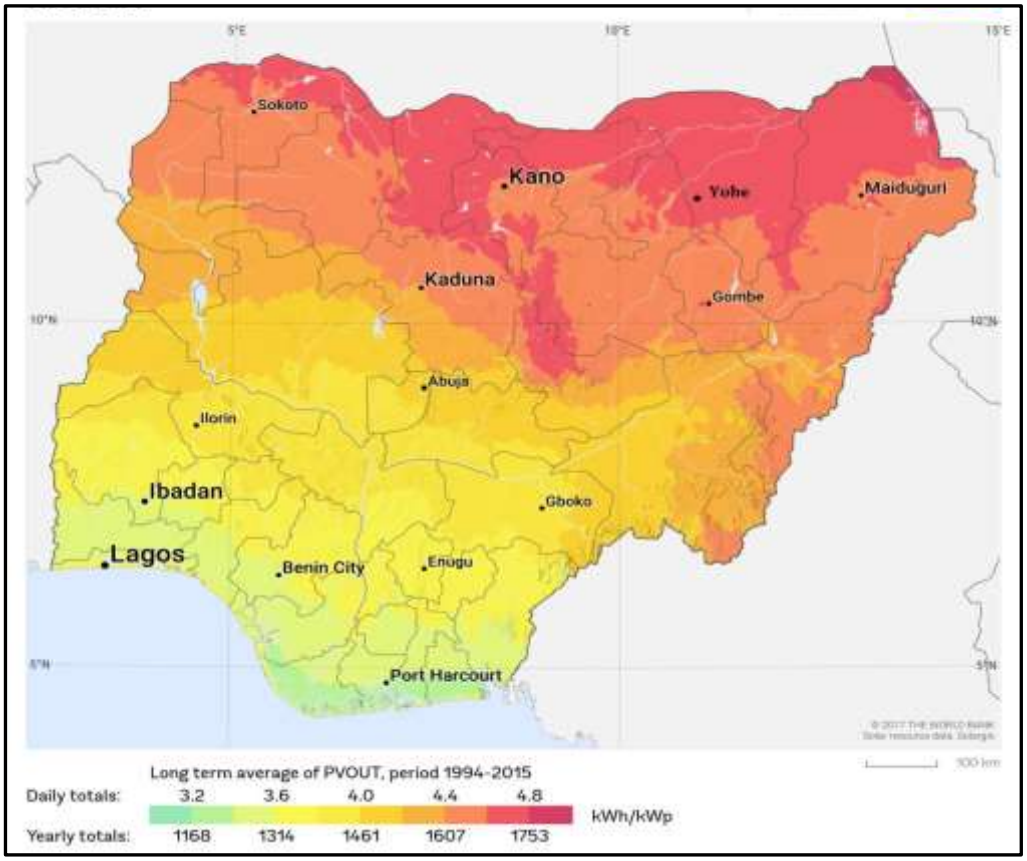



**Figure 2.1: Photovoltaic power potential of Nigeria**
*(**Source**: The World Bank, Solar resource data: Solargis)*

**Table 2.3: Comparison between CSP and PV Solar Technology**

| Features | CSP Technology | PV Technology |
|---|---|---|
| **Description** | CSP technology uses concentrated radiation from the sun, to heat a liquid substance which is used to generate steam which in turn passes through a steam-turbine to generate electricity. CSP Technology produces electricity through indirect means. Energy output with CSP technology is of AC type | PV technology uses sunlight through the 'photovoltaic effect' to generate direct electric current (DC). PV Technology produces electricity through direct means. Energy output with PV technology is of DC type but commonly converted to AC through an inverter. |
| **Applications/Scale** | CSP is used for utility scale power generation, mostly for Grid Connections, and also supporting conventional thermal power and desalination plants. | PV technology is suitable for off grid small and medium-sized applications, and for utility scale applications |
| **Land requirement** | CSP technology is best suited for areas of high direct normal solar radiation. CSP technology requires about 4 hectares of land per MW of capacity | PV technology has a wider geographical area of application.<br>PV technology requires about 2 hectares of land per MW of capacity |
| **Land requirement** | CSP technology is best suited for areas of high direct normal solar radiation. CSP technology requires about 4 hectares of land per MW of capacity | PV technology has a wider geographical area of pplication. PV technology requires about 2 hectares of land per MW of capacity |
| **Cost** | CSP technology has an high installation and maintenance cost compared to PV | PV technology has a low installation and maintenance cost in comparison to CSP |
| **Construction Time** | CSP plant construction is technical more complex than PV | Utility scale PV plants are easier to install and require less time than CSP for Plant construction |
| **Water Requirement** | Water requirement is variable depending on the CSP technology option adopted. CSP may utilize wet, dry, and hybrid cooling techniques | Typically requires less water than CSP technology. Water is occasionally required for cleaning of dust from the panels |
| **Design Options** | Less flexible in comparison to PV technology. Can be hybridized with fossil fuels like natural gas. | Highly flexible and adaptable to the project specific requirement |
| **Average life span** | 25 years | 25 years |
| **Efficiency** | Power production efficiency of CSP technology are as high as 45% | Power production fluctuates with the sunlight's intensity. For practical use this usually requires conversion to certain desired voltages or AC, through the use of inverters. |
| **Environmental Risks** | CSP systems have been recorded to pose environmental risks to bird species, which may be killed by the intense heat generated by the concentrated solar radiation which is reflected off the mirrors. | PV systems are considered to be generally benign. |

### 2.6.3 Panel Technology Alternatives Considered

Three commercially available photovoltaic panel technologies were reviewed during project planning, namely Monocrystalline, Polycrystalline and Thin-Film solar panels. Monocrystalline panels generally provide the highest conversion efficiency, require less land area for the same power output and have longer service lives. Polycrystalline panels are relatively less expensive but produce lower energy output per unit area. Thin-film panels perform well under certain environmental conditions but require significantly larger installation areas to achieve comparable electricity generation. Considering the available project footprint, expected energy demand and long-term operational efficiency, **Monocrystalline photovoltaic panels** are considered the most suitable technology for the proposed project.

**Table 2.4: Comparison of PV Panel Technologies**

| Feature | Monocrystalline | Polycrystalline | Thin-Film |
|---|---|---|---|
| Efficiency | High | Moderate | Low to moderate |
| Land requirement | Lowest | Moderate | Highest |
| Capital cost | Relatively high | Moderate | Variable |
| Market availability | High | High | More limited |
| Temperature performance | Moderate | Moderate | Generally good |
| Suitability for FUHSO | **Highly suitable** | Suitable | Less suitable |



**Figure 2.2: Typical appearance of mono-crystalline silicon PV panels**



**Figure 2.3: Typical Appearance of Polycrystalline Silicon PV panels**



**Figure 2.4: Typical appearance of Thin-Film CdTe panels**

### 2.6.4 Solar Battery Alternatives Considered

Battery Energy Storage Systems (BESS) are essential components of the proposed solar-hybrid power system because they store excess electricity generated during daylight hours for use during periods of low solar radiation or at night. The battery technologies evaluated include Lead-Acid, Lithium-Ion, Nickel-Cadmium and Flow Batteries. Lead-acid batteries are relatively inexpensive but have shorter service lives, lower energy density and higher maintenance requirements. Nickel-Cadmium batteries are durable but contain hazardous materials and are less environmentally desirable. Flow batteries have excellent operational life but remain costly and are not widely deployed for institutional solar systems in Nigeria. Lithium-Ion batteries offer high energy density, longer operational life, faster charging, minimal maintenance requirements and superior overall lifecycle performance. These features make them the preferred option for the proposed project.

**Table 2.5: Comparison of Battery Technologies**

| Feature | Lead-Acid | Lithium-Ion | Nickel-Cadmium | Flow Battery |
|---|---|---|---|---|
| Capital cost | Low | Moderate to high | High | High |
| Energy density | Low | High | Moderate | Low |
| Depth of discharge | Limited | High | High | Very high |
| Maintenance | Moderate to high | Low | Low | Moderate |
| Cycle life | Short to moderate | Long | Long | Very long |
| Environmental concern | Lead and acid | Fire and end-of-life management | Cadmium toxicity | Electrolyte management |
| Space requirement | High | Low | Moderate | High |
| Suitability | Limited | **Preferred** | Low | Limited |

## 2.7 Project Development Options

Three development scenarios were considered for the proposed project, namely the No Project Option, Delayed Project Option and Go-Ahead Option.

### 2.7.1 No Project Option

Under this option, the proposed project would not be implemented. Consequently, the University would continue to depend on unreliable electricity supply and diesel-powered generators to support future activities at the Permanent Campus. This would result in continued high operating costs, increased greenhouse gas emissions and delayed realization of the academic, environmental and socio-economic benefits associated with the project.

### 2.7.2 Delayed Project Option

This option involves postponing project implementation until a later date. While this may allow additional time for planning or financing, it would delay the provision of reliable electricity to the Permanent Campus, increase project costs due to inflation and postpone the environmental and developmental benefits expected from the project.

### 2.7.3 Go-Ahead Option

The Go-Ahead Option involves implementing the project as proposed, subject to regulatory approval and implementation of the recommended mitigation measures. This option will provide reliable and sustainable electricity, reduce dependence on fossil fuels, improve educational and research activities, enhance campus security, stimulate local economic activities and contribute to Nigeria's renewable energy and climate change objectives.

**Table 2.6: Comparison of Project Development Options**

| Option | Overall Assessment | Decision |
|---|---|---|
| **No Project** | Project benefits will not be realized and reliance on diesel generation will continue. | Not Preferred |
| **Delayed Project** | Benefits deferred and project costs likely to increase. | Not Preferred |
| **Go-Ahead Project** | Delivers the greatest technical, environmental, economic and social benefits. | **Preferred Option** |

# CHAPTER THREE
# PROJECT DESCRIPTION

## 3.1 Introduction

This chapter describes the proposed 2 MW Solar Photovoltaic (PV) Hybrid Power Project and Associated Infrastructure to be developed within the Permanent Site of the Federal University of Health Sciences, Otukpo (FUHSO), Benue State, Nigeria. It provides an overview of the project components, implementation activities, engineering requirements and operational characteristics, forming the basis for the subsequent environmental and social impact assessment. The proposed project forms part of the Nigeria Electrification Project (NEP) Phase II – Desert-to-Power (DtP) Programme, being implemented by the Rural Electrification Agency (REA) with financial support from the African Development Bank (AfDB). The project is intended to provide reliable, sustainable and environmentally friendly electricity to support academic, research, administrative and residential activities within the University's Permanent Campus.

The proposed development comprises the design, procurement, construction, installation, testing, commissioning, operation and maintenance of a utility-scale solar-hybrid electricity generation system together with all associated electrical and civil infrastructure required for efficient operation of the facility. The project will occupy approximately 10 hectares (100,235.02 m²) of land at approximately Latitude 7.067222° N, and Longitude 8°05′46″ E (WGS 84) within the University's Permanent Campus. At the time of the ESIA study, the project area consisted of undeveloped greenfield land characterized by secondary Guinea Savannah vegetation and gently undulating terrain. No completed institutional buildings or occupied facilities were located within the proposed project footprint.



**Plate 3.1: Proposed Project Site**

The project has been designed to improve energy reliability at the Permanent Campus while reducing dependence on fossil-fuel-based electricity generation. The hybrid configuration combines photovoltaic electricity generation with battery energy storage to provide stable electricity supply during periods of reduced solar radiation and outside daylight hours.
The major infrastructure proposed under the project includes:

- Solar Photovoltaic (PV) Farm;

- Battery Energy Storage System (BESS);
- Power Station/Substation;
- Underground Medium-Voltage Distribution Network;
- Control Building;
- Renewable Energy Workshop and Training Centre;
- Internal Access Roads;
- Laydown and Staging Area;
- Weather Monitoring Station;
- Solar-powered Street Lighting; and
- Other ancillary electrical and civil infrastructure required for safe and efficient operation.

The proposed facility has been planned to comply with applicable engineering standards, environmental regulations and international good practice applicable to utility-scale solar photovoltaic developments. The project has also been designed to minimize adverse environmental and social impacts through appropriate site selection, engineering design, environmental management and implementation of mitigation measures identified in this ESIA. A summary of the proposed project is presented in Table 3.1.

**Table 3.1: General Description of the Proposed Project**

| Project Item | Description |
|---|---|
| Project Title | 2 MW Solar Photovoltaic (PV) Hybrid Power Project and Associated Infrastructure |
| Project Proponent | Rural Electrification Agency (REA) |
| Beneficiary Institution | Federal University of Health Sciences, Otukpo (FUHSO) |
| Project Location | Permanent Site, FUHSO, Otukpo, Benue State, Nigeria |
| Funding Programme | Nigeria Electrification Project (NEP) Phase II – Desert-to-Power (DtP) |
| Funding Agency | African Development Bank (AfDB) |
| Installed Capacity | 2 MW Solar PV Hybrid System |
| Project Footprint | Approximately 10 ha (100,235.02 m²) |
| Development Type | Greenfield Development |
| Electricity Source | Solar Energy with Battery Energy Storage |
| Expected Operational Life | Approximately 25 years |

## 3.2 Key Project Components

The proposed project comprises a number of integrated electrical and civil engineering facilities designed to operate as a single solar-hybrid power system. Collectively, these components will generate, store, control and distribute electricity to the Permanent Campus of the Federal University of Health Sciences, Otukpo.

The principal project components include:

- Solar Photovoltaic (PV) Farm;
- Battery Energy Storage System (BESS);
- Power Station/Substation;
- Underground Medium-Voltage Distribution Network;
- Control Building;
- Renewable Energy Workshop and Training Centre;
- Internal Access Roads;
- Laydown and Staging Area;

- Weather Monitoring Station;
- Solar-powered Street Lighting; and
- Associated security, drainage and ancillary infrastructure.

The overall arrangement of these facilities will be optimized during the detailed engineering design stage to achieve maximum operational efficiency while minimizing environmental disturbance and ensuring compliance with applicable engineering standards. The general project layout is expected to incorporate appropriate setbacks, internal circulation routes, drainage systems, equipment foundations, cable routes and security installations to support safe operation throughout the project lifecycle.

The power plant will use solar panels fitted on fixed structures (mounts). The main characteristics of the fixed mounted structure is stated in Table 3.2. The advantages of solar energy include its non-polluting nature; it is non-depletable, reliable, and free fuel. The disadvantages of solar energy are that the solar energy concentration is very dilute, so collectors with large surface area are needed. In addition, solar radiation is neither constant nor continuous for terrestrial applications (i.e. low capacity factor). The solar energy received depends on latitude, season, time-of-day, and atmospheric conditions.

**Table 3.2: Main characteristics of the fixed mounting structure**

| **Fixed structure characteristics** | |
|---|---|
| Structure type | 1H |
| Tilt angle | 9.0 ° |
| Poles type | Bi pole |
| Pitch distance | 3.04 m |
| Designed for | MONOFACIAL modules |
| Minimum ground clearance | 0.2 M |
| Gap between modules in the axis direction | 0.0 mm |
| Gap between modules in the pitch direction | 0.0 mm |

*(**Source**: REA EEP 3 FEED)*

Table 3.3 gives a summary of the project's characteristics and Figure 3.1 shows the electrical configuration of the PV plant.

**Table 3.3: Key Project Characteristics**

| **Main characteristics** | |
|---|---|
| Location | Nigeria, Otukpo, Benue State |
| Rated power (AC) | 4180.0 kWac |
| Peak Power (DC) | 5018.3 kWdc |
| Ratio DC/ AC | 1.20 |
| **Civil characteristics** | |
| Suitable plot area | 10.20 ha |
| Ground coverage ratio (GCR) | 32.00 % |
| Structure type | Fixed structure |
| Pitch distance | 3.07m |
| **Electrical characteristics** | |
| PV modules 335.0 (Wp) | 14980 |
| Power station (up to 1980.0 kW) | 3 |
| Number of inverters (up to 110.0 KVA) | 38 |

| Environmental Characteristics | |
|---|---|
| Gaseous Emissions | None |
| Discharges | Uncontaminated storm water to be diverted around plant, to be made discharged to natural watercourses as appropriate. |
| Noise | < 15 dB(A) at nearest noise sensitive premises<br>≤ 15 dB(A) at plant boundary |
| Roads | An existing single road offering access to the field will be rehabilitated within the university to link the plants perimeter. All other means of transportation will be held within the boundaries of the field. |

*(**Source**: REA EEP 3 FEED)*

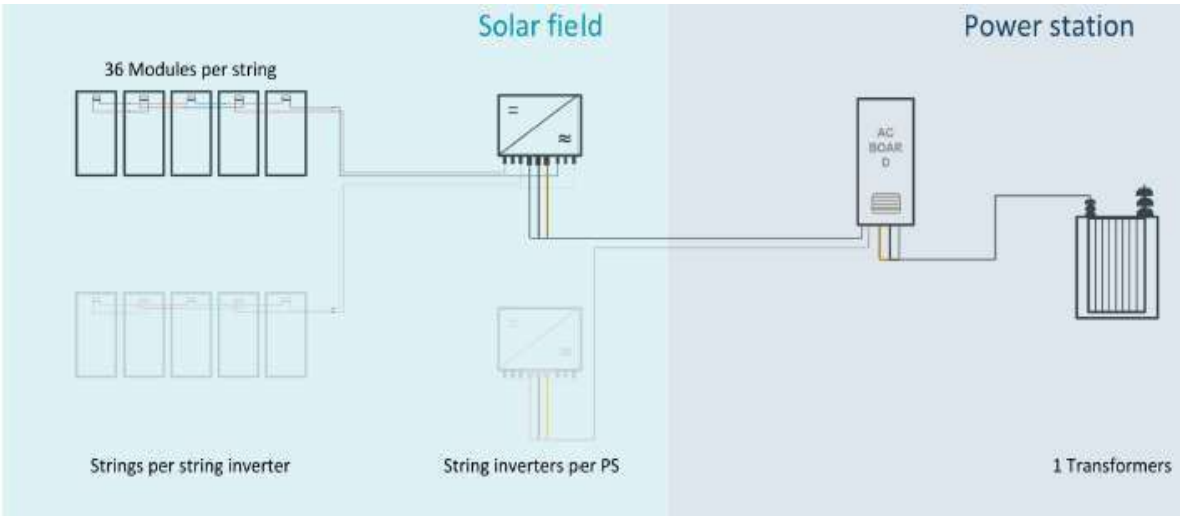



**Figure 3.1: Simplified electrical configuration diagram**

*(**Source**: REA EEP 3 Front End and Engineering Design)*

### 3.2.1 Component 1: Solar PV Farm

- *Solar PV Modules*

A PV cell is a semiconductor device that converts sunlight into electricity using photovoltaic effect. Multiple cells can be combined to form a PV module. The efficiency of a PV module is measured by its ability to absorb light particles called photons. The more photons that are absorbed, the more efficient the panel is at converting light into electricity. The proposed solar farm would consist of arrays modules, mounted on fixed structures to obtain a total project capability of about 2,000 (kWp) of direct current (DC). The feedstock (solar radiation) is readily available as a byproduct from sunlight, and the long-term supply is guaranteed. The panels are generally considered to have a lifetime of upwards of 30 years. The selected minimum reference photovoltaic module has a peak power of 415.0 W, and the technology of the cells is Si-poly. The features of the photovoltaic module are shown in Table 3.4, an example picture of a Monofacial Si-poly module is shown in Figure 3.2.

**Table 3.4: Photovoltaic module characteristics**

| **Main characteristics** | |
|---|---|
| Technology | Si-poly |
| Type of module | Monofacial |
| Maximum voltage | 1500 V |
| **Standard test conditions (STC)** | |
| Peak power | 415.0 W |
| Efficiency | 18.79 % |
| MPP voltage | 39.3 V |
| MPP current | 10.55 A |
| Open circuit voltage | 47.8 V |
| Short circuit current | 11.14 A |
| **Temperature coefficients** | |
| Power coefficient | -0.370 %/°C |
| Voltage coefficient | -0.291 %/°C |
| Current coefficient | 0.050 %/°C |
| **Mechanical characteristics** | |
| Length | 2108.0 mm |
| Width | 1048.0 mm |
| Thickness | 0.04 mm |
| Weight | 24.9 kg |

*(**Source**: REA SEEP 3 FEED)*



**Figure 3.2: Example of a Monofacial Si-poly photovoltaic module**

*(**Source**: REA EEP 3 FEED)*

❖ Inverters

Inverters are installed in the containers or outside on proper mounting solution. Inverter receives DC electrical energy that flows from photovoltaic panels and transforms it into AC electrical energy that is passed to the national grid. The inverter adapts itself to the photovoltaic string to get the maximum electrical energy available and pass it to the grid. This method is called Maximum Power Point Tracking (MPTT). In Figure 3.3, a commonly used photovoltaic inverter for utility-scale PV plant. is presented, and its characteristics detailed in Table 3.5. The single line diagram for the inverter is shown in Figure 3.4.



**Figure 3.3: Example of string photovoltaic inverter**

*(**Source**: REA EEP 3 FEED)*

**Table 3.5: Inverter characteristics**

| **Inverter characteristics** | |
|---|---|
| **Main characteristics** | |
| Inverter type | STRING |
| Maximum DC to AC conversion efficiency | 98.79 % |
| **Input side (DC)** | |
| MPPT search range | 880- 1300 V |
| Maximum input voltage | 1500 V |
| **Output side (AC)** | |
| Rated power | 110.0 Kva |
| Power at 30 C (datasheet) | 110.0 kVA |
| Power at 50 C (datasheet) | 100.0 kVA |
| Output voltage | 800 V |
| Output frequency | 50 Hz |

*(**Source**: REA EEP 3 FEED)*

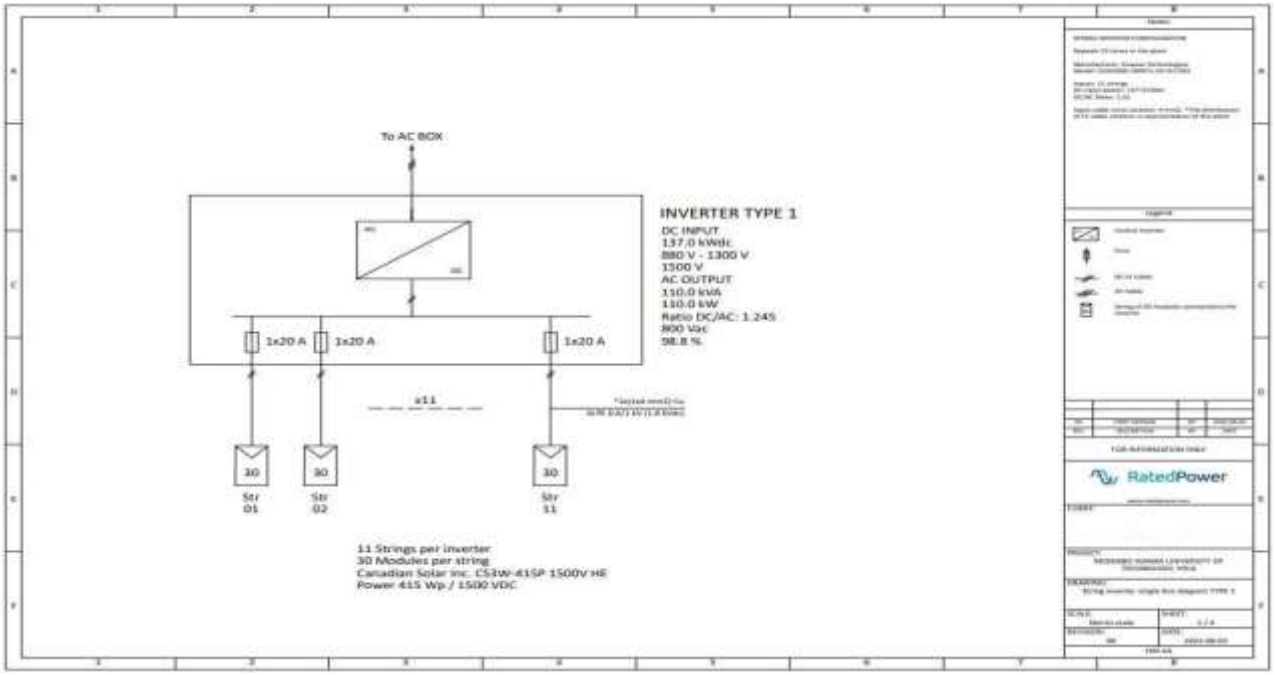



**Figure 3. 4: String Inverter Single Line Diagram**
*(**Source**: EEP3 FEED)*

❖ Transformers

All inverters are connected to a transformer. The role of the transformers is to step- up the voltage from an inverter nominal voltage to a medium voltage of the national grid. Transformers consist of three coils. One coil is connected to the high voltage; two coils are connected to each of the inverter unit's master / slave. The proposed project layout comprising the solar power plant site and transmission line have taken into account the solar radiation, wind direction and evacuation corridor. An example of a power transformer is shown in Figure 3.5.



**Figure 3. 5: Example of Transformer**
*(**Source**: REA EEP 3 FEED)*

The main features of the power transformer are shown in Table 3.6.

**Table 3.6: Transformer characteristics**

| Transformer characteristics | |
|---|---|
| Rated power | 1980.0 kVA |
| Voltage ratio | 0.8/ 11.0kV |
| Cooling system | ONAN |
| Tap changer | 2.5%, 5%, 7.5%, 10% |
| Short circuit (Xcc) | 0.08 |

*(**Source**: REA EEP 3 FEED)*

- Weather Station

The Solar Monitoring Weather Station includes common meteorological sensors, mounting accessories, a data logger or the signal translator, power supply, and communications hardware. The equipment can be powered from a solar panel power system. The standard sensor array includes two pyranometers, a combined temperature and relative humidity sensor, wind speed and wind direction sensors, and surface mounted temperature sensors to measure solar panel temperature.

### 3.2.2 Component 2: Power station

The power stations or transformer stations are indoor buildings or containers. The voltage of the energy collected from the solar field is increased to a higher level to facilitate the evacuation of the generated energy. The power transformers will be housed in the power station. An example of an Indoors power station is shown in Figure 3.6.



**Figure 3. 6: Example of a power station**

*(**Source**: REA EEP 3 FEED)*

The power station shall be supplied with medium voltage switchgears that include one transformer protection unit, one direct incoming feeder unit, one direct outcoming feeder unit and electrical boards. Particularly, for the first power station of each MV line, a direct incoming unit will not be installed. The main features of the default power station are shown in Table 3.7, and Figure 3.7 is the Power Station Single Line Diagram.

**Table 3.7: Power station characteristics**

| Power station characteristics | |
|---|---|
| Number of transformers | 1 |
| Voltage ratio | 0.8/20.0kV |
| Service Indoors | Indoors |

*(**Source**: REA EEP 3 FEED)*

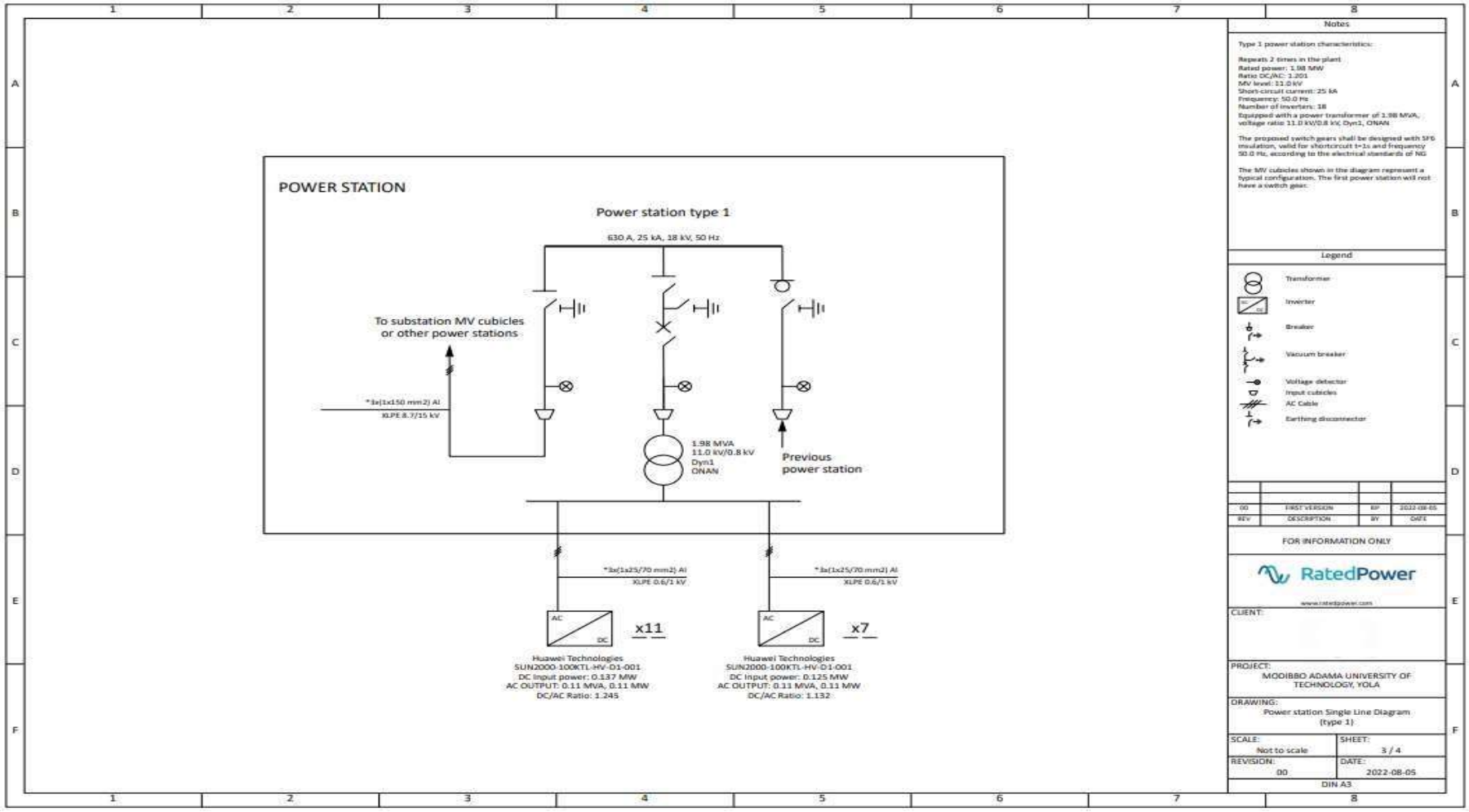



**Figure 3.7: Power station Single line Diagram**
*(**Source**: EEP3 FEED)*

### 3.2.3 Component 3: Access Roads

Gravel-paved access roads will be constructed within the Project area to provide access to the solar PV arrays, Battery Energy Storage System (BESS), substation, control room, and other associated facilities (Figure 3.8). The roads will be designed to facilitate the movement of personnel, equipment, construction materials, and maintenance vehicles throughout the Project lifecycle.

Construction of the access roads will involve the following activities:

- Site surveying, setting out, and alignment of the road corridor;
- Vegetation clearing and grubbing within the approved right-of-way;
- Stripping and temporary stockpiling of topsoil for subsequent site restoration;
- Earthworks, including excavation, filling, grading, and compaction of the road formation;
- Construction of drainage features, where necessary, to control surface runoff and prevent erosion;
- Placement and compaction of approved gravel materials to form the road surface;
- Installation of road signage and other traffic safety measures, where required; and
- Site reinstatement and stabilization of disturbed areas following completion of construction.

During operation, the access roads will be inspected and maintained periodically to ensure safe access for routine operation, inspection, and maintenance activities. For the design of the proposed PV plant, roads of 4.0 m have been used.

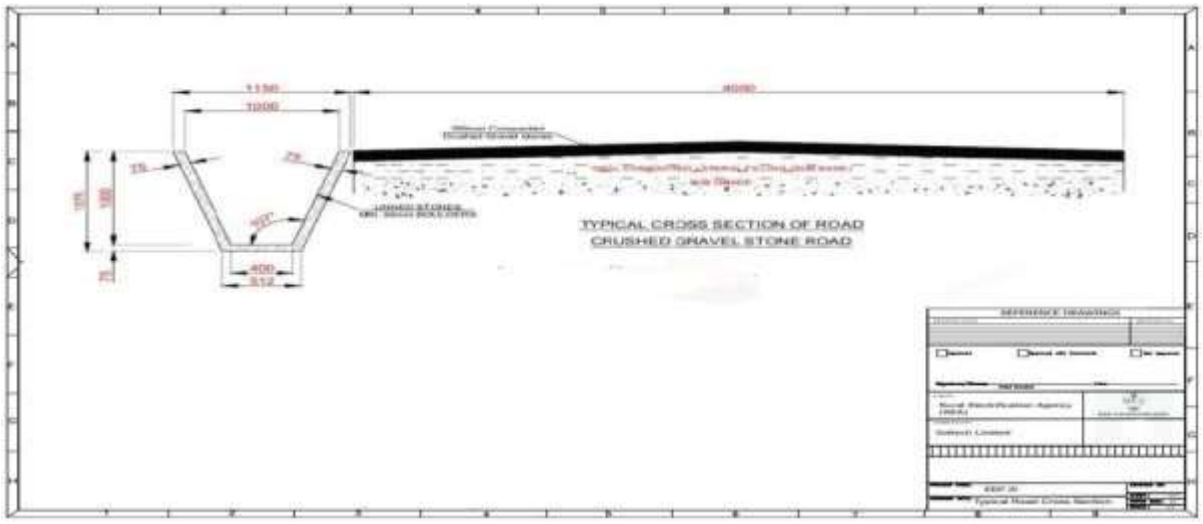



**Figure 3.8: Typical Road Cross Section**
*(**Source**: EEP3 FEED)*

### 3.2.4 Component 4: Buildings

A renewable workshop centre will be built and ancillary facilities that include residential quarters for the security, maintenance, and control room staff who will be required full-time, a guard house and an office/control centre. Figure 3.9 is an illiustration of the elevation plans of the training Centre.

❖ *Control Building*

The control building would take up an area of approximately 30 m × 12 M. The main construction compound would temporarily require an area of approximately 60 m × 40 m, however; this area would be fully reinstated after construction.

❖ *Lay down and Staging Area*

A temporary laydown and staging area will be established within the Project site during the construction phase to facilitate the receipt, inspection, storage, and assembly of solar photovoltaic (PV) modules, mounting structures, electrical components, and other construction materials prior to installation. The staging area will be secured with temporary fencing and controlled access to safeguard personnel, equipment, and materials.



**Figure 3.9: Elevation plans of the training Centre**

*(**Source**: EEP3 FEED)*

### 3.3.5 Component 5: Transmission Line

The power generated from the proposed 2 MW solar-hybrid power plant will be evacuated through an 11 kV underground transmission line to the University's central load center. The underground cable will be routed alongside the existing internal road network within the campus to minimize land disturbance and avoid interference with existing infrastructure. The total distribution network length is approximately 3 km downstream, with no upstream extension required since the generation source is located within the university premises. The underground installation is designed to enhance system reliability, improve safety, reduce visual impact, and protect the infrastructure from weather-related damage and vandalism.

### 3.2.6 Component 6: Street lights Quantity

As part of the associated infrastructure under the project, a total of 200 single-arm streetlights and 10 double-arm streetlights will be installed across the university campus. The street lighting system is intended to improve visibility, enhance security, and support academic and social activities during night-time hours. The lighting units will be energy-efficient and integrated into the hybrid power system to ensure sustainable and reliable operation. This component will contribute significantly to campus safety, operational efficiency, and overall improvement of the learning environment.

**Operation and Maintenance:** Operation and maintenance of the system would be expected to occur on a limited basis at certain points during the system's estimated 25-year life cycle. To enhance the performance and reliability of the plant, the following types of maintenance will be carried out:

**Preventive Maintenance**: which involves routine inspection and servicing of plant equipment to prevent breakdowns. This includes panel cleaning, vegetation management, wildlife prevention, water drainage, monitoring of electrical components. It also involves retro- commissioning to improve the efficiency of the PV plant by detecting and solving problems in the system.

**Corrective Maintenance:** which involves repair of broken-down equipment. This includes on-site monitoring and mitigation, and critical and non-critical repairs of plant components.

**Condition-based maintenance**: which involves monitoring equipment and plant operations real-time and addressing potential problems early on in order to prevent plant downtime. This includes continuous monitoring via remote and on-site methods, warranty enforcement, and planned and unplanned equipment replacement. Maintenance activities will be carried out by skilled manpower with backgrounds in electrical/electronic engineering and unskilled local labour where applicable. Specific maintenance activities include the following:

❖ PV Modules

The photovoltaic (PV) modules shall be inspected regularly and cleaned as required, taking into account seasonal dust accumulation, rainfall patterns, and system performance monitoring. Cleaning frequency shall be determined based on manufacturer's recommendations, site-specific environmental conditions, and operational performance to maintain optimum energy generation while minimizing water consumption. Where feasible, water-efficient cleaning methods, including the use of soft brushes, deionized water, or other approved cleaning technologies, shall be adopted. The availability of water for cleaning activities shall be considered during operation, and cleaning shall be scheduled to optimize both system performance and resource efficiency. In addition, the cabling around the modules shall be inspected regularly for damage, while the panels shall be routinely checked for cracks, breakages, and other defects. Performance testing shall be undertaken periodically in accordance with the manufacturer's operation and maintenance requirements to ensure continued operational efficiency and compliance with warranty conditions.

❖ Electrical System

- Inverter components need to be checked to prevent breakdown which can occur during very hot weather conditions.

- Electrical wiring and earthing protection need to be checked for wear and tear. Also, the underground cabling needs to be monitored regularly for damages from pests. Infra- red technology may be employed to identify spots where there are electricity leaks.

❖ Civil Structures

- Mounting structures need to be checked regularly for bending damage which can affect the PV modules
- Access roads, drainage works, plant foundation and array structures need to be checked by visual inspection for water damage during the rainy season.

❖ Vegetation

- Growth of shrubs and other vegetation needs to be curtailed to prevent shadowing effect on the solar panels leading to a decrease in the output from the plant. Weeds also need to be eliminated as they present a fire hazard.
- Vegetation around the transmission line RoW needs to be cleared quarterly to maintain a vegetation height at less than 2 ft (0.61 m).

A stockpile of spare parts will be kept on-site to facilitate replacement of broken-down or out-dated solar panels and inverters. On-site security and inventory management will be implemented to prevent theft of spare parts and installed plant components. Monitoring of the PV system components needs to be conducted to ensure increased system output and to reduce down-time. Traditional monitoring methods that compare actual energy generation against predicted energy generation will help to track the system's relative health.

## 3.3 Project Phases for Implementation

### 3.3.1 Pre-construction Phase Activities

Following the completion of engineering design for the Project and receipt of relevant approvals, the major activities during this phase include site clearing and preparation, and mobilization of equipment, materials and personnel to site. Clearing will involve removal of existing vegetation from the site and preparing a level working surface in readiness for construction activities.

### 3.3.2 Construction Phase Activities

The construction phase of the Project will include civil, mechanical and electrical works; installation of PV panels and associated plant facilities; construction of a training centre; installation of streetlights as well as underground armoured cable for power evacuation. Also, where required, an upgrade of some of the existing power distribution infrastructure within the University will be carried out. It is envisaged that the construction phase will require an estimated 80–120 workers, with a peak workforce of approximately 120 personnel, depending on the construction schedule and activities being undertaken. The workforce will comprise unskilled workers, semi-skilled personnel such as drivers, equipment operators and technicians, and skilled personnel including engineers, supervisors, HSE officers and electrical specialists. Most of the unskilled and semi-skilled workers would be drawn from the nearby local community (located outside the University campus) to enhance the job opportunities associated with the proposed Project. Moderate level of migrant workers may also be associated with the construction phase

activities (potential impacts associated with the migrant workers as well as the proffered mitigation measures are covered in Chapters 5 and 6).

### 3.3.3 Commissioning Phase Activities

The commissioning phase of the proposed Project will include testing and checking individual equipment /system, as well as the associated infrastructure to ensure they have been installed correctly and can be handed over for use.

### 3.3.4 Operational Phase Activities

The operational phase of the Project will involve power generation and distribution to various sections of the University as well as the preventative, corrective and predictive maintenance of the power plant and associated facilities. In addition, the training centre will be put into use to enhance learning in renewable energy. The EPC contractor shall develop standard operating procedures (SOPs) for the operation and maintenance of the solar panels, inverters, batteries, and other associated components of the Project. If need be, the SOPs shall be further reviewed and updated by the O&M Contractor during operation. The day-to-day operations of the plant will involve both regular preventive and corrective maintenance carried out by the O&M contractor in order to keep the power plant in optimal working condition throughout its operating life. The preventive maintenance follows a routine service schedule aimed at preventing faults from occurring and keeping the power plant operating at its optimum level. The frequency of the preventive maintenance would depend on a number of factors such as the technology selected, environmental conditions of the site, warranty terms and seasonal variances. It contains, for example, activities like PV panel cleaning, inverter servicing, and checks on structural integrity of the mounting structure. Corrective maintenance will be carried out in response to failures, for example, the repair / exchange of damaged or faulty equipment. Maintenance will consist mostly of panel / battery replacement and other mechanical and electrical infrastructure repairs. Faulty components will be replaced as soon as the problems are identified. The average life span of the PV power plant is 25 years which can be extended through regular maintenance. Even after the 25 years, the PV panels can still generate up to 90% of the design capacity. Chapter 8 of this report contains detailed information on the activities associated with the decommissioning of the proposed solar power plant and its ancillary facilities (in the event of final decommissioning), including the environmental and social measures to be implemented to address potential impacts of the decommissioning activities.

## 3.4 Manpower Requirement

The proposed project will require personnel during the pre-construction, construction, operation and decommissioning phases. Workforce requirements will vary depending on the nature and intensity of activities at each stage of project implementation. During the pre-construction phase, manpower requirements will primarily comprise project managers, engineers, surveyors, environmental and social specialists, health and safety personnel, and other technical professionals responsible for detailed engineering design, site surveys, environmental compliance, procurement and project planning. The construction phase is expected to generate the highest labour demand and will involve civil, mechanical and electrical works, installation of photovoltaic (PV) modules and mounting structures, battery energy storage systems, transformers, switchgear, underground electrical distribution network, internal access roads, drainage facilities, street lighting, the

renewable energy training centre and other associated infrastructure. It is anticipated that the construction phase will require approximately 80–120 personnel, with a peak workforce of about 120 workers, depending on the construction programme and the level of concurrent activities on site. The workforce is expected to comprise:

- **Unskilled workers** (general labourers and artisans);
- **Semi-skilled personnel** (equipment operators, drivers, electricians, welders and technicians); and
- **Skilled personnel** (engineers, supervisors, HSE officers, quality control personnel, surveyors, project managers and other technical specialists).

Priority will be given to the employment of suitably qualified labour from the host area and surrounding communities for positions where the required skills are locally available. However, specialized personnel and technical experts may be engaged from outside the project area for activities requiring specific competencies and experience in utility-scale solar PV installations. During the operation and maintenance phase, the workforce will reduce considerably and will consist mainly of operations personnel, electrical technicians, maintenance engineers, security personnel, cleaners, administrative staff and HSE personnel responsible for the routine operation, inspection, maintenance and monitoring of the facility. The decommissioning phase is expected to require a workforce comparable to, but generally smaller than, that of the construction phase. Activities will include dismantling of electrical equipment, removal of PV modules, battery systems and associated infrastructure, waste segregation, recycling, site restoration and environmental rehabilitation. A summary of the estimated manpower requirements is presented in Table 3.8.

**Table 3.8: Estimated Manpower Requirement**

| Project Phase | Estimated Workforce | Typical Personnel |
|---|---|---|
| Pre-Construction | 15–25 | Project managers, engineers, surveyors, environmental and social specialists, procurement personnel |
| Construction | 80–120 | Labourers, artisans, operators, electricians, technicians, engineers, supervisors, HSE personnel |
| Operation & Maintenance | 15–25 | Facility manager, electrical technicians, maintenance personnel, security, administrative and HSE staff |
| Decommissioning | 40–80 | Engineers, technicians, equipment operators, labourers, waste management personnel and HSE officers |

## 3.5 Water Requirement and Supply

The proposed 2 MW Solar Photovoltaic (PV) Hybrid Power Project has relatively low water requirements compared to conventional thermal power generation facilities. Since electricity will be generated directly from solar energy, water is not required for the electricity generation process itself but only for limited construction and operational activities. During the construction phase, water will be required for minor civil works, dust suppression where necessary, equipment

cleaning and domestic use by the construction workforce. Water demand during this phase is expected to be temporary and relatively low.

During the operation and maintenance phase, water will be required primarily for the periodic cleaning of photovoltaic (PV) modules to remove dust, bird droppings and other surface deposits that may reduce power generation efficiency. Additional water may be required for routine cleaning of equipment and other minor maintenance activities. The frequency of panel cleaning will depend on seasonal dust conditions, rainfall patterns, operational performance monitoring and the manufacturer's operation and maintenance recommendations. The overall water demand for the proposed project is expected to be relatively low and will not constitute a major operational requirement throughout the project life cycle. Water required for both the construction and operational phases will be supplied from a dedicated borehole to be developed within the project site. Since the Permanent Campus currently has no functional electricity supply, the borehole will be equipped with a solar-powered pumping system to provide a reliable and sustainable source of water independent of the national grid or diesel-powered generators. This will ensure continuous water availability for panel cleaning, routine maintenance activities and other ancillary water needs throughout the operation of the facility.

Water use will be managed through efficient housekeeping practices, condition-based panel cleaning and regular inspection of the water supply system to minimize wastage and promote sustainable water use. The anticipated level of groundwater abstraction is expected to be relatively low and is not likely to exert significant pressure on local groundwater resources. Potential impacts associated with groundwater abstraction and the corresponding mitigation measures are presented in the subsequent chapters of this report.

## 3.6 Solar PV Network Installation Standards and Codes

The design, procurement, installation, testing and commissioning of the proposed 2 MW Solar Photovoltaic (PV) Hybrid Power Project and Associated Infrastructure shall be undertaken in accordance with internationally recognized engineering standards, industry best practices and applicable Nigerian regulatory requirements. Compliance with these standards will ensure the safety, reliability, quality and long-term performance of the electrical and civil engineering components of the project. The engineering design and installation works shall comply, where applicable, with the requirements of the International Electrotechnical Commission (IEC), International Organization for Standardization (ISO), British Standards/European Norms (BS EN), Institute of Electrical and Electronics Engineers (IEEE), the Standards Organization of Nigeria (SON), and the Nigerian Electricity Management Services Agency (NEMSA).

The principal standards applicable to the proposed project include, but are not limited to, those governing:

- Solar photovoltaic (PV) modules and arrays;
- Battery Energy Storage Systems (BESS);
- Inverters and power conversion systems;
- Electrical wiring and underground cable installations;
- Transformers, switchgear and protection systems;
- Earthing and lightning protection systems;
- Structural design and mounting systems;

- Electrical safety, testing and commissioning; and
- Occupational health and safety during installation and operation.

Typical standards relevant to the proposed project include IEC 62548 (Design Requirements for Photovoltaic Arrays), IEC 60364 (Low-Voltage Electrical Installations), IEC 62446 (Grid-connected Photovoltaic Systems – Testing, Documentation and Commissioning), IEC 61730 (Photovoltaic Module Safety Qualification), BS EN 60529 (Degrees of Protection Provided by Enclosures – IP Code), ISO 45001 (Occupational Health and Safety Management Systems), ISO 14001 (Environmental Management Systems), and other applicable standards adopted by the Standards Organization of Nigeria (SON) and the Nigerian Electricity Management Services Agency (NEMSA). All electrical equipment and materials to be supplied for the project shall be certified by the respective manufacturers and, where applicable, comply with the Mandatory Conformity Assessment Programme (MANCAP) of the Standards Organization of Nigeria. Furthermore, all electrical installations shall be inspected, tested and certified by the appropriate regulatory authorities before commissioning and energization of the facility. A summary of the principal standards applicable to the proposed project is presented in Table 3.9.

**Table 3.9: Principal Engineering Standards Applicable to the Project**

| Standard/Code | Description | Application |
|---|---|---|
| IEC 62548 | Photovoltaic (PV) Arrays – Design Requirements | PV system design and installation |
| IEC 62446 | Grid-connected PV Systems – Testing and Commissioning | Inspection, testing and documentation |
| IEC 61730 | Photovoltaic Module Safety Qualification | PV module safety requirements |
| IEC 60364 | Low-Voltage Electrical Installations | Electrical installation and wiring |
| BS EN 60529 | Degrees of Protection by Enclosures (IP Code) | Equipment enclosure protection |
| ISO 14001 | Environmental Management Systems | Environmental management |
| ISO 45001 | Occupational Health and Safety Management Systems | Occupational health and safety |
| SON/MANCAP Requirements | Nigerian product conformity requirements | Equipment certification |
| NEMSA Requirements | Electrical installation inspection and certification | Testing, commissioning and energization |

## 3.7 Health and Safety

The construction, operation and maintenance of the proposed 2 MW Solar Photovoltaic (PV) Hybrid Power Project and Associated Infrastructure will be undertaken in accordance with applicable occupational health and safety legislation, internationally recognized industry standards and the Environmental, Health and Safety (EHS) requirements of the Rural Electrification Agency (REA). Appropriate measures will be implemented to protect project personnel, University staff, students, visitors, contractors and members of the public from hazards associated with project activities. Health and safety considerations have been integrated into the project design to minimize risks associated with civil works, electrical installations, equipment handling, working

at height, excavation, lifting operations and vehicular movement. During construction, the EPC Contractor shall develop and implement a Construction Health, Safety and Environment (HSE) Management Plan consistent with the requirements of this ESIA and applicable regulatory standards. The Contractor shall ensure that all personnel receive appropriate induction and task-specific safety training before commencing work. Suitable Personal Protective Equipment (PPE) shall be provided and its use strictly enforced throughout the project duration. Appropriate warning signs, barricades and restricted access measures shall also be provided to prevent unauthorized entry into active work areas.

Routine safety measures to be implemented during project execution shall include:

- Provision and mandatory use of appropriate Personal Protective Equipment (PPE);
- Safety induction and toolbox meetings for all site personnel;
- Permit-to-work procedures for high-risk activities;
- Safe lifting and material handling practices;
- Lock-Out/Tag-Out (LOTO) procedures during electrical works;
- Fire prevention and fire-fighting equipment at strategic locations;
- First aid facilities and trained first aid personnel on site;
- Good housekeeping to maintain a safe working environment;
- Traffic management and speed control within the project area; and
- Incident reporting, investigation and corrective action procedures.

During the operational phase, routine inspection and preventive maintenance of the solar photovoltaic arrays, Battery Energy Storage System (BESS), transformers, switchgear, underground electrical network and other associated infrastructure will be undertaken by competent personnel. Access to electrical installations will be restricted to authorized personnel, while warning signage, emergency isolation devices, earthing systems and lightning protection measures will be maintained throughout the operational life of the facility. The Project Proponent shall also establish appropriate emergency preparedness and response procedures to address potential incidents such as fire, electrical faults, accidental injuries, equipment failure and other emergencies. Emergency response equipment shall be regularly inspected and maintained to ensure operational readiness. Detailed occupational health and safety requirements, emergency response procedures and institutional responsibilities are presented in the Environmental and Social Management Plan (ESMP) in Chapter Seven of this report.

## 3.8 Emergency Shutdown Measures

The proposed 2 MW Solar Photovoltaic (PV) Hybrid Power Project will incorporate appropriate emergency shutdown measures to ensure the safety of personnel, protect electrical equipment and minimize the consequences of equipment malfunction, fire, electrical faults or other emergency situations. The emergency shutdown system will be integrated into the overall electrical protection and control system of the facility. The solar PV system, Battery Energy Storage System (BESS), inverters, transformers and associated electrical equipment will be equipped with protective devices capable of automatically or manually isolating faulty sections of the network to prevent equipment damage and ensure personnel safety. Appropriate emergency shutdown procedures will also be established for routine maintenance and emergency response activities.

The emergency shutdown measures for the proposed project will include:

- Emergency shutdown switches strategically located at critical facilities;
- Automatic isolation of faulty electrical circuits through protection relays and circuit breakers;
- Battery isolation and disconnect systems for the Battery Energy Storage System (BESS);
- Lock-Out/Tag-Out (LOTO) procedures during maintenance activities;
- Lightning and surge protection systems;
- Earthing and bonding of electrical installations;
- Fire detection and firefighting equipment at critical installations;
- Emergency communication and incident reporting procedures; and
- Restricted access to energized electrical installations.

In the event of an emergency, only trained and authorized personnel shall undertake shutdown and isolation procedures in accordance with the approved Operations and Maintenance Manual and the site's Emergency Response Plan. Following any emergency shutdown, the affected equipment shall be inspected, tested and certified safe before being returned to service. Detailed emergency response procedures, responsibilities and communication protocols for managing emergency situations are provided in the Environmental and Social Management Plan (ESMP) presented in Chapter Seven of this report.

## 3.9 Waste Management

Effective waste management will form an integral part of the proposed 2 MW Solar Photovoltaic (PV) Hybrid Power Project throughout its lifecycle. Waste generated during the pre-construction, construction, operation and decommissioning phases will be managed in accordance with the principles of the waste management hierarchy, applicable national environmental regulations, and international good industry practice. A Site Waste Management Plan (SWMP) shall be prepared and implemented by the EPC Contractor to ensure that all waste streams are properly identified, segregated, handled, stored, transported and disposed of in an environmentally sound manner.

The Project will adopt the following waste management hierarchy:

- **Source Reduction:** Minimize waste generation through efficient planning, procurement and material utilization.
- **Reuse:** Reuse suitable materials where practicable without compromising quality or safety.
- **Recycling:** Segregate recyclable materials and transfer them to licensed recycling facilities.
- **Treatment and Disposal:** Dispose of non-recyclable wastes through government-approved or licensed waste management contractors.

The principal waste streams anticipated during the various phases of the project are described below.

### 3.9.1 Pre-Construction Phase

Waste generation during the pre-construction phase is expected to be relatively minimal and will mainly result from site preparation, vegetation clearance and administrative activities.

Typical waste streams will include:

- Cleared grasses, shrubs and other vegetation;
- Domestic refuse from project personnel;
- Food waste;
- Plastic bottles and packaging materials; and

- Paper and office waste.

Vegetation cleared during site preparation will, where practicable, be composted or reused for erosion control and landscaping. General wastes will be segregated at source and collected for disposal through approved waste management contractors.

### 3.9.2 Construction Phase

The construction phase is expected to generate the highest volume and diversity of waste due to civil, mechanical and electrical installation activities.

Expected construction wastes include:

- Excavated soil and earth materials;
- Concrete and masonry waste;
- Scrap metals;
- Timber off-cuts;
- Plastic, cartons and packaging materials;
- Damaged cables and electrical fittings;
- Defective photovoltaic (PV) modules;
- Food waste and domestic refuse;
- Used oils, lubricants and contaminated rags; and
- Other hazardous maintenance materials.

Construction wastes will be segregated at source into recyclable, reusable and non-recyclable categories. Suitable excavated materials will be reused as backfill where applicable, while scrap metals and recyclable materials will be transferred to licensed recycling companies. Hazardous wastes shall be stored in appropriately labelled containers within designated storage areas before being collected by licensed waste management contractors in accordance with applicable environmental regulations.

### 3.9.3 Operation and Maintenance Phase

Waste generation during the operational phase is expected to be relatively low and will primarily arise from routine maintenance and facility management activities.

The principal waste streams will include:

- Domestic waste;
- Maintenance waste;
- Damaged electrical components;
- Defective PV modules;
- End-of-life batteries;
- Damaged inverters;
- Packaging materials; and
- Sanitary waste.

Electronic and electrical wastes generated during operation shall be managed under an Extended Producer Responsibility (EPR) approach. Where practicable, defective PV modules, batteries, inverters and other electrical components shall be returned to the manufacturer or supplied to licensed recycling facilities for recovery and environmentally sound recycling. Spent batteries shall be temporarily stored in designated containers before transportation to accredited recycling facilities. Domestic solid wastes shall be managed through the University's approved waste

management system, while sanitary wastewater shall be conveyed to a septic tank designed for the facility.

### 3.9.4 Decommissioning Phase

Waste streams generated during decommissioning will generally be similar to those produced during construction but will include additional quantities of electrical and electronic equipment removed from service.

Expected wastes include:

- PV modules;
- Batteries;
- Inverters;
- Electrical cables;
- Transformers and switchgear;
- Scrap metals;
- Concrete debris;
- Packaging materials; and
- General demolition waste.

All reusable and recyclable materials will be recovered where practicable. Electrical and electronic equipment shall be managed in accordance with applicable e-waste regulations, while non-recyclable wastes will be disposed of through licensed waste management contractors. The decommissioning contractor shall prepare and implement a specific Waste Management Plan prior to commencement of decommissioning activities.

**Table 3.10: Summary of Anticipated Waste Streams and Management Measures**

| Project Phase | Major Waste Streams | Management Measures |
|---|---|---|
| **Pre-Construction** | Cleared vegetation, domestic refuse, packaging materials | Composting where applicable, segregation, reuse and disposal through approved contractors |
| **Construction** | Cut soil, concrete waste, scrap metals, packaging materials, defective PV modules, hazardous wastes | Reuse of excavated soil, recycling of metals and packaging materials, licensed disposal of hazardous wastes |
| **Operation** | Domestic waste, damaged PV modules, spent batteries, defective inverters, sanitary waste | EPR programme, recycling, University waste management system, septic tank for sanitary waste |
| **Decommissioning** | PV modules, batteries, electrical equipment, demolition debris, scrap metals | Recovery, recycling, e-waste management and disposal through licensed contractors |

The detailed waste management procedures, institutional responsibilities, monitoring requirements and waste handling protocols for each phase of the project are presented in the Waste Management Plan contained in Chapter Seven of this report.

## 3.10 Project Schedule

The implementation of the proposed 2 MW Solar Photovoltaic (PV) Hybrid Power Project and Associated Infrastructure will be undertaken in a phased manner to ensure effective planning, regulatory compliance, quality control and timely completion of the project. The implementation programme will cover the pre-construction, construction, commissioning and operational phases. The pre-construction phase will include detailed engineering design, statutory approvals, procurement activities, contractor mobilization and site preparation. This will be followed by the construction phase involving civil works, installation of photovoltaic (PV) modules, Battery Energy Storage System (BESS), transformers, underground electrical distribution network, street lighting, the Renewable Energy Training Centre and other associated infrastructure. Upon completion of construction, the project will undergo testing, commissioning and performance verification before being handed over for operation and maintenance. The operation phase will involve routine inspection, preventive maintenance, environmental monitoring and periodic replacement of components as required throughout the project life. The implementation schedule presented in Table 3.11 is indicative and may be reviewed during detailed engineering design and project execution.

**Table 3.11: Tentative Project Implementation Schedule**

| Project Activity | Pre-Construction | Construction | Commissioning | Operation |
|---|---|---|---|---|
| Detailed Engineering Design | ✓ | | | |
| Regulatory Approvals and Permits | ✓ | | | |
| Procurement of Equipment and Materials | ✓ | ✓ | | |
| Contractor Mobilization | ✓ | | | |
| Site Preparation and Survey | ✓ | | | |
| Civil Works | | ✓ | | |
| Installation of PV Modules | | ✓ | | |
| Installation of Battery Energy Storage System | | ✓ | | |
| Installation of Transformers and Electrical Equipment | | ✓ | | |
| Underground Cable Installation | | ✓ | | |
| Construction of Renewable Energy Training Centre | | ✓ | | |
| Installation of Street Lighting | | ✓ | | |
| Testing and Commissioning | | | ✓ | |
| Operation and Maintenance | | | | ✓ |
| Environmental Monitoring | ✓ | ✓ | ✓ | ✓ |

The detailed construction programme, activity sequencing and implementation timeline will be finalized by the Engineering, Procurement and Construction (EPC) Contractor in consultation with the Rural Electrification Agency (REA) prior to commencement of construction activities.

# CHAPTER FOUR
# DESCRIPTION OF THE EXISTING ENVIRONMENT

## 4.1 Introduction

This chapter presents the existing environmental conditions within the proposed 2 MW Solar Photovoltaic (PV) Power Project and Associated Infrastructure at the Permanent Site of the Federal University of Health Sciences, Otukpo (FUHSO), Benue State, and its immediate area of influence. It describes the baseline physical and biological environment of the project area prior to implementation and provides the environmental reference conditions against which the potential impacts of the proposed project are evaluated.

The environmental characteristics of the project area were established through desktop studies, field investigations, environmental sampling and measurements, laboratory analyses, direct observations and interpretation of the generated data. Where appropriate, relevant secondary information obtained from government agencies and published literature was reviewed to complement the primary data collected during the field investigations.

The baseline environmental components described in this chapter include:

- Climate and meteorology;
- Topography and geology;
- Soils;
- Surface water and drainage;
- Ambient air quality;
- Ambient noise;
- Terrestrial ecology (flora and fauna);
- Land use and existing infrastructure; and
- Health, Safety, Security and Environmental (HSSE) conditions.

The information generated from these baseline investigations provides the environmental reference against which potential project impacts will be assessed and forms the basis for the development of appropriate mitigation measures, environmental monitoring programmes and the Environmental and Social Management Plan (ESMP) presented in the subsequent chapters of this report.

## 4.2 Baseline Data Collection

The baseline environmental data acquisition exercise adopted a multidisciplinary approach and was implemented within the framework of the project's Quality, Health, Safety, Security and Environment (QHSSE) management procedures. The approach ensured that environmental data were collected in accordance with applicable Federal Ministry of Environment (FMEnv) guidelines, recognized international standards and established scientific procedures using appropriately calibrated equipment and qualified personnel.

The baseline study comprised the following activities:

- Review of available literature and existing environmental information relevant to the project area;

- Development of field sampling and monitoring programmes consistent with the scope of the ESIA;
- Pre-field mobilization activities, including equipment inspection, calibration and verification of field procedures;
- Reconnaissance survey of the proposed project site;
- GPS verification of the project boundary and sampling locations;
- Soil sampling and in-situ soil measurements;
- Surface water sampling and in-situ water quality measurements;
- Ambient air quality monitoring;
- Ambient noise level measurements;
- Ecological (flora and fauna) assessment;
- Site drainage and land-use assessment;
- Photographic documentation of environmental features;
- Sample preservation, chain-of-custody documentation and transportation to an accredited environmental laboratory for physicochemical, microbiological and heavy metal analyses; and
- Interpretation and quality assurance review of laboratory and field data.

### 4.2.1 Desktop Studies and Literature Review

Desktop studies involved the review of available information relating to the project area to complement the field investigations. Relevant environmental information was obtained from applicable and relevant government authorities Federal Ministry of Environment (FMEnv) regulations, the Nigerian Meteorological Agency (NiMet), published literature, topographic maps, satellite imagery and other available secondary sources. The information obtained was used to support the planning of the field survey, identify data gaps and guide the selection of appropriate sampling locations and environmental receptors.

### 4.2.2 Field Investigations

The field investigation commenced with a reconnaissance survey of the proposed project site to verify the project location, assess the existing environmental conditions and identify suitable sampling locations for the baseline studies. The project footprint was inspected to evaluate the terrain, existing land use, vegetation cover, drainage characteristics, accessibility, surrounding environmental features and ongoing infrastructural development. The project boundary and all environmental sampling locations were confirmed using a handheld Global Positioning System (GPS) receiver.

**Minutes of Stakeholder Consultation Meetings**

These minutes document the reconnaissance visit and site-verification engagements held with FUHS management, regulatory representatives, and the ESIA consultant team in relation to the proposed 2 MW Solar Photovoltaic Power Project at the FUHS Permanent Campus, Otukpo, Benue State.

| **ENGAGEMENT 1: RECONNAISSANCE VISIT AND SITE VERIFICATION** | |
|---|---|
| **Date** | Saturday, 3 July 2026 |
| **Time** | 12 p.m. |
| **Project** | 2 MW Solar Photovoltaic Power Project and Associated Infrastructure under the Nigeria Electrification Program (NEP) Desert to Power Phase II (DTP II), by the Rural Electrification Agency |
| **Venue** | FUHSO Permanent Campus, Otukpo, Benue State. |
| **Participants** | • Deputy Vice-Chancellor (representing the Vice-Chancellor), FUHSO<br>• Registrar, FUHSO<br>• Director, Projects and Planning, FUHSO<br>• Chief Security Officer, FUHSO<br>• University Management and Administrative Staff<br>• Representative of the Federal Ministry of Environment (FMEnv)<br>• Representatives of the Benue State Ministry of Environment<br>• Representative of the Benue State Ministry of Water Resources, Environment and Climate Change<br>• ESIA Consultant Team |

**PROCEEDINGS**

**Introduction**

The ESIA consultant team, accompanied by representatives of the Federal Ministry of Environment, Benue State Ministry of Environment, and the Benue State Ministry of Water Resources, Environment and Climate Change, conducted a scheduled reconnaissance visit and site verification at the permanent campus of the Federal University of Health Sciences, Otukpo. The meeting commenced at 12:00 noon in front of the proposed project site.

The Deputy Vice Chancellor **Prof. Friday G. Okibe** formally introduced himself, after which the Registrar **Michael Okoko Ogiji**, the Director of Projects and Planning **Arc. Jonah J. Akogwu**, the Chief Security Officer **Mr. Michael S. Asiebi** and other members of the University management and administrative staff, ministry representatives and members of the consultant team introduced themselves individually.

**Aim**

The aim of the engagement was to introduce the project and the ESIA team to the University management, verify the proposed project site, obtain relevant institutional and site information, inspect the equipment proposed for baseline studies, and facilitate the commencement of the environmental and socio-economic baseline exercise.

**Welcome Address/Presentation**

The Deputy Vice-Chancellor, on behalf of the Vice-Chancellor and management of FUHSO, formally welcomed everyone and expressed appreciation to the African Development Bank (AfDB), the Rural Electrification Agency (REA), the Federal Ministry of Environment, the Benue State ministries and the ESIA consultants BOLBEN LTD for their commitment to the successful implementation of the proposed project.

He briefed the team that the permanent campus occupies approximately 600 hectares of land, of which 10 hectares had been designated for the proposed solar project. He further stated that several major facilities were under construction and that the University planned to relocate from its temporary campus to the permanent campus in the next academic session upon completion of the essential infrastructure.

The team was informed that the project site lies within university-owned land acquired from the Akwete-Akpa Community. The Deputy Vice Chancellor also explained that the permanent campus had neither an electricity supply nor a connection to the national grid. He noted that the proposed solar power project would provide a reliable and sustainable source of electricity for academic, administrative, research and healthcare activities when the University relocates to the permanent campus.

The representatives of the Federal and State ministries reiterated the importance of the ESIA process in ensuring that environmental and social considerations are adequately integrated into the planning and implementation of the proposed project.

**Site Verification and Baseline Activities**

At the end of the presentations, the ministry representatives inspected the equipment to be used for baseline data collection. Thereafter, the teams proceeded to the proposed project site for site verification and commencement of the baseline exercise.

**Observations.**

- The University is located along the Otukpo-Igumale Road, a major route linking Benue State to Ebonyi State.
- Existing developments at the permanent campus include the Main Administrative Building, Boys' Hostel, Girls' Hostel, College of Medicine Building and College of Science Building.
- The proposed project site is covered by natural vegetation comprising mainly trees, shrubs and grasses; no farming activities were observed within the site.
- No surface water body or groundwater source was observed within the proposed project site.

The institution was not in academic session during the survey period, and only a few management staff were present at the permanent campus.

**Resolutions**

- It was resolved that the socioeconomic questionnaires be administered to the available management staffs present on-site during the site verification and baseline data gathering exercise
- Because academic activities had not commenced at the permanent campus, stakeholder consultation and questionnaire administration also be extended to the host community.
- The University management would continue to provide the consultant team and regulators with the necessary site access and institutional information required for the ESIA study.

| **ENGAGEMENT 2: HOST COMMUNITY STAKEHOLDER ENGAGEMENT** | |
|---|---|
| **Time** | 3 P.m. |
| **Venue** | Residence of the Grand Patron, Akwete-Akpa Community, Otukpo, Benue State. |

| | |
|---|---|
| **Participants** | • Grand Patron, Akwete-Akpa Community<br>• Community Chairman<br>• Community Secretary<br>• Community Chief<br>• Community Chairlady<br>• Community Youth Leader<br>• Akwete-Akpa Community Representative in FUHSO<br>• Chief Security Officer, FUHSO<br>• Representative of the Federal Ministry of Environment (FMEnv)<br>• ESIA Consultant Team<br>• Community Members |

**PROCEEDINGS**

**Introduction**

The host community stakeholder engagement took place at the residence of the Grand Patron of Akwete-Akpa Community. The meeting began at 3:00 p.m. with formal introductions by the ESIA consultant, the representative of the Federal Ministry of Environment, the Grand Patron, community leaders, and other participants.

The Grand Patron **Chief Ogah Raphael** welcomed the team and expressed appreciation for informing the community about the proposed project.

The presentations and discussions were delivered in English and interpreted into Akwaya by the community representative to ensure that the information communicated was clearly understood by all participants.

**Aim**

The aim of the engagement was to formally inform the host community about the proposed project and the ESIA study, obtain baseline socio-economic information, administer questionnaires, identify community concerns and expectations, and collect surface-water samples from the river within the community.

**Welcome Address/Presentation**

The consultant presented an overview of the project, its objectives and anticipated benefits, and explained the purpose and requirements of the ESIA study. Participants were informed that the engagement formed part of the baseline socio-economic data collection for the project, with the FMEnv representative **Mr. Ogbidi Matthew Tabi** highlighting the importance of community participation, accurate information sharing, and environmental compliance in supporting a transparent and effective ESIA process.

Following the presentations and discussions, the Grand Patron granted permission for the socio-economic survey to proceed and encouraged the community members present to participate actively in responding to the questionnaires. The consultant team administered socio-economic questionnaires to available community members. At the end of the engagement, the ESIA team proceeded to Aloma River to collect surface-water samples before returning to the project site at the University.

**OBSERVATIONS**

- Akwete-Akpa Community is located approximately 3.2 km from the University.
- The community is predominantly rural and has basic social infrastructure, including a primary school, health clinic, community hall that also serves as a church, residential buildings and small-scale socio-economic activities.
- No significant environmental issue or conflict associated with the proposed project was identified during the engagement.
- Aloma River, located approximately 1 km from the community square, was identified as the nearest suitable surface-water body for baseline water-quality sampling.

**RESOLUTIONS AND KEY ACTIONS**

- In the absence of surface-water and groundwater sources within the project area, Aloma River would serve as the representative surface-water sampling point; three surface-water samples were collected.
- The concerns, expectations and socio-economic information obtained from the host community would be incorporated into the ESIA study and project planning process.

Following the reconnaissance exercise, baseline environmental investigations were undertaken within the proposed project area and included soil sampling, ambient air quality monitoring, ambient noise level measurements, terrestrial ecological assessment, drainage assessment, photographic documentation and geospatial data acquisition. Soil samples were collected using a stainless-steel hand soil auger and preserved in appropriately labelled sample containers for laboratory analysis. Ambient air quality parameters were measured in situ using a portable multi-parameter air quality monitor, while ambient noise levels were measured using a digital sound level meter. Water quality measurements at the representative surface water sampling locations were carried out using a portable multi-parameter water quality meter for the determination of selected field parameters.

As no operational groundwater source was available within the University campus and no surface water body occurred within the project site, groundwater sampling was not undertaken. The nearest available surface water body, the Aloma River, located approximately 3.2 km from the proposed project site in Akwete-Akpa Community, was sampled at upstream, midstream and downstream locations to establish representative background surface water quality conditions for the wider project environment. Instantaneous field measurements of selected water quality parameters were undertaken before samples were preserved and transported for laboratory analysis.

Throughout the field exercise, photographs of the project site, environmental features, sampling locations, drainage infrastructure and surrounding conditions were obtained using a GPS-enabled digital camera, thereby providing georeferenced photographic records of the baseline conditions. Field observations and measurements were recorded using standardized field data sheets and notebooks to ensure consistency and traceability of environmental information.

All field samples were appropriately labelled, preserved and transported under established Quality Assurance and Quality Control (QA/QC) procedures to the accredited Ministry of Environment and Climate Change, Pollution Control Laboratory, Kano, for detailed physicochemical, microbiological and heavy metal analyses. Instrument calibration was verified before commencement of field measurements, while standard operating procedures were followed throughout the sampling programme to ensure the reliability and integrity of the baseline data. The analytical results generated from both the field measurements and laboratory investigations provide the baseline environmental conditions presented in this chapter.

*See Plate 4.1 for pictorial evidence of Reconnaissance Visit and Site Verification.*
*See more pictorial evidence of Reconnaissance Visit, Stakeholder engagement and Site Verification activities in Appendix V.*

**Table 4.1: Field Equipment, Instruments and Materials Used During the Baseline Environmental Survey**

| S/N | Equipment/Instrument | Purpose/Environmental Component |
|---|---|---|
| **1** | Handheld Global Positioning System (GPS) | Confirmation of project boundary coordinates, sampling locations and georeferencing |
| **2** | Stainless-steel hand soil auger | Collection of soil samples |
| **3** | Portable multi-parameter air quality monitor | Measurement of ambient air quality parameters |
| **4** | Digital sound level meter | Measurement of ambient noise levels |
| **5** | Portable multi-parameter water quality meter (pH/EC/TDS/Temperature) | In-situ water quality measurements |
| **6** | Sample bottles (polyethylene) | Collection and preservation of water samples |
| **7** | Soil sample bags/containers | Collection, storage and transportation of soil samples |
| **8** | Ice chest (cooler box) | Preservation and transportation of environmental samples under controlled temperature |
| **9** | GPS-enabled camera | Photographic documentation and georeferenced field records |
| **10** | Disposable nitrile gloves | Prevention of sample contamination and personnel protection |
| **11** | Permanent markers and waterproof labels | Sample identification and chain-of-custody documentation |
| **12** | Field notebooks and standardized data sheets | Recording field observations, measurements and sampling information |
| **13** | Measuring tape | Measurement of sampling distances and field verification |
| **14** | Personal Protective Equipment (PPE) | Health and safety of personnel during field activities |

**Source:** Bolben Ltd. Fieldwork Survey, 2026




**Plate 4.1: Reconnaissance Visit and Site Verification**




**Plate 4.2: Field equipment and instruments used during the baseline environmental investigation at the proposed project site with Federal and State Ministry of Environments officers.**

*(**Source**: Bolben Ltd Field Survey, 2026)*

## 4.3 Regional Physical Environment

### 4.3.1 Climate and Meteorology

Climate and meteorological conditions constitute important environmental factors influencing both the design and long-term operation of solar photovoltaic (PV) facilities. Parameters such as air temperature, rainfall, relative humidity, wind characteristics, sunshine duration and cloud cover influence solar radiation availability, photovoltaic conversion efficiency, stormwater generation, vegetation dynamics, erosion processes and the dispersion of atmospheric pollutants. Consequently, an understanding of the prevailing climatic conditions of the project area is essential for establishing the baseline environmental conditions against which the potential impacts of the proposed project can be evaluated. Baseline meteorological conditions for the proposed project area were established using the latest meteorological data obtained from the Nigerian Meteorological Agency (NiMet). Since no long-term meteorological station exists within the Permanent Site of the Federal University of Health Sciences, Otukpo (FUHSO), the nearest representative NiMet station and published climatic records for Benue State were adopted as representative of the project area.

The region lies within the Southern Guinea Savannah ecological zone of Nigeria and experiences a tropical wet-and-dry (Aw) climate, characterized by two distinct seasons. The climatic regime is controlled primarily by the seasonal movement of the Inter-Tropical Discontinuity (ITD), which separates the moist south-westerly maritime air mass originating from the Atlantic Ocean from the dry north-easterly continental air mass associated with the Sahara Desert. The interaction and seasonal migration of these air masses result in two well-defined seasons: the rainy season, which generally extends from April to October, and the dry season, which occurs between November and March. During the dry season, Harmattan conditions occasionally prevail, resulting in reduced atmospheric humidity, lower visibility and increased dust concentrations.

The prevailing climatic conditions support the natural Guinea Savannah vegetation, agricultural activities and favourable solar radiation regime observed within the project area. The principal climatic characteristics of the area are discussed below.

**(a) Air Temperature**

Air temperature within the project area is generally high throughout the year, reflecting the tropical climatic conditions of Benue State. Mean monthly temperatures remain relatively uniform, although seasonal variations occur between the dry and wet seasons. Maximum temperatures are generally experienced during the late dry season, particularly between February and April, while relatively lower temperatures occur during the peak rainy season owing to increased cloud cover, rainfall and evaporative cooling. Daily temperature variations are also characteristic of the region, with maximum temperatures commonly occurring during the early afternoon (approximately 1300–1500 hours), while minimum temperatures are recorded during the early morning hours before sunrise. Such temperature variations are typical of tropical continental climates and have implications for evapotranspiration, soil moisture conditions and photovoltaic module performance. NiMet records indicate that mean annual temperatures within the project area generally range between 26°C and 32°C, while daily maximum temperatures may exceed 35°C during the hottest months of the year.

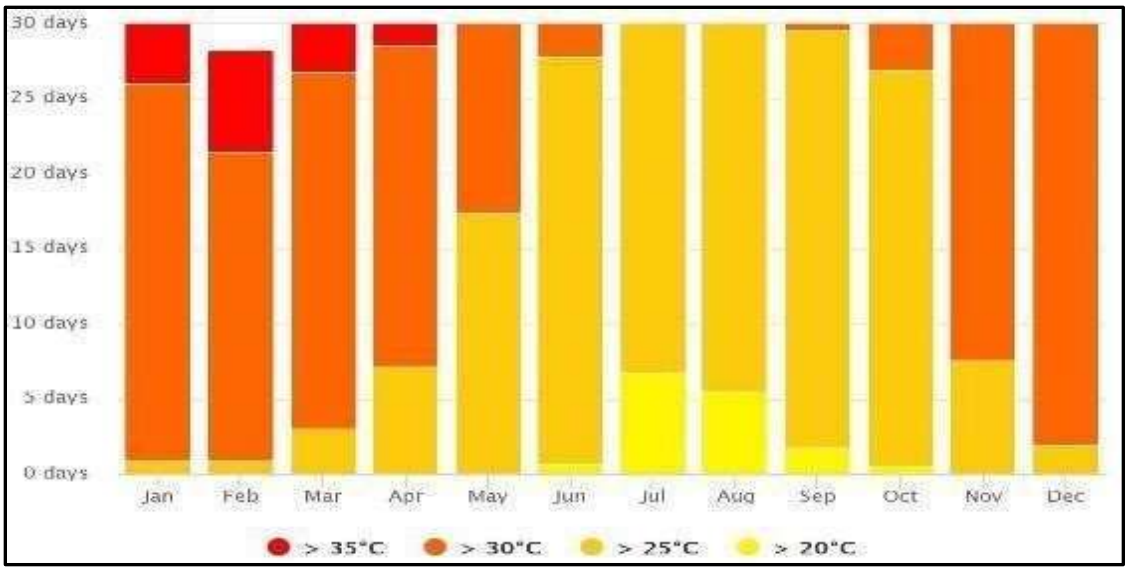



**Figure 4.1: Monthly Average Temperature for 10-Years Period**
*(**Source**: NiMET, 2024)*

**(b) Relative Humidity**

Relative humidity within the project area varies seasonally in response to rainfall distribution and the prevailing air masses. Humidity values are generally highest during the rainy season when atmospheric moisture content is greatest, and lowest during the Harmattan period when dry continental air dominates. Historical climatic records indicate that average relative humidity generally ranges between 50% and 90%, with peak values occurring between July and September during the height of the rainy season.

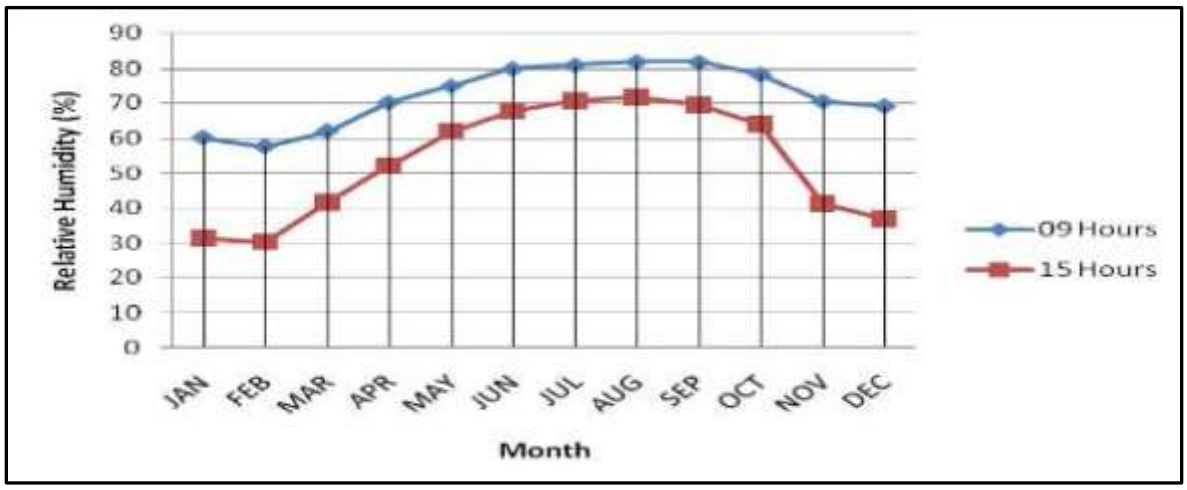



**Figure 4.2: Monthly Average Relative Humidity for 10-Years Period**
*(**Source**: NiMET, 2024)*

Conversely, the lowest humidity values are usually experienced between December and February, when Harmattan conditions prevail. Relative humidity influences vegetation growth, atmospheric

stability, evapotranspiration rates and the efficiency of photovoltaic systems through its effect on atmospheric transmissivity and solar radiation.

**(c) Rainfall**

Rainfall within the proposed project area is seasonal and is directly controlled by the annual migration of the Inter-Tropical Discontinuity (ITD). Rainfall generally commences in April, reaches maximum intensity between July and September, and gradually declines towards October before the onset of the dry season. Average annual rainfall within the Otukpo area generally ranges between 1,100 mm and 1,500 mm, providing favourable moisture conditions for agricultural production and sustaining the natural Guinea Savannah vegetation. Rainfall also contributes significantly to groundwater recharge and surface runoff generation. Although heavy rainfall events may occasionally produce localized runoff accumulation within low-lying drainage corridors, no evidence of flooding or prolonged waterlogging was observed within the proposed project footprint during the field investigation. The relatively elevated position of the proposed development site promotes natural drainage and reduces the potential for flood-related impacts.

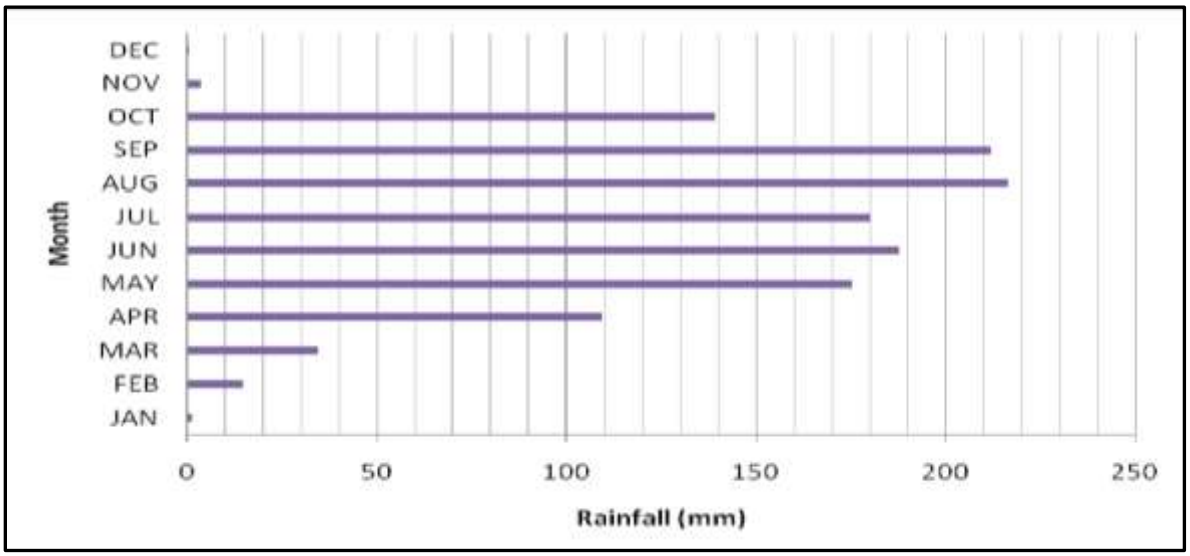



**Figure 4.3: Monthly average rainfall for 10-Years Period**
*(**Source**: NiMET, 2024)*

**(d) Wind Speed and Direction**

Wind characteristics within the project area exhibit distinct seasonal variations associated with the prevailing regional atmospheric circulation. South-westerly winds dominate during the rainy season, transporting moist maritime air inland, while north-easterly Harmattan winds prevail during the dry season and are characterized by relatively dry and dust-laden conditions.

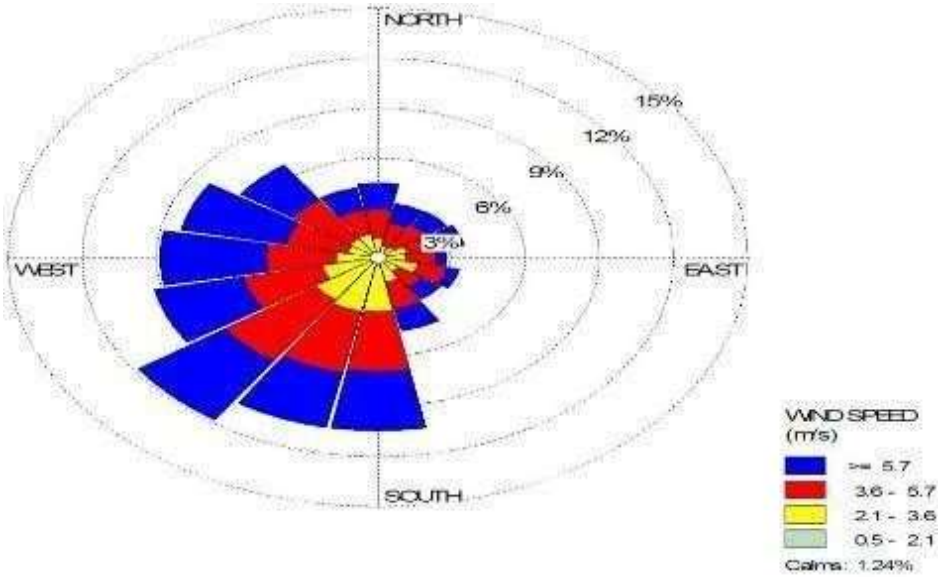



**Figure 4.4: Prevailing Wind Directions in the Study Region**

*(**Source**: NiMET, 2024)*

Wind speeds within the area are generally light to moderate and are not expected to constitute significant constraints to the proposed Solar PV development. Nevertheless, consideration of prevailing wind conditions is important in the structural design of solar mounting systems and in predicting the dispersion of dust generated during construction activities.

**(e) Sunshine Duration and Solar Radiation**

The project area experiences relatively high sunshine duration throughout the year owing to its tropical location. Sunshine hours are generally greatest during the dry season when cloud cover is minimal and lowest during the peak rainy season due to increased cloud formation. Mean daily sunshine duration typically ranges between 5 and 8 hours, providing favourable conditions for solar energy harvesting throughout most of the year. The combination of relatively high solar radiation, moderate cloud cover and stable climatic conditions makes the project area suitable for photovoltaic electricity generation and supports the long-term viability of the proposed Solar PV installation.

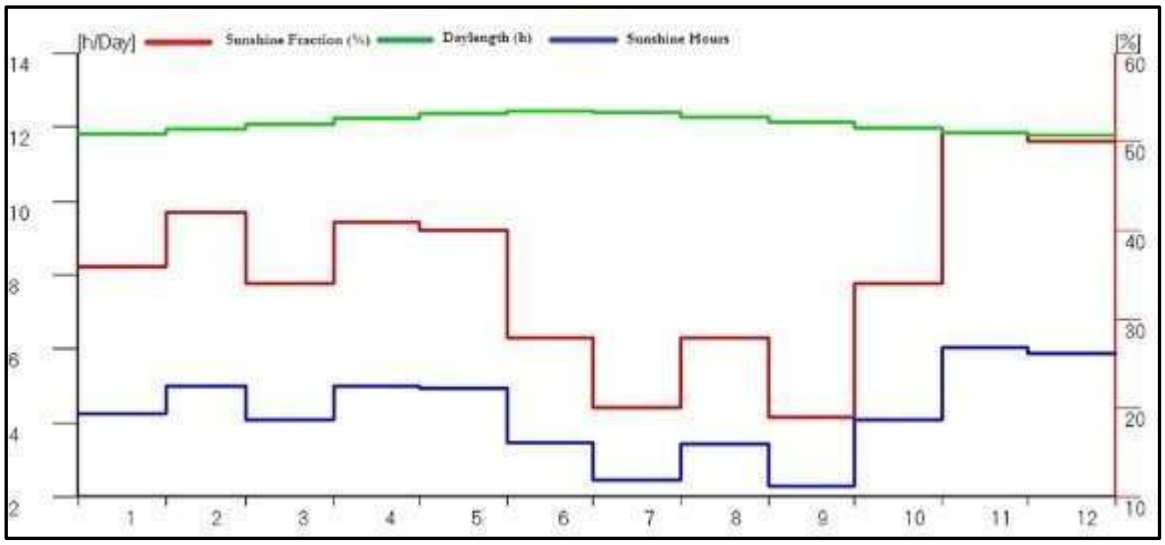



**Figure 4.5: Sunshine of the study area over the period of Twenty-five years**
*(**Source**: NiMet 2024)*

**(f) Cloud Cover and Visibility**

Cloud cover within the project area varies seasonally and closely follows the rainfall regime. Increased cloudiness is experienced during the rainy season, while clearer skies prevail during the dry season, particularly during periods outside the Harmattan.

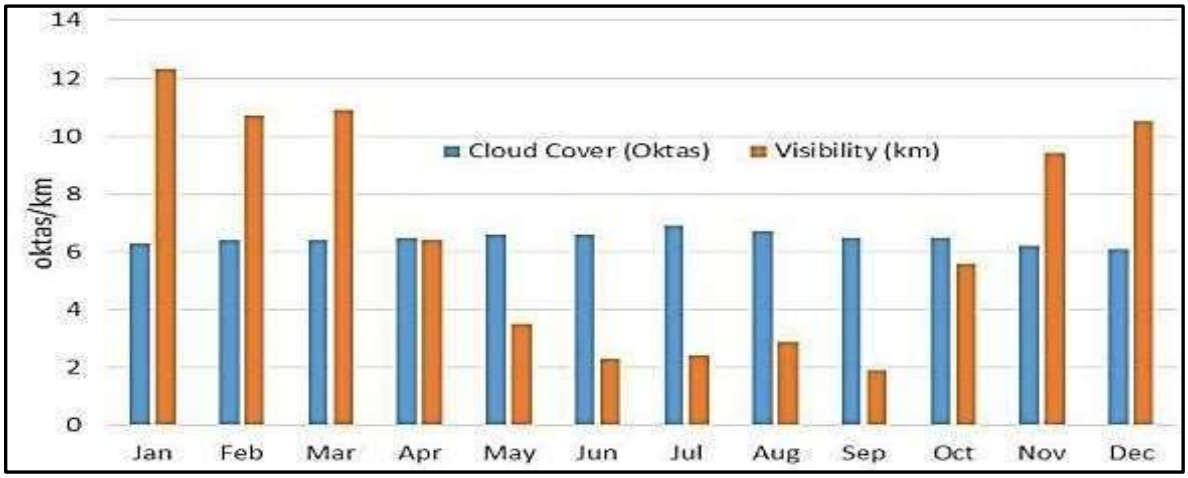



**Figure 4.6: Cloud Cover and Visibility Data for the study Region**
*(**Source**: NiMET, 2024)*

Visibility is generally good throughout the year but may be temporarily reduced during intense rainfall events or Harmattan dust episodes. Despite these seasonal variations, the prevailing atmospheric conditions are considered favourable for the implementation and operation of the proposed Solar Photovoltaic Power Project.

### 4.3.3 Geology and Hydrogeology

The proposed project area is located within Otukpo Local Government Area of Benue State, in the Lower Benue Trough, which forms part of the larger Benue Trough sedimentary basin of Nigeria. The Benue Trough is a major northeast–southwest trending intracontinental rift basin that developed during the Early Cretaceous as a result of crustal extension associated with the separation of the African and South American continental plates and the opening of the South Atlantic Ocean. The basin extends from the Niger Delta in the south through central Nigeria to the Chad Basin in the northeast and comprises thick sequences of marine and continental sedimentary rocks deposited under varying depositional environments over geological time.

Within Benue State, the geology is dominated by sedimentary formations of Cretaceous age, consisting principally of shales, sandstones, siltstones, mudstones and localized limestone horizons. These formations are represented by several lithostratigraphic units, including the Asu River Group, Eze-Aku Formation, Awgu Formation, and the younger Makurdi Sandstone, which collectively characterize much of the Lower Benue Trough. Extensive weathering of these sedimentary rocks has resulted in the development of lateritic overburden and residual soils that support the Guinea Savannah vegetation and agricultural activities prevalent throughout the State. The geology around Otukpo is predominantly underlain by sedimentary rocks belonging mainly to the Asu River Group and associated Lower Benue Basin formations. The bedrock is generally overlain by moderately thick weathered materials comprising lateritic sandy clay, sandy loam and residual soils derived from prolonged tropical weathering. These soils are generally well drained, moderately permeable and suitable for agriculture, which explains the widespread cultivation observed within the surrounding communities. The weathered profile also provides favourable engineering conditions for shallow civil works, although localized variations in soil thickness and competence may occur.

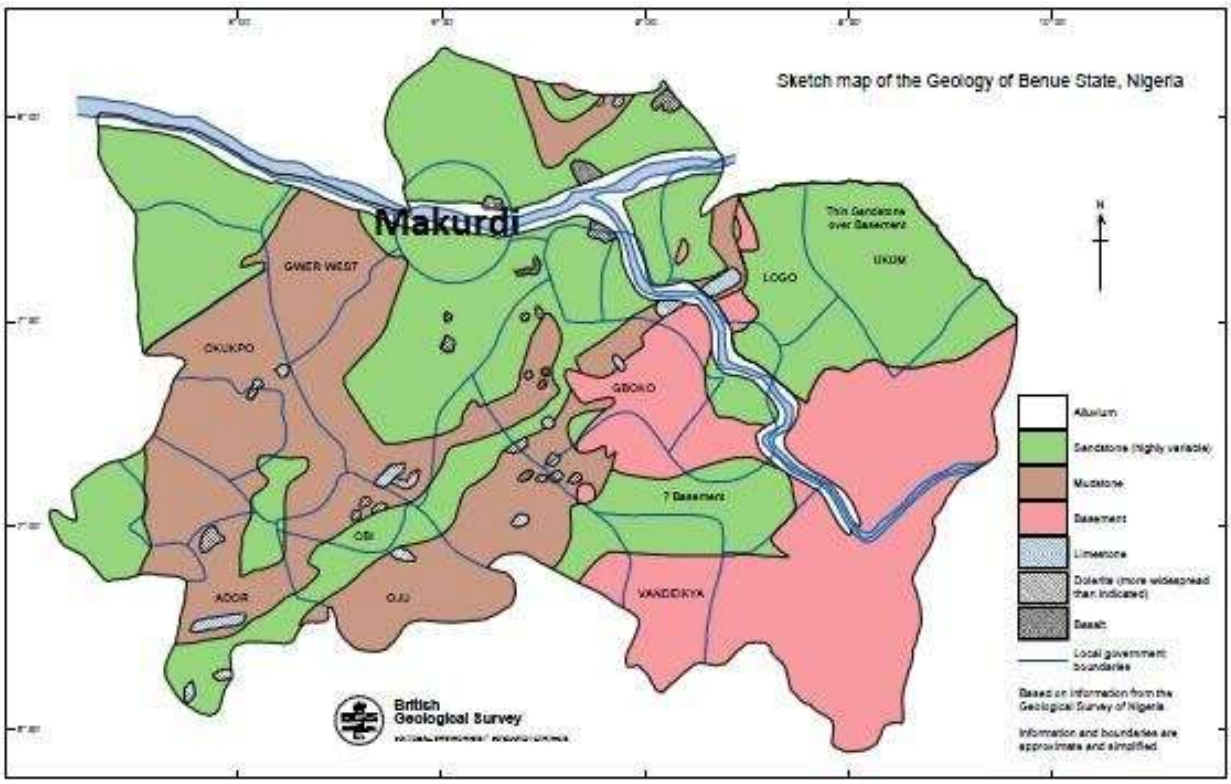



**Figure 4.7: Geological and Hydrogeological Map of Benue State**
*(**Source**: British Geological Survey)*

Hydrogeologically, groundwater occurrence within the Otukpo area is controlled primarily by the porosity and permeability of the underlying sedimentary formations as well as the thickness of the weathered overburden. Groundwater is commonly encountered within weathered zones, fractured sandstone units and intergranular aquifers developed within permeable sedimentary formations. Recharge occurs mainly through direct infiltration of rainfall during the wet season, while groundwater discharge contributes to the sustenance of streams and seasonal drainage channels within the surrounding catchment.

From an engineering perspective, the geological and hydrogeological conditions of the proposed project area are generally favourable for the development of a utility-scale Solar Photovoltaic (PV) facility. The absence of significant rock outcrops, active faulting, unstable geological features or major geohazards, together with the relatively competent lateritic overburden and well-drained site conditions, indicates that the area is suitable for conventional shallow foundation systems typically adopted for solar PV mounting structures. Nevertheless, detailed geotechnical investigations should be undertaken during the detailed engineering design stage to confirm subsurface conditions, determine allowable bearing capacities and optimize foundation design for the proposed solar infrastructure.

## 4.4 Project Site Location and Existing Land Use

### 4.4.1 Project Location

The proposed 2 MW Solar Photovoltaic (PV) Power Project and Associated Infrastructure is located within the Permanent Site of the Federal University of Health Sciences, Otukpo (FUHSO), Benue State, Nigeria. The project forms part of the Nigeria Electrification Project (NEP) Desert to Power Phase II (DTP II) being implemented by the Rural Electrification Agency (REA) to provide reliable and sustainable electricity to selected federal tertiary institutions across Nigeria. The proposed development occupies approximately 10 hectares (100,235.02 m²) within land legally owned by the University. The Permanent Site is currently under development and is intended to serve as the University's main academic campus upon completion. At the time of the ESIA field survey, several institutional buildings were at various stages of construction, including the Administrative Building, Staff Quarters, Male Hostel, College of Medicine and College of Science buildings. However, none of these facilities had been commissioned or occupied.

The project boundary was confirmed during the field survey using a handheld Global Positioning System (GPS). The boundary coordinates (WGS 84, Decimal Degrees) are presented in Table 4.2.

**Table 4.2: Project Site Boundary Coordinates**

| Boundary Point | Latitude (Decimal Degrees) | Longitude (Decimal Degrees) |
|---|---|---|
| Point A | 7.066800 | 8.097606 |
| Point B | 7.063336 | 8.098189 |
| Point C | 7.066381 | 8.100336 |
| Point D | 7.063417 | 8.100586 |




**Figure 4.8: Air Quality/Noise Level Sampling Location Map for the Study**
*(AQ=Air quality point, AQC-Air Quality Control point)*
***Source:*** *Bolben Ltd. Fieldwork Survey, 2026*

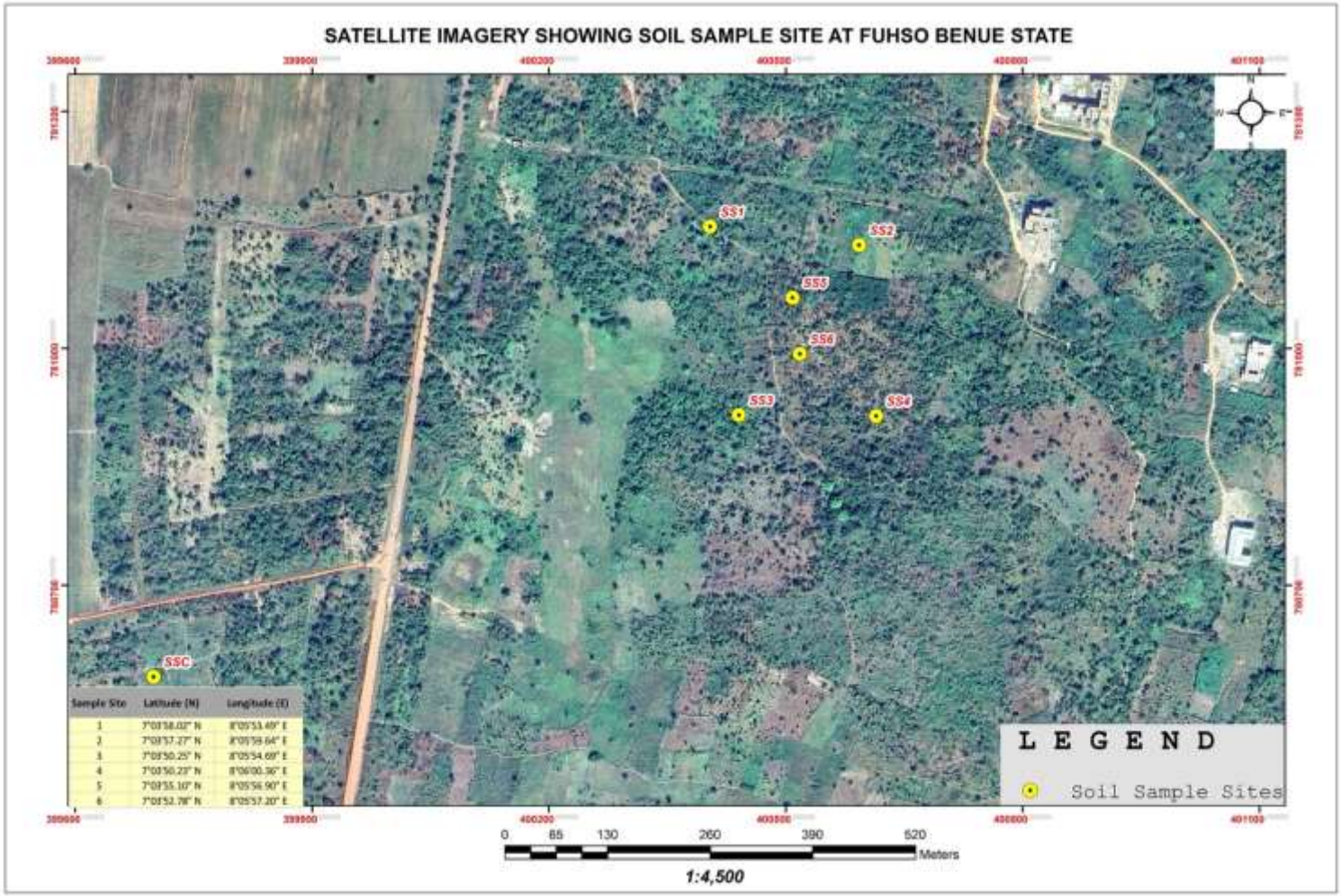



**Figure 4.9: Soil Sampling, Sampling Location Map for the Study**
**(SS=Soil Sampling point, SSC=Soil sampling Control point)**

### 4.4.2 Existing Land Use

The proposed project site is a predominantly greenfield environment characterized by secondary vegetation, cultivated farmland and fallow land. Existing land use is primarily agricultural, with evidence of seasonal cultivation of crops including cassava, maize, yam and banana, interspersed with scattered indigenous trees, shrubs, grasses and oil palm. Portions of the site also comprise naturally regenerating secondary vegetation resulting from previous land disturbance and farming activities. No residential buildings, commercial establishments, industrial facilities or other permanent economic activities were observed within the proposed project footprint. Likewise, there were no active academic activities or student occupation within the Permanent Site during the field survey, as the campus remains under construction. The existing land use indicates that the project site has already been substantially modified by previous agricultural activities and therefore does not represent a pristine or ecologically sensitive environment.




**Plate 4.3: General view of the proposed project site showing secondary vegetation.**
***Source:*** *Bolben Ltd. Fieldwork Survey, 2026*

### 4.4.3 Site Accessibility

The Permanent Site is directly accessible from the Otukpo–Igumale Road, an important transportation corridor linking Otukpo and adjoining communities within Benue State and providing connectivity towards neighbouring Ebonyi State. The access road provides vehicular access to the University and the proposed project site. Information obtained during the field investigation indicated that the Federal Government has awarded the reconstruction of the Otukpo–Igumale Road, which is expected to significantly improve accessibility to the Permanent Site upon completion and facilitate the transportation of construction materials, equipment and personnel during project implementation. Within the campus, access roads have been partially developed to serve the ongoing construction works. The proposed Solar PV site is located approximately 3 km from the main entrance gate of the Permanent Site and is readily accessible through the existing internal road network.




**Plate 4.4: Internal access road to the proposed Solar PV project site.**




**Plate 4.5: External access road into the institution.**
***Source:*** *Bolben Ltd. Fieldwork Survey, 2026*

### 4.4.4 Existing Infrastructure

Although the Permanent Site is still under development, several institutional facilities have been constructed or are at advanced stages of construction. These include the Administrative Building, Boys' Hostel, Girls' Hostel, College of Medicine, College of Science and associated supporting infrastructure. At the time of the field survey, the campus had no connection to the national electricity grid, which underscores the need for the proposed Solar PV project. Two groundwater boreholes had been drilled within the campus; however, neither was operational during the field investigation because they could only be operated using a generator, which was unavailable during the survey.

Consequently, groundwater sampling could not be undertaken as part of the baseline environmental investigations. No natural surface water body occurs within the University campus.

Surface runoff from the site is conveyed through an existing reinforced concrete twin-cell culvert located along the main access road into a natural drainage channel situated behind the proposed project area. The culvert was still under construction during the field survey and is intended to improve stormwater conveyance across the access road. Although localized waterlogging was observed within the downstream drainage corridor, the proposed Solar PV project site occupies relatively higher ground and remained well-drained throughout the field investigation.




**Plate 4.6: Three-cell reinforced concrete culvert under construction along the project access road.**

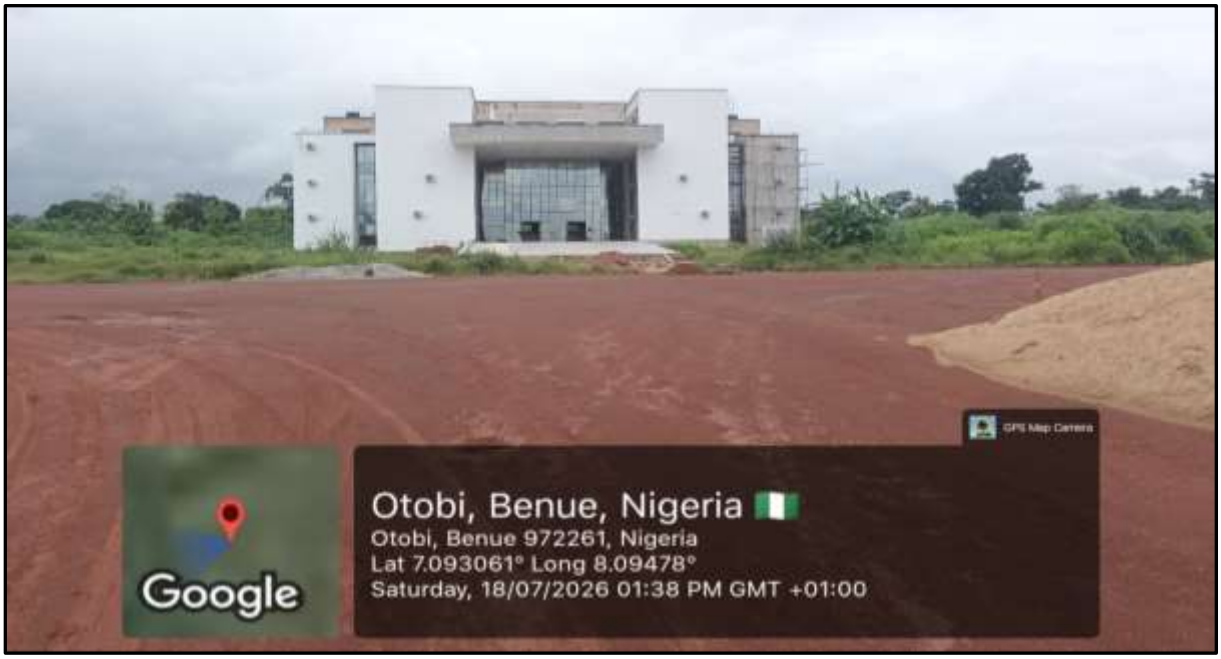



**Plate 4.7: Ongoing Administrative Building opposite the Proposed Site.**




**Plate 4.8: Ongoing Lecture Theatre Adjacent the Proposed Site.**
***Source:*** *Bolben Ltd. Fieldwork Survey, 2026*

### 4.4.5 General Site Characteristics

The proposed project area occupies approximately 10 hectares of relatively level to gently undulating terrain with stable ground conditions suitable for infrastructure development. The site is underlain predominantly by lateritic soils ranging from sandy loam to loamy soils, with localized clayey horizons identified during the soil investigation.

Vegetation within the project area is dominated by secondary growth comprising shrubs, grasses, herbs, climbers and scattered indigenous trees, together with cultivated food crops including cassava (*Manihot esculenta*), maize (*Zea mays*), yam (*Dioscorea* spp.) and banana (*Musa* spp.). Scattered oil palm (*Elaeis guineensis*) and fruit-bearing trees such as guava (*Psidium guajava*) were also observed within and around the proposed development footprint. The vegetation reflects previous agricultural activities and natural regeneration typical of a disturbed greenfield environment.

No evidence of active erosion, gullying, flooding or significant environmental degradation was observed within the proposed project footprint. The relatively permeable soils, gentle topography and elevated terrain promote natural infiltration of rainfall and contribute to the favourable drainage conditions observed during the field survey.

Ecologically, the project area supports common terrestrial flora and fauna associated with secondary vegetation and cultivated farmland. No mammals, reptiles or amphibians were observed during the survey, although vocalizations of common bird species and sounds of insects were recorded from the surrounding vegetation. No critical habitats, protected species or

environmentally sensitive ecological features were identified within the proposed development footprint.

Overall, the project site presents favourable physical, ecological and environmental conditions for the proposed Solar PV development. The principal constraint identified during the baseline investigation was the prevailing regional security situation, which necessitated the conduct of all field investigations under continuous military and police security escort. Despite this external security challenge, the field investigations were successfully completed, providing a comprehensive baseline dataset for the subsequent environmental and social impact assessment.

## 4.5 Soil Sampling and Quality

### 4.5.1 Soil Sampling and Field Activities

Soil sampling was undertaken to establish the baseline physicochemical characteristics and contamination status of soils within the proposed project area prior to the commencement of construction activities. The sampling programme was designed to provide representative spatial coverage of the proposed project and Associated Infrastructure at the Permanent Site of the Federal University of Health Sciences, Otukpo (FUHSO), Benue State, and to generate baseline reference data for future environmental monitoring during the construction, operation, maintenance and decommissioning phases of the project. The baseline information generated from the investigation will provide a basis for assessing any future changes in soil quality arising from project-related activities including vegetation clearing, earthworks, excavation, foundation construction, equipment movement, accidental spills, waste generation and stormwater runoff.

Field observations during the ESIA survey revealed that although the internal access road leading to the project site has already been constructed with lined concrete drainage channels, the proposed development area itself remains largely undeveloped. The site is predominantly covered by secondary forest vegetation, dense grasses, shrubs and scattered mature trees, interspersed with isolated portions of cultivated farmlands, principally consisting of maize, yam and other seasonal crops. Beyond these localized agricultural activities, the surrounding landscape retains its natural character, extending into extensive woodland and wild vegetation.

No industrial facilities, waste disposal sites, workshops or other significant anthropogenic activities capable of influencing baseline soil quality were observed within or immediately adjacent to the proposed development area. The relatively undisturbed nature of the site therefore provides suitable baseline conditions for establishing existing soil quality prior to project implementation. The surrounding land use is characterized principally by natural vegetation, regenerating forest, cultivated farmlands and the University's internal road infrastructure. These environmental characteristics were considered during the design of the soil sampling programme to ensure representative characterization of the existing soil conditions across the project footprint. Considering the relatively large size of the proposed development area (approximately 10 ha) and the anticipated spatial variability in soil properties, seven representative soil sampling locations were established for the baseline investigation.

**Project Site Soil Sampling:** Six sampling locations (L1–L6) were strategically distributed across the project site to provide adequate spatial representation of the northwestern, northeastern, southwestern, southeastern and central portions of the proposed development area. Four sampling

locations were positioned within the interior of the site but set back from the project boundaries to minimize edge effects, while two additional locations were established within the central portion of the site at approximately equal spacing to characterize the average soil conditions across the interior of the proposed development area.

**Control Soil Sampling:** One control sampling location (L7) was established outside the University property at the FUHSO Security Checkpoint; along the Otukpo–Igumale Road. The control location was selected within a relatively undisturbed environment exhibiting similar geological setting, topography, vegetation and soil-forming conditions to those of the project site. The control samples provide background soil quality conditions against which any future project-related changes can be assessed.

At each sampling location, surface vegetation, grasses, roots, stones and loose organic debris were carefully cleared prior to sampling. Soil samples were then collected using a hand-operated stainless-steel Edelman soil auger from two standard depth intervals comprising Topsoil (0–15 cm) and Subsoil (15–30 cm). These depth intervals represent the biologically active surface horizon and the shallow subsurface soils most likely to be affected by site preparation, vegetation clearing, excavation, foundation construction, stormwater infiltration and other project-related activities.

Following collection, all soil samples were transferred into clean polyethylene sample bags, appropriately labelled, and sealed. GPS coordinates, sampling depths, sample identification numbers and field observations were recorded for each sampling location to ensure complete traceability throughout the investigation. The samples were subsequently transported to the accredited Ministry of Environment and Climate Change, Pollution Control Laboratory, Kano, for detailed physicochemical, nutrient and heavy metal analyses. Overall, a total of fourteen (14) soil samples were collected from the seven sampling locations, comprising seven topsoil samples and seven corresponding subsoil samples. The analytical results generated from these investigations provide the baseline soil quality conditions against which any future environmental changes associated with the implementation of the proposed project can subsequently be evaluated.
***See Plate 4.9 for pictorial evidence of Soil Sampling Activities.***
***See more pictorial evidence of soil sampling activities for different locations in Appendix VI.***

**Table 4.3: Soil Sampling Locations, Coordinates and Sample Details**

| Location ID | Sampling Position | Latitude (N) | Longitude (E) | Sample IDs | Sampling Depth (cm) | Description |
|---|---|---|---|---|---|---|
| **L1** | Northwestern Interior | **7°03′58.02″ N** | **8°05′53.49″ E** | **SS1 (Topsoil);**<br><br>**SS2 (Subsoil)** | 0–15;<br><br>15–30 | Located within the northwestern section of the project site and set back from the adjoining boundaries to represent baseline soil conditions while minimizing edge effects. |
| **L2** | Northeastern Interior | **7°03′57.27″ N** | **8°05′59.64″ E** | **SS3 (Topsoil);** | 0–15; | Located within the northeastern section of the project site and set back from the adjoining |

| Location ID | Sampling Position | Latitude (N) | Longitude (E) | Sample IDs | Sampling Depth (cm) | Description |
|---|---|---|---|---|---|---|
| | | | | **SS4 (Subsoil)** | 15–30 | boundaries to provide representative coverage of the northeastern portion of the project area. |
| **L3** | Southwestern Interior | **7°03′50.25″ N** | **8°05′54.69″ E** | **SS5 (Topsoil);**<br>**SS6 (Subsoil)** | 0–15;<br>15–30 | Located within southwestern section of the project site and set back from the adjoining boundaries to characterize baseline soil conditions within the southwestern portion of the site. |
| **L4** | Southeastern Interior | **7°03′50.23″ N** | **8°06′00.36″ E** | **SS7 (Topsoil);**<br>**SS8 (Subsoil)** | 0–15;<br>15–30 | Located within the southeastern section of the project site and set back from the adjoining boundaries to characterize baseline soil conditions within the southeastern portion of the project area. |
| **L5** | North-central Interior | **7°03′55.10″ N** | **8°05′56.90″ E** | **SS9 (Topsoil);**<br>**SS10 (Subsoil)** | 0–15;<br>15–30 | Located within the central portion of the project site, north of the approximate site centre, to characterize representative soil conditions across the interior of the development area. |
| **L6** | South-central Interior | **7°03′52.78″ N** | **8°05′57.20″ E** | **SS11 (Topsoil);**<br>**SS12 (Subsoil)** | 0–15;<br>15–30 | Located within the central portion of the project site, south of the approximate site centre and approximately equally spaced from L5, providing representative coverage of the central development area. |
| **L7** | Control Location | **7°03′39.42″ N** | **8°05′30.55″ E** | **SS13 (Topsoil);**<br>**SS14 (Subsoil)** | 0–15;<br>15–30 | Control soil sampling location established outside the University property at FUHSO Security Checkpoint, some distance away along the Otukpo–Igumale Road. The location was selected within a relatively undisturbed natural environment to provide |

| Location ID | Sampling Position | Latitude (N) | Longitude (E) | Sample IDs | Sampling Depth (cm) | Description |
|---|---|---|---|---|---|---|
| | | | | | | background soil quality for comparison with samples collected within the project site. |
| **Total** | **Seven representative sampling locations (including one control location)** | | | **SS1–SS14 (14 Samples)** | | Representative spatial coverage of the project site together with an external background control location. |

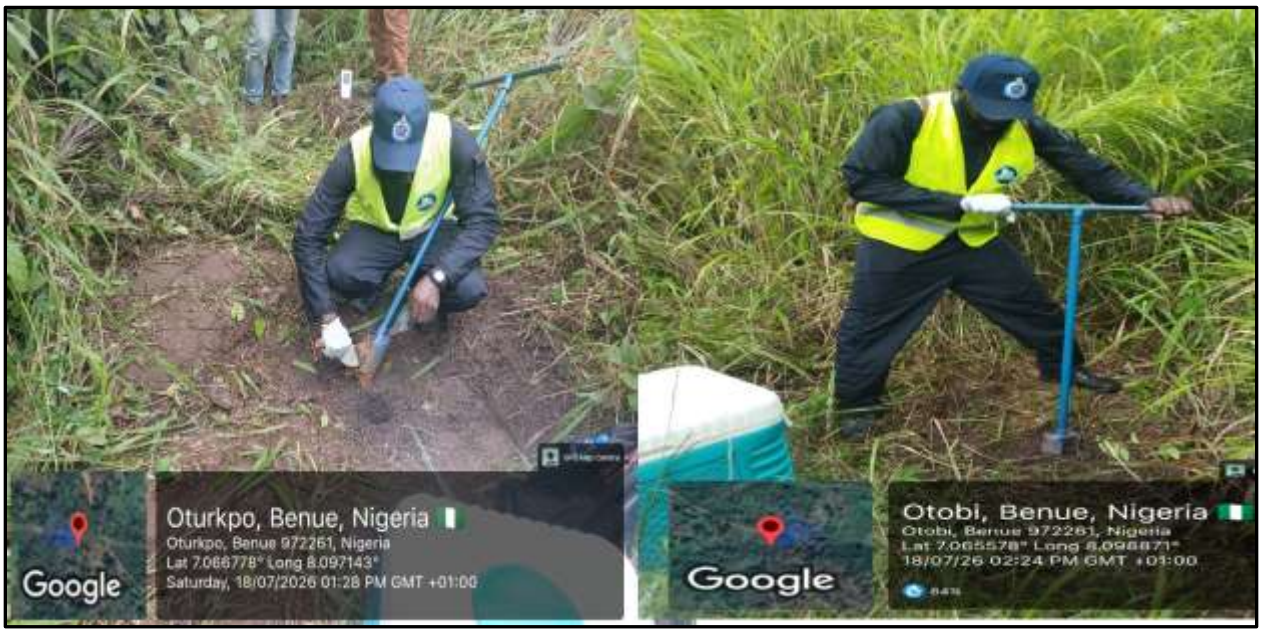



**Plate 4.9: Soil Sampling Activities**
***Source:*** *Bolben Ltd. Fieldwork Survey, 2026*

### 4.5.2 Soil Laboratory Analysis, Interpretation and Discussions

The soil laboratory results provide baseline information on the physical, chemical, geochemical, organic, textural and microbiological characteristics of soils within the proposed 2 MW Solar Photovoltaic (PV) Power Project and Associated Infrastructure at the Permanent Site of the Federal University of Health Sciences, Otukpo (FUHSO), Benue State. Fourteen soil samples were analysed, comprising twelve project-site samples collected as paired topsoil and subsoil samples from six locations (L1–L6), together with topsoil and subsoil control samples collected at L7. The investigated parameters were grouped into physical properties, exchangeable cations, exchangeable anions, heavy metals, organic contaminants, particle-size characteristics and microbiological indicators. This parameter-by-parameter approach follows the structure adopted in the soil laboratory analytical results table (Table 4.4), which considers the environmental, ecological and engineering significance of each parameter group.

Overall, the results indicate predominantly slightly acidic to near-neutral, non-saline and oxidizing soils with moderate electrical conductivity and variable nutrient composition. Heavy metals occurred at concentrations substantially below the adopted guideline limits, while oil and grease, mercury and BTEX were not detected. Phenol was detected at low concentrations, with the highest values occurring in the control samples. The soils were predominantly sandy to loamy, although inconsistencies were observed in some particle-size totals. *Escherichia coli* and fungi were detected across the project and control locations, indicating biologically active soils with an existing background sanitary influence.

#### 4.5.2.1 Physical and General Physicochemical Characteristics

The physical and general physicochemical properties of soil influence nutrient availability, microbial activity, contaminant mobility, vegetation performance, erosion susceptibility and suitability for construction. The parameters assessed comprised soil colour, pH, electrical conductivity, temperature, salinity and oxidation-reduction potential.

**a. Soil pH:** Soil pH controls nutrient availability, microbial processes, metal mobility and vegetation establishment. The recorded values ranged from 5.88 to 7.30 across the project-site samples, while the control samples recorded 6.61 and 6.70. The highest pH was recorded in SS1 at L1, while the lowest occurred in SS10 at L5. All samples complied with the adopted guideline range of 6.0–8.5, except SS10, which was marginally below the lower limit. The results indicate that the soils are generally **slightly acidic to near neutral**, with one moderately acidic subsoil occurrence. The slightly acidic conditions are typical of humid tropical soils affected by rainfall, leaching, vegetation decomposition and mineral weathering. The lower pH in SS10 may reflect localized organic-matter decomposition, stronger leaching, differences in parent material or moisture conditions. The corresponding topsoil at L5 recorded a pH of 6.64, indicating that the acidity is localized within the subsoil rather than characteristic of the entire sampling location. The generally near-neutral pH is favourable for nutrient availability, microbial activity and vegetation establishment. It also limits the mobility of most heavy metals. No widespread pH-related soil degradation was identified. However, acidic construction materials, chemical spills and poorly managed waste should be prevented from further lowering soil pH.

**b. Electrical Conductivity:** Electrical conductivity indicates the concentration of soluble ions within the soil solution. Values ranged from 866 to 1,778 µS/cm across the project area and from 1,663 to 1,756 µS/cm at the control location. All samples were below the adopted guideline value of 4,000 µS/cm. The lowest conductivity occurred in SS3 at L2, while the highest was recorded in SS7 at L4. The relatively narrow range among most samples indicates broadly similar ionic conditions across the project site.

## Table 4.4: Soil Laboratory Analytical Results

| S/N | Parameter | Unit | L 1 | | L2 | | L3 | | L4 | | L5 | | L6 | | L7 (Control) | | Guideline / Limit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | SS1 | SS2 | SS3 | SS4 | SS5 | SS6 | SS7 | SS8 | SS9 | SS10 | SS11 | SS12 | SS13 | SS14 | |
| **A. Physical Parameters** | | | | | | | | | | | | | | | | | |
| **1** | pH | – | 7.30 | 6.60 | 6.75 | 6.34 | 6.68 | 6.94 | 6.64 | 6.76 | 6.64 | 5.88 | 7.05 | 6.61 | 6.61 | 6.70 | 6.0–8.5 |
| **2** | Electrical Conductivity | µS/cm | 1,768 | 1,768 | 866 | 1,660 | 1,714 | 1,758 | 1,778 | 1,491 | 1,272 | 1,485 | 1,543 | 1,467 | 1,756 | 1,663 | <4,000 |
| **3** | Temperature | °C | 30.9 | 30.1 | 31.8 | 32.0 | 31.4 | 32.3 | 31.4 | 32.0 | 31.4 | 32.8 | 31.6 | 32.1 | 32.8 | 33.0 | Ambient |
| **4** | Salinity | % | 0.08 | 0.08 | 0.04 | 0.08 | 0.08 | 0.08 | 0.08 | 0.07 | 0.07 | 0.07 | 0.07 | 0.06 | 0.08 | 0.08 | <0.2 |
| **5** | Oxidation-Reduction Potential (ORP) | Mv | 114 | 134 | 124 | 163 | 110 | 114 | 199 | 166 | 80 | 121 | 207 | 131 | 145 | 158 | NS |
| **6** | Colour | TCU | Dark yellow-brown | Dark brown | Dark brown | Dark yellowish-brown | Dark yellowish-brown | Dark yellowish-brown | Very dark brown | Black | Dark brown | Yellowish-brown | Dark brown | Dark yellowish-brown | Dark yellowish-brown | Dark yellow-brown | NS |
| **B. Exchangeable Cations** | | | | | | | | | | | | | | | | | |
| **7** | Calcium ($Ca^{2+}$) | mg/kg | 0.41 | 3.46 | 0.39 | 3.27 | 1.52 | 1.78 | 2.23 | 2.96 | 1.43 | 0.86 | 2.44 | 2.44 | 0.56 | 0.74 | NS |
| **8** | Magnesium ($Mg^{2+}$) | mg/kg | 1.88 | 2.99 | 1.45 | 1.92 | 0.86 | 0.92 | 1.14 | 1.17 | 2.22 | 2.01 | 1.06 | 1.07 | 0.05 | 0.32 | NS |
| **9** | Aluminium ($Al^{3+}$) | mg/kg | 1.066 | 1.234 | 0.862 | 0.966 | 0.112 | 0.173 | 0.863 | 0.934 | 1.005 | 0.396 | 0.000 | 0.042 | 0.000 | 0.000 | NS |
| **10** | Potassium ($K^{+}$) | mg/kg | 2.7 | 3.8 | 2.3 | 2.5 | 2.5 | 2.3 | 0.9 | 1.7 | 3.7 | 6.9 | 2.3 | 2.1 | 0.7 | 1.0 | NS |
| **11** | Ammonium ($NH_4^{+}$) | mg/kg | 0.11 | 0.47 | 0.93 | 1.86 | 0.77 | 1.02 | 0.56 | 0.34 | 0.19 | 0.29 | 0.34 | 1.55 | 0.06 | 0.12 | NS |
| **C. Exchangeable Anions** | | | | | | | | | | | | | | | | | |
| **12** | Chloride ($Cl^{-}$) | mg/kg | 2.7 | 0.7 | 1.4 | 0.0 | 0.3 | 0.6 | 1.8 | 2.7 | 1.9 | 1.9 | 2.6 | 1.5 | 0.0 | 0.0 | NS |
| **13** | Fluoride ($F^{-}$) | mg/kg | 0.00 | 0.13 | 0.32 | 0.41 | 0.72 | 0.11 | 0.05 | 0.04 | 0.51 | 0.36 | 0.51 | 0.86 | 0.10 | 0.00 | NS |
| **14** | Nitrate ($NO_3^{-}$) | mg/kg | 21.4 | 20.6 | 15.4 | 23.5 | 16.8 | 35.1 | 29.7 | 30.3 | 27.7 | 18.5 | 24.6 | 24.9 | 11.6 | 8.9 | <50 |
| **15** | Nitrite ($NO_2^{-}$) | mg/kg | 0.047 | 0.011 | 0.026 | 0.037 | 0.032 | 0.006 | 0.001 | 0.030 | 0.026 | 0.110 | 0.306 | 0.002 | 0.000 | 0.000 | <3 |
| **16** | Sulphate ($SO_4^{2-}$) | mg/kg | 53 | 59 | 63 | 74 | 44 | 39 | 68 | 90 | 28 | 19 | 42 | 33 | 20 | 14 | NS |
| **17** | Phosphate ($PO_4^{3-}$) | mg/kg | 6.47 | 4.33 | 2.86 | 2.81 | 3.34 | 2.94 | 2.86 | 3.00 | 2.55 | 1.89 | 2.04 | 2.77 | 1.36 | 0.04 | NS |
| **D. Heavy Metals** | | | | | | | | | | | | | | | | | |
| **18** | Chromium (Cr) | mg/kg | 0.02 | 0.09 | 0.00 | 0.01 | 0.04 | 0.03 | 0.15 | 0.02 | 0.22 | 0.05 | 0.11 | 0.36 | 0.01 | 0.08 | 100 |

| S/N | Parameter | Unit | L 1 | | L2 | | L3 | | L4 | | L5 | | L6 | | L7 (Control) | | Guideline / Limit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | SS1 | SS2 | SS3 | SS4 | SS5 | SS6 | SS7 | SS8 | SS9 | SS10 | SS11 | SS12 | SS13 | SS14 | |
| **19** | Copper ($Cu^{2+}$) | mg/kg | 1.05 | 0.24 | 1.00 | 1.03 | 2.04 | 2.02 | 0.47 | 0.86 | 0.51 | 0.36 | 0.17 | 0.17 | 0.02 | 0.03 | 100 |
| **20** | Iron ($Fe^{2+}$) | mg/kg | 0.86 | 1.19 | 0.46 | 0.41 | 1.88 | 1.24 | 0.36 | 0.39 | 0.52 | 0.09 | 1.26 | 0.86 | 0.11 | 0.10 | NS |
| **21** | Lead ($Pb^{2+}$) | mg/kg | 0.000 | 0.000 | 0.025 | 0.044 | 0.000 | 0.000 | 0.000 | 0.000 | 0.004 | 0.000 | 0.001 | 0.001 | 0.000 | 0.000 | 85 |
| **22** | Manganese (Mn) | mg/kg | 0.2 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.0 | 0.0 | NS |
| **23** | Mercury (Hg) | µg/kg | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 300 |
| **24** | Cobalt ($Co^{2+}$) | mg/kg | 0.2 | 0.1 | 0.2 | 0.3 | 0.2 | 0.4 | 0.7 | 0.7 | 0.1 | 0.2 | 0.1 | 0.0 | 0.0 | 0.1 | 20 |
| **25** | Nickel ($Ni^{2+}$) | mg/kg | 0.002 | 0.001 | 0.003 | 0.000 | 0.014 | 0.003 | 0.136 | 0.148 | 0.056 | 0.037 | 0.004 | 0.004 | 0.006 | 0.006 | 35 |
| **E. Organic Parameters** | | | | | | | | | | | | | | | | | |
| **26** | Oil and Grease | mg/kg | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | <1,000 |
| **27** | Phenol | mg/kg | 0.034 | 0.031 | 0.118 | 0.033 | 0.116 | 0.026 | 0.034 | 0.011 | 0.056 | 0.118 | 0.021 | 0.341 | 0.962 | 0.565 | 5 |
| **28** | BTEX | mg/kg | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | <0.5 |
| **F. Soil Particle-Size Characteristics** | | | | | | | | | | | | | | | | | |
| **29** | Sand | % | 55 | 48 | 58 | 60 | 58 | 63 | 64 | 69 | 67 | 54 | 72 | 56 | 59 | 41 | NS |
| **30** | Loam | % | 31 | 25 | 37 | 28 | 33 | 31 | 25 | 34 | 28 | 38 | 21 | 40 | 36 | 50 | NS |
| **31** | Clay | % | 9 | 13 | 0 | 9 | 6 | 1 | 18 | 2 | 2 | 7 | 2 | 0 | 4 | 6 | NS |
| **32** | Silt | % | 5 | 10 | 5 | 3 | 3 | 5 | 21 | 14 | 3 | 1 | 5 | 4 | 1 | 3 | NS |
| **G. Microbiological Parameters** | | | | | | | | | | | | | | | | | |
| **33** | *Escherichia coli* | CFU/100 kg | 34 | 19 | 14 | 35 | 32 | 21 | 6 | 17 | 43 | 29 | 15 | 27 | 18 | 18 | Nil |
| **34** | Fungal Count | CFU/100 kg | 219 | 56 | 62 | 294 | 301 | 87 | — | 69 | 396 | 94 | 65 | 99 | 54 | 54 | NS |

**Standards**

- **Federal Ministry of Environment (FMEnv).** *National Environmental (Soil Quality Control) Regulations*, 2011 (where applicable).
- **Department of Petroleum Resources (DPR).** *Environmental Guidelines and Standards for the Petroleum Industry in Nigeria (EGASPIN)*, Revised Edition, 2018.
- **Dutch Target and Intervention Values for Soil Quality**, latest applicable edition (used where Nigerian standards are unavailable).

**Notes**

- **SS1, SS3, SS5, SS7, SS9 and SS11** are project-site topsoil samples collected at 0–15 cm.
- **SS2, SS4, SS6, SS8, SS10 and SS12** are corresponding project-site subsoil samples collected at 15–30 cm.
- **SS13** is the control topsoil sample and **SS14** is the control subsoil sample.
- **NS** = No specific guideline or limit stated.
- **µS/cm** = Microsiemens per centimetre.
- **mg/kg** = Milligram per kilogram.
- **µg/kg** = Microgram per kilogram.
- **CFU** = Colony-forming unit.
- **BTEX** = Benzene, Toluene, Ethylbenzene and Xylene.

The control samples also exhibited comparatively high conductivity, demonstrating that the measured ionic content is not restricted to the development footprint. The combination of moderate conductivity and low salinity suggests that conductivity is primarily associated with naturally occurring nutrient ions, mineral weathering products and dissolved soil constituents rather than harmful salt accumulation. The results do not indicate salinity-related soil degradation or a major risk of salt-induced corrosion.

**c. Soil Temperature:** Soil temperatures ranged from 30.1°C to 32.8°C across the project area, while the control samples recorded 32.8°C and 33.0°C. The values represent ambient tropical daytime conditions. The limited variation likely reflects differences in vegetation cover, soil moisture, shading, sampling depth and time of measurement. The highest project-site temperature occurred in SS10, while the lowest was recorded in SS2. These temperatures support active microbial processes, organic-matter decomposition and nutrient cycling. No evidence of abnormal thermal conditions or heat-related soil degradation was observed.

**d. Salinity:** Soil salinity ranged from 0.04% to 0.08%, with both control samples recording 0.08%. All values were below the adopted guideline of 0.2%. The soils are therefore non-saline. The similarity between the project-area and control samples indicates that the measured salt content represents natural background soil chemistry. The low salinity is favourable for vegetation establishment and reduces the likelihood of osmotic stress, clay dispersion, concrete deterioration or corrosion of buried infrastructure.

**e. Oxidation-Reduction Potential:** ORP values ranged from 80 to 207 mV across the project site and from 145 to 158 mV at the control location. All values were positive. Positive ORP values indicate predominantly oxidizing and generally aerated soil conditions. SS9 recorded the lowest value of 80 mV, suggesting comparatively weaker oxidizing conditions, potentially associated with greater moisture retention, organic-matter decomposition or lower aeration. SS11 recorded the highest project-site value of 207 mV, indicating strongly oxidizing conditions. No negative ORP values were recorded, and there was no evidence of widespread anaerobic, sulphide-generating or persistently waterlogged conditions. Positive ORP also limits the mobility of iron and manganese by favouring relatively stable oxidized mineral forms.

**f. Soil Colour:** The soils ranged from dark yellow-brown and dark yellowish-brown to dark brown, very dark brown and black. The predominant dark colours likely reflect varying concentrations of organic matter, moisture and weathered mineral constituents. Yellowish-brown colours are consistent with oxidized iron-bearing minerals commonly present in tropical soils. SS8 was described as black. This may indicate higher organic-matter accumulation, greater moisture retention or localized reducing conditions. However, the sample recorded a positive ORP of 166 mV and contained no oil and grease or BTEX. The black colour therefore does not independently indicate petroleum contamination. The colour variation reflects natural differences in soil-forming conditions, vegetation cover, organic-matter content, drainage and weathering. No visible colour pattern demonstrating widespread chemical or hydrocarbon contamination was established.

**Relationship Among the Physical Parameters:** The physical results present a generally coherent baseline condition. The soils are predominantly slightly acidic to near neutral, non-saline and oxidizing, with moderate electrical conductivity and normal tropical temperatures. Control samples displayed conductivity and salinity values comparable to those from the project footprint,

supporting the conclusion that the ionic conditions represent natural background characteristics. The dark to yellowish-brown colours are consistent with organic matter and weathered iron-bearing tropical soils. The isolated pH value of 5.88 and lower ORP value of 80 mV represent localized variation rather than widespread degradation.

**Table 4.5: Summary of Soil Physical and General Physicochemical Characteristics**

| Parameter | Range/Observation | Interpretation | Environmental/Engineering Significance |
|---|---|---|---|
| **pH** | 5.88–7.30 | Slightly acidic to near neutral. SS10 was marginally below the adopted range. | Generally favourable for vegetation and microbial activity. Localized acidity at L5 should be considered during revegetation. |
| **Electrical Conductivity** | 866–1,778 µS/cm | Moderate ionic content, with all values below 4,000 µS/cm. | No salinity-related constraint. Conductivity reflects natural mineral and nutrient ions. |
| **Temperature** | 30.1–33.0°C | Typical tropical ambient soil temperatures. | Supports biological activity and nutrient cycling; no thermal degradation. |
| **Salinity** | 0.04–0.08% | Non-saline soils. | Low risk of vegetation stress, concrete deterioration or metallic corrosion. |
| **ORP** | 80–207 mV | Positive and predominantly oxidizing conditions. | Indicates generally aerated soils without widespread waterlogging or reducing conditions. |
| **Colour** | Dark yellow-brown to black | Reflects organic matter, soil moisture and weathered iron minerals. | No visible evidence of widespread petroleum contamination. |
| **Overall Condition** | Slightly acidic, non-saline, oxidizing and moderately conductive | Generally stable baseline soil chemistry. | Suitable for project development subject to drainage, erosion control and topsoil conservation. |

### 4.5.2.2 Exchangeable Cations

Exchangeable cations are positively charged ions retained by clay minerals and soil organic matter. They influence soil fertility, nutrient availability, aggregate stability, chemical buffering and vegetation growth. Their concentrations vary according to parent material, weathering, leaching, vegetation, organic matter and land use.

**a. Exchangeable Calcium:** Calcium concentrations ranged from 0.39 to 3.46 mg/kg across the project area and from 0.56 to 0.74 mg/kg in the control samples. The highest concentration was recorded in SS2, while SS3 recorded the lowest. At L1 and L2, subsoil concentrations were substantially higher than the corresponding topsoil values. This may reflect downward leaching, localized calcium-bearing minerals or differences in soil texture. The project-site concentrations were generally higher than the controls. Calcium is a beneficial nutrient that supports root development, microbial processes and soil aggregation. The measured concentrations do not

indicate contamination. Greater calcium in some subsoils may improve aggregate stability and reduce clay dispersion.

**b. Exchangeable Magnesium:** Magnesium ranged from 0.86 to 2.99 mg/kg across the project site, except for the lower values of 0.86–0.92 mg/kg at L3. The control concentrations were markedly lower at 0.05 and 0.32 mg/kg. The highest concentration occurred in SS2, while the lowest was recorded in control topsoil SS13. Project-area soils generally contained more magnesium than the control soils. Magnesium is an essential nutrient required for chlorophyll production and enzyme activity. The distribution reflects natural mineral variability and nutrient cycling rather than contamination.

**c. Exchangeable Aluminium:** Aluminium ranged from below detection to 1.234 mg/kg. It was not detected in SS11, SS13 or SS14 and occurred at only 0.042 mg/kg in SS12. The highest concentration was recorded in SS2. Higher aluminium values occurred at L1, L2, L4 and L5, while L3 and L6 recorded relatively low values. The generally slightly acidic to near-neutral soil pH limits aluminium solubility and reduces the risk of root toxicity. No applicable numerical limit was specified. The measured aluminium is considered primarily geogenic, resulting from weathering of aluminosilicate minerals. No evidence of aluminium-related soil degradation was identified.

**d. Exchangeable Potassium:** Potassium concentrations ranged from 0.9 to 6.9 mg/kg across the project site, compared with 0.7–1.0 mg/kg in the control samples. The highest concentration occurred in SS10 at L5. Most project-site samples contained more potassium than the controls, likely reflecting weathering of potassium-bearing minerals, decomposition of vegetation and possible influence from cultivated portions of the site. The comparatively high SS10 value may reflect localized nutrient accumulation, organic residue or past fertilizer use. Potassium is beneficial for plant growth, water regulation and resistance to environmental stress. The results indicate useful nutrient reserves for existing vegetation and future site restoration.

**e. Exchangeable Ammonium:** Ammonium concentrations ranged from 0.11 to 1.86 mg/kg across the project area and 0.06–0.12 mg/kg in the control soils. The highest concentration occurred in SS4 at L2, followed by SS12 at L6. Project-site concentrations were generally higher than the controls. Potential sources include decomposition of vegetation, soil organic matter, animal activity and localized agricultural inputs. The positive ORP values indicate that aerobic nitrification is likely occurring, converting some ammonium to nitrite and nitrate. Although no guideline was specified, the concentrations do not independently demonstrate severe ammonium pollution. They indicate active nitrogen cycling and localized nutrient enrichment.

**Table 4.6: Summary of Exchangeable Cation Characteristics**

| Parameter | Range/Observation | Interpretation | Environmental/Engineering Significance |
|---|---|---|---|
| **Calcium** | 0.39–3.46 mg/kg | Variable natural distribution; often higher in subsoil. | Beneficial for soil aggregation and vegetation; no contamination concern. |
| **Magnesium** | 0.05–2.99 mg/kg | Project soils generally higher than controls. | Supports plant growth and chemical stability. |

| Parameter | Range/Observation | Interpretation | Environmental/Engineering Significance |
|---|---|---|---|
| **Aluminium** | ND–1.234 mg/kg | Low to moderate geogenic concentrations. | Limited toxicity risk under slightly acidic to near-neutral conditions. |
| **Potassium** | 0.7–6.9 mg/kg | Localized enrichment, particularly at L5. | Useful nutrient reserve; topsoil conservation recommended. |
| **Ammonium** | 0.06–1.86 mg/kg | Higher within the project site, reflecting active nitrogen cycling. | No evidence of severe pollution, but runoff and fertilizer inputs should be controlled. |
| **Overall Status** | Variable nutrient cation composition | Consistent with natural weathering, vegetation and localized cultivation. | Suitable for development without chemical remediation. |

#### 4.5.2.3 Exchangeable Anions and Nutrient Indicators

Exchangeable anions are relatively mobile and are influenced by rainfall, infiltration, biological activity, fertilizer use and organic-matter decomposition. They provide information on salinity, nutrient availability and possible anthropogenic inputs.

**a. Chloride:** Chloride concentrations ranged from 0.0 to 2.7 mg/kg across the project area and were not detected in either control sample. The highest concentrations occurred in SS1 and SS8. The values were low and consistent with the low salinity results. No evidence of saline intrusion, substantial wastewater influence or excessive chloride-bearing fertilizer accumulation was observed. The measured chloride poses negligible risk to vegetation, microorganisms or buried metallic infrastructure.

**b. Fluoride:** Fluoride ranged from 0.00 to 0.86 mg/kg. The highest value occurred in SS12, while the control topsoil contained 0.10 mg/kg and the control subsoil recorded no fluoride. No applicable limit was specified. The distribution may reflect natural mineral weathering and spatial variation in fluoride-bearing soil constituents. The low concentrations do not indicate significant contamination.

**c. Nitrate:** Nitrate concentrations ranged from 15.4 to 35.1 mg/kg across the project area and from 8.9 to 11.6 mg/kg in the control samples. All samples complied with the adopted guideline of less than 50 mg/kg. The highest concentration occurred in SS6 at L3. Project-area soils consistently contained more nitrate than the control soils. This likely reflects active organic-matter decomposition, microbial nitrification, vegetation cycling and localized cultivated land or fertilizer influence. Although concentrations remained compliant, their generally higher levels within the development area indicate appreciable nutrient availability. Vegetation clearing and topsoil removal could reduce this nutrient pool or transport nitrate through runoff and erosion.

**d. Nitrite:** Nitrite concentrations ranged from 0.001 to 0.306 mg/kg across the project area and were not detected in the control samples. All results remained below the adopted guideline of 3 mg/kg. SS11 recorded the highest concentration, followed by SS10. The comparatively elevated SS11 value may represent localized nitrogen transformation, recent organic inputs or temporary incomplete nitrification. The concentrations do not indicate harmful nitrite contamination but demonstrate active nitrogen cycling within the soils.

**e. Sulphate:** Sulphate ranged from 19 to 90 mg/kg across the project area and from 14 to 20 mg/kg in the controls. The highest concentration occurred in SS8 at L4. Project-site values were generally higher than control concentrations, particularly at L2 and L4. This may reflect weathering of sulphur-bearing minerals, decomposition of organic matter or localized agricultural inputs. No limit was specified. The concentrations do not, by themselves, demonstrate sulphate contamination. However, high-sulphate locations should be considered during concrete and foundation design if subsequent geotechnical or chemical testing indicates aggressive soil conditions.

**f. Phosphate:** Phosphate ranged from 1.89 to 6.47 mg/kg across the project area, compared with 0.04–1.36 mg/kg at the control location. SS1 recorded the highest concentration. Project-site soils contained substantially more phosphate than the control soils. Potential explanations include vegetation decomposition, cultivated land, fertilizer application and natural accumulation in iron- and aluminium-bearing tropical soils. The concentrations indicate useful phosphorus availability but also show spatial nutrient enrichment. No evidence of extreme phosphorus contamination was established because no applicable numerical limit was provided.

**Table 4.7: Summary of Exchangeable Anion Characteristics**

| Parameter | Range/Observation | Interpretation | Environmental/Engineering Significance |
|---|---|---|---|
| **Chloride** | ND–2.7 mg/kg | Low concentrations consistent with non-saline soils. | Negligible risk to vegetation and buried infrastructure. |
| **Fluoride** | ND–0.86 mg/kg | Low and spatially variable natural concentrations. | No identified fluoride-related constraint. |
| **Nitrate** | 8.9–35.1 mg/kg | Higher within the project site but below 50 mg/kg. | Indicates active nutrient cycling and possible cultivated-land influence. |
| **Nitrite** | ND–0.306 mg/kg | Low concentrations below 3 mg/kg. | No harmful accumulation; active nitrogen transformation. |
| **Sulphate** | 14–90 mg/kg | Variable, with higher project-site concentrations. | No clear contamination; include in construction-material compatibility assessment where necessary. |
| **Phosphate** | 0.04–6.47 mg/kg | Project soils enriched relative to controls. | Beneficial nutrient reserve; prevent erosion and nutrient loss. |
| **Overall Status** | Nutrient-enriched but compliant where limits apply | Reflects natural cycling, vegetation and localized cultivation. | No anion-related remediation required. |

#### 4.5.2.4 Heavy Metals and Trace Elements

Heavy metals occur naturally through mineral weathering but may also originate from industrial activity, waste disposal, fuels, batteries, paints and agrochemicals. The assessment evaluated chromium, copper, iron, lead, manganese, mercury, cobalt and nickel.

**a. Chromium:** Chromium concentrations ranged from 0.00 to 0.36 mg/kg, far below the adopted guideline of 100 mg/kg. The highest value occurred in SS12. The concentrations represent less than 1% of the applicable limit and indicate no chromium contamination. The distribution is consistent with trace natural occurrence in parent materials.

**b. Copper:** Copper ranged from 0.17 to 2.04 mg/kg within the project site and from 0.02 to 0.03 mg/kg in the controls. All values were far below the guideline of 100 mg/kg. L3 recorded the highest concentrations. While project samples were generally higher than the controls, the absolute values remained very low. Copper likely reflects natural mineral weathering and biological nutrient cycling. No toxic enrichment was identified.

**c. Iron:** Iron ranged from 0.09 to 1.88 mg/kg across the project site and 0.10–0.11 mg/kg in the controls. The highest concentration occurred in SS5 at L3. No numerical limit was specified. Project soils generally contained more iron than the controls, consistent with the dark yellowish-brown colours and weathering of iron-bearing tropical soils. The positive ORP conditions suggest that much of the iron occurs in stable oxidized forms with limited mobility. Iron represents a natural soil constituent rather than evidence of contamination.

**d. Lead:** Lead ranged from below detection to 0.044 mg/kg, far below the guideline of 85 mg/kg. The highest concentration occurred in SS4 at L2. Lead was absent from most samples and occurred only at trace levels in others. No evidence of significant contamination from batteries, paints, traffic, waste disposal or industrial activity was identified.

**e. Manganese:** Manganese ranged from below detection to 0.3 mg/kg. The highest value occurred in SS2. No guideline was specified. The values are low and consistent with natural tropical soil conditions. Positive ORP values suggest that manganese is predominantly present in less-mobile oxidized forms.

**f. Mercury:** Mercury was not detected in any sample. All results were below the adopted guideline of 300 µg/kg. The absence of mercury indicates favourable baseline conditions with no evidence of mercury-bearing waste, industrial contamination or chemical inputs.

**g. Cobalt:** Cobalt ranged from below detection to 0.7 mg/kg, substantially below the adopted guideline of 20 mg/kg. The highest values were recorded in SS7 and SS8 at L4. The localized higher values may reflect natural mineral variability. They remain only 3.5% of the adopted limit and do not indicate contamination.

**h. Nickel:** Nickel concentrations ranged from below detection to 0.148 mg/kg, far below the adopted guideline of 35 mg/kg. The highest concentration occurred in SS8 at L4. L4 contained higher nickel and cobalt than the other locations, suggesting localized parent-material or mineralogical influence. However, concentrations remained environmentally insignificant relative to the guideline limits.

**Relationship Between Heavy Metals and Soil Chemistry:** The metal results correspond well with the slightly acidic to near-neutral pH, low salinity and positive ORP values. These conditions generally restrict metal mobility through adsorption and retention within stable mineral phases. Iron was the most abundant measured metal, while toxic metals were absent or present only at trace concentrations. The reference document similarly assesses low metal concentrations together with pH and ORP to distinguish natural geochemical background from anthropogenic contamination.

**Table 4.8: Summary of Heavy-Metal Characteristics**

| Parameter | Range/Observation | Compliance | Interpretation and Significance |
|---|---|---|---|
| **Chromium** | ND–0.36 mg/kg | Compliant | Extremely low; no chromium contamination. |
| **Copper** | 0.02–2.04 mg/kg | Compliant | Low natural concentrations; no toxicity concern. |
| **Iron** | 0.09–1.88 mg/kg | NS | Natural tropical-soil constituent associated with soil colour and weathering. |
| **Lead** | ND–0.044 mg/kg | Compliant | Absent or present only at negligible trace levels. |
| **Manganese** | ND–0.3 mg/kg | NS | Low natural concentrations under oxidizing conditions. |
| **Mercury** | Not detected | Compliant | No mercury contamination. |
| **Cobalt** | ND–0.7 mg/kg | Compliant | Localized natural variation, particularly at L4. |
| **Nickel** | ND–0.148 mg/kg | Compliant | Very low; no nickel-related ecological risk. |
| **Overall Status** | All regulated metals substantially below limits | Compliant | Favourable baseline geochemical quality with no requirement for remediation. |

#### 4.5.2.5 Organic Contaminants

Organic parameters provide evidence of possible contamination from petroleum products, lubricants, solvents, combustion, waste disposal and natural organic-matter decomposition.

**a. Oil and Grease:** Oil and grease were not detected in any project or control sample. All results complied with the adopted guideline of less than 1,000 mg/kg. The absence of oil and grease indicates that the soils had not been significantly affected by fuel spills, lubricants, machinery leakage or petroleum waste before project implementation.

**b. Phenol:** Phenol concentrations ranged from 0.011 to 0.341 mg/kg across the project site and from 0.565 to 0.962 mg/kg in the control samples. All values were below the adopted guideline of 5 mg/kg. The highest project-site value occurred in SS12, while the highest overall value occurred in control topsoil SS13. The control concentrations were considerably higher than most project-area values. This is important because it indicates that phenol occurrence is not confined to the development footprint and may reflect natural organic-matter decomposition, vegetation, burning

or diffuse background conditions. The project-site values do not indicate widespread phenolic contamination. The higher control concentrations reinforce their characterization as part of the wider environmental background.

**c. BTEX:** BTEX compounds were not detected in any sample. All values complied with the adopted guideline of less than 0.5 mg/kg. The absence of benzene, toluene, ethylbenzene and xylene confirms that there was no detectable volatile petroleum-hydrocarbon contamination from fuels, solvents or related products.

**Table 4.9: Summary of Organic Contaminants**

| Parameter | Range/Observation | Compliance | Interpretation and Significance |
|---|---|---|---|
| **Oil and Grease** | Not detected | Compliant | No evidence of petroleum-oil contamination. |
| **Phenol** | 0.011–0.962 mg/kg | Compliant | Low concentrations; highest values occurred in control soils, indicating wider background influence. |
| **BTEX** | Not detected | Compliant | No detectable volatile petroleum-hydrocarbon contamination. |
| **Overall Status** | Petroleum indicators absent; low phenol | Compliant | Favourable baseline with no organic-contaminant remediation required. |

### 4.5.2.6 Soil Particle-Size Distribution and Textural Characteristics

Soil texture controls infiltration, drainage, water retention, aeration, nutrient storage, erosion susceptibility, compaction and foundation performance. The laboratory reported sand, loam, clay and silt as separate percentages. The results provide an indication of relative texture and particle-size distribution of the proposed project site.

**a. Sand Content:** Sand ranged from 48% to 72% across the project site and from 41% to 59% in the control samples. The highest sand content occurred in SS11, while the lowest project-site value occurred in SS2. The project soils are generally sand-rich and likely to exhibit relatively high permeability, rapid infiltration and good aeration. However, sandy soils have lower water- and nutrient-retention capacity and may allow contaminants to migrate downward rapidly if spills occur.

**b. Loam Content:** The reported loam fraction ranged from 21% to 40% across the project site and from 36% to 50% in the controls. The highest project-site value occurred in SS12, while control subsoil SS14 recorded the highest overall value. Higher loam content generally indicates more balanced drainage, moisture retention and nutrient-storage properties. The control soils appear finer and more moisture-retentive than many of the project-site soils.

**c. Clay Content:** Clay ranged from 0% to 18% across the project site and from 4% to 6% in the controls. SS7 recorded the highest reported clay proportion. Clay-rich areas may retain more moisture and nutrients but may also exhibit greater plasticity, compaction sensitivity, reduced infiltration and shrink–swell potential. Samples with very low or zero reported clay are expected to drain rapidly and provide limited contaminant attenuation.

**d. Silt Content:** Silt ranged from 1% to 21% across the project site and from 1% to 3% in the controls. The highest value occurred in SS7, followed by SS8. Higher-silt locations may be more susceptible to erosion, surface sealing and loss of strength when wet. Effective erosion controls will be important during clearing and earthworks.

**Table 4.10: Summary of Soil Textural Characteristics**

| Parameter | Range/Observation | Interpretation | Environmental/Engineering Significance |
|---|---|---|---|
| **Sand** | 41–72% | Sand is the dominant reported fraction. | Promotes drainage and ease of excavation but increases potential contaminant migration and erosion. |
| **Reported Loam** | 21–50% | Variable balanced-texture component; higher in controls. | Supports moisture retention, vegetation and moderate structural stability. |
| **Clay** | 0–18% | Generally low but locally higher at L4. | Localized clay may increase moisture retention, compaction and plasticity. |
| **Silt** | 1–21% | Generally low, but elevated at L4. | Higher-silt areas may be erosion-prone and lose strength when wet. |
| **Overall Texture** | Predominantly sandy with variable finer material | Generally permeable and well aerated. | Suitable for development subject to erosion control, drainage and geotechnical confirmation. |

#### 4.5.2.7 Microbiological Characteristics

Soil microorganisms support organic-matter decomposition, nutrient cycling, aggregation and ecosystem functioning. The reported microbiological indicators were *Escherichia coli* and fungal count. The laboratory reported both parameters in CFU/100 kg. This is an unusual soil microbiological unit and should be confirmed against the signed Certificate of Analysis. The interpretation below retains the unit exactly as presented.

**a. *Escherichia coli*:** *E. coli* counts ranged from 6 to 43 CFU/100 kg across the project site and were 18 CFU/100 kg in both control samples. The adopted guideline was nil; consequently, all samples were non-compliant. The highest count occurred in SS9 at L5, followed by SS4 and SS1. Detection in every project sample and both controls indicates that microbiological influence occurs across the wider environment and is not confined to the project footprint. Potential sources include animal activity, wildlife, cultivated land, organic wastes, open defecation, contaminated runoff and natural redistribution of faecal organisms through soil and water. Because the campus is not operational and contains no student population, the results are more likely associated with existing rural land use, animals and wider environmental conditions than institutional wastewater. The presence of *E. coli* does not prevent construction but indicates the need for good hygiene, suitable personal protective equipment and effective sanitation facilities for workers.

**b. Fungal Count:** Reported fungal counts ranged from 54 to 396 CFU/100 kg, excluding SS7, which presented no counts. The control samples both recorded 54 CFU/100 kg. The highest count occurred in SS9, followed by SS5 and SS4. Higher fungal counts are consistent with the forested and vegetated character of the project site, where leaf litter, roots and organic residues support active fungal decomposition. Fungi are normal components of healthy soil ecosystems and contribute to nutrient release, organic-matter decomposition and soil aggregation. The results

therefore indicate biological activity rather than contamination. The results similarly interpret fungal populations as indicators of active organic-matter decomposition, while treating *E. coli* as evidence of sanitary influence extending across both project and control locations.

**Table 4.11: Summary of Soil Microbiological Characteristics**

| Parameter | Range/Observation | Compliance | Interpretation and Significance |
|---|---|---|---|
| ***E. coli*** | 6–43 CFU/100 kg | Non-compliant at all locations | Indicates widespread background sanitary influence from animals, runoff, cultivation or other diffuse sources. |
| **Fungal Count** | 54–396 CFU/100 kg | NS | Demonstrates active biological decomposition and nutrient cycling within forested and vegetated soils. |
| **Overall Status** | Biologically active soils with detectable *E. coli* | Mixed | Implement worker hygiene, sanitation, PPE and runoff controls during construction. |

### 4.5.2.8 Spatial and Vertical Distribution of Soil Quality

The paired topsoil and subsoil results demonstrate substantial spatial and vertical variability across the proposed development area. At **L1**, the subsoil contained higher calcium, magnesium and aluminium than the topsoil, while the topsoil contained more potassium, chloride, nitrate, phosphate, copper and phenol. This indicates surface nutrient and organic enrichment alongside greater accumulation of base cations in the subsoil. At **L2**, subsoil ammonium, nitrate and lead exceeded the corresponding topsoil values. The location may have experienced localized organic input or agricultural influence, although all regulated metals remained well within guideline values. At **L3**, both topsoil and subsoil recorded the highest copper concentrations, while the subsoil contained the highest nitrate value. These results suggest localized mineral or nutrient enrichment but not harmful contamination. At **L4**, cobalt and nickel concentrations were highest relative to the rest of the site, and the reported particle-size results contained the highest clay and silt proportions. This may reflect a locally different parent material or soil-forming environment. Nevertheless, metal concentrations remained far below guideline limits. At **L5**, SS10 recorded the lowest pH and highest potassium, while SS9 recorded the lowest ORP and highest *E. coli* and fungal count. This location exhibits greater biological activity and localized acidity, possibly reflecting organic-matter accumulation and moisture retention. At **L6**, SS12 recorded the highest fluoride and project-site phenol concentrations, while SS11 recorded the highest nitrite, sand content and ORP. The contrasting conditions show vertical variability in soil texture and chemistry at the location.

The **control location L7** recorded lower nitrate, phosphate, metals and exchangeable nutrient concentrations than many project-site samples but substantially higher phenol concentrations. *E. coli* was also detected in both control samples. This demonstrates that phenol occurrence and sanitary influence form part of the wider background environment and cannot be attributed solely to the proposed project footprint.

**Table 4.12: Overall Soil Quality Assessment**

| Assessment Aspect | Overall Status | Key Findings | Project Implication |
|---|---|---|---|
| **Physical Condition** | Good | Mostly compliant pH, moderate EC, low salinity and positive ORP. | Suitable for development; protect drainage and topsoil. |
| **Nutrient Status** | Moderate to Good | Project soils generally contain more nitrate, phosphate, potassium, calcium and magnesium than controls. | Preserve topsoil for revegetation and rehabilitation. |
| **Heavy Metals** | Good | All regulated metals were far below adopted limits; mercury absent. | No heavy-metal remediation required. |
| **Organic Contaminants** | Good | Oil and grease and BTEX absent; phenol below limit and higher in controls. | Favourable baseline; strict spill prevention required. |
| **Soil Texture** | Generally suitable, subject to verification | Predominantly sandy with variable loam, clay and silt. Several percentage totals are inconsistent. | Confirm with geotechnical particle-size testing before foundation design. |
| **Microbiological Quality** | Impacted | *E. coli* detected throughout project and control locations; fungi indicate active decomposition. | Provide worker sanitation, PPE and hygiene controls. |
| **Control Comparison** | Background variability evident | Controls had lower nutrients and metals but higher phenol and detectable *E. coli*. | Existing contamination indicators should not automatically be attributed to the project. |
| **Overall Baseline Status** | Generally favourable | No widespread chemical, petroleum or heavy-metal contamination. | Project may proceed without prior soil remediation, subject to ESMP implementation. |

The soil baseline investigation indicates that the FUHSO solar PV project area is generally suitable for development. The soils are slightly acidic to near neutral, non-saline, oxidizing and moderately conductive, with natural variations in nutrients and anions. Heavy metals were well below applicable limits, mercury was not detected, and oil and grease and BTEX were absent. Phenol remained within the guideline limit, with the highest values recorded in the control soils, indicating no widespread petroleum, industrial or hazardous-metal contamination. The main concern is the presence of *E. coli* in both project and control samples, suggesting a wider background sanitary influence. Appropriate hygiene, sanitation, runoff and waste-management measures will therefore be required. The soils are predominantly sandy, and a dedicated geotechnical investigation should precede final foundation design. No soil remediation is required, provided that topsoil conservation, erosion control, spill prevention, proper fuel and battery management, waste handling, site restoration and periodic monitoring are implemented.

## 4.6 Surface Water Sampling and Analysis

### 4.6.1 Surface Water Sampling and Field Activities

Surface water sampling was undertaken to establish the baseline physicochemical, microbiological, and heavy metal quality of the nearest available surface water source to the proposed 2 MW Solar Photovoltaic (PV) Power Project and Associated Infrastructure at the Permanent Site of the Federal University of Health Sciences, Otukpo (FUHSO), Benue State. The sampling programme was designed to characterize the existing surface water quality conditions prior to project implementation and to generate baseline data for reference during future environmental monitoring.

At the time of the ESIA field exercise, the FUHSO permanent campus was largely undeveloped and predominantly covered by forest and vegetation, with several buildings still under construction and not yet commissioned. The campus had no operational student population, neighbouring residential communities, or functional infrastructure within the immediate project area. No surface water body was identified within the University campus or the proposed project site. The nearest available surface water body was the Aloma River within Akwete-Akpa Community, approximately 3.2 km from the proposed project site. As the river lies outside the project's direct Area of Influence, it was selected as the nearest representative control surface water source for establishing the prevailing background water quality conditions within the wider project environment. It is therefore not considered a direct project-related surface water receptor.

To characterize the water quality along the river reach, three representative sampling stations were established at the upstream, midstream, and downstream sections of the river. The sampling arrangement followed the upstream–midstream–downstream configuration used in the reference document, which provides separate sampling locations for determining background, prevailing, and downstream water quality conditions.

**Upstream Sampling Point (SW1):** The upstream sampling location, SW1, was established to represent the background water quality entering the selected sampling reach. The station was positioned upstream of the central sampling point, where the river was bordered by dense riparian vegetation and showed limited evidence of direct human disturbance. A grab surface water sample was collected directly from the flowing section of the river using standard environmental sampling procedures. The sample was obtained below the water surface while facing upstream to minimize contamination from disturbed bank materials, floating debris, and surface films. Following collection, the sample was transferred into pre-cleaned sampling containers, appropriately labelled, preserved, and stored under cooled conditions pending laboratory analysis. The provisional coordinates for the upstream sampling point are: Latitude: 7°02′25.19″ N and Longitude: 8°05′08.41″ E.

**Midstream Sampling Point (SW2):** The midstream sampling location, SW2, was established approximately midway along the selected river sampling reach. This point represents the central section of the river and provides information on the prevailing ambient surface water quality conditions within the sampled reach. A grab water sample was collected from the flowing section of the river. Care was taken to collect the sample below the water surface and away from disturbed bottom sediments and floating materials. The sample was immediately transferred into pre-cleaned containers, appropriately preserved, labelled, and stored in an ice chest prior to laboratory

transportation. The coordinate recorded at the midstream sampling point was: Latitude: 7°02′24.50″ N and Longitude: 8°05′08.98″ E.

**Downstream Sampling Point (SW3):** The downstream sampling location, SW3, was established further along the direction of river flow beyond the midstream station. The station was selected to characterize the surface water quality leaving the sampled river reach and to provide a downstream reference point for comparison with the upstream and midstream samples. A grab sample was collected from the main flowing section of the river using standard environmental sampling procedures. The sampling container was submerged below the water surface while facing upstream to minimize the inclusion of floating debris, surface films, and disturbed sediments. Following collection, the sample was appropriately labelled, preserved, sealed, and stored under cooled conditions prior to laboratory analysis. The provisional coordinates for the downstream sampling point are: Latitude: 7°02′23.80″ N and Longitude: 8°05′09.56″ E. Following the establishment of the three representative sampling stations, the sampling locations, geographical coordinates, descriptions, and corresponding sample identification numbers are presented in the table below. The table provides a summary of the surface water sampling design adopted for the baseline assessment and serves as a reference for subsequent laboratory analyses and long-term environmental monitoring.

***See Plate 4.10 for pictorial evidence of Surface Water Sampling and In-Situ Testing Activities. See more pictorial evidence of Surface Water Sampling and In-Situ Testing activities for different locations in Appendix VIII.***




**Plate 4.10: Surface Water Sampling and In-Situ Testing Activities**

***Source:*** *Bolben Ltd. Fieldwork Survey, 2026*

**Table 4.13: Surface Water Sampling Locations and Sample Details**

| Sample ID | Location ID | Sampling Location | Latitude (N) | Longitude (E) | Description | No. of Samples |
|---|---|---|---|---|---|---|
| **SW1** | L1 | Upstream | 7°02′25.19″ N | 8°05′08.41″ E | Surface water sample collected from the upstream section of the Aloma River to establish the background water quality entering the selected sampling reach. | 1 |
| **SW2** | L2 | Midstream | 7°02′24.50″ N | 8°05′08.98″ E | Surface water sample collected from the central section of the Aloma River to characterize the prevailing ambient surface water quality within the sampling reach. | 1 |
| **SW3** | L3 | Downstream | 7°02′23.80″ N | 8°05′09.56″ E | Surface water sample collected from the downstream section of the Aloma River to characterize the water quality leaving the selected sampling reach and provide a downstream reference point. | 1 |
| **Total** | **3 Locations and 3 Samples** | | | | | |

### 4.6.2 Surface Water In-Situ Testing and Laboratory Analysis

Immediately after collection, the surface water samples were subjected to **in-situ** measurements using a calibrated portable multiparameter meter to minimize changes in water quality parameters that may occur during storage and transportation. The field parameters measured included temperature, pH, oxidation-reduction potential (ORP), electrical resistivity, electrical conductivity (EC), total dissolved solids (TDS), salinity, salt specific gravity (S.G.), and fertility. As previously noted, groundwater sampling could not be undertaken because no operational borehole was accessible during the ESIA field exercise.

The in-situ measurements provided immediate field-based information on the prevailing physicochemical characteristics of the surface water at the time of sampling. These measurements are particularly important for parameters that are sensitive to environmental changes and may vary rapidly after sample collection, such as temperature, pH, ORP, and electrical conductivity.

**Table 4.14: Surface Water In-Situ Testing**

| Sample ID | Temperature (°C) | pH | ORP (mV) | Resistivity (MΩ·cm) | Electrical Conductivity (µS/cm) | Total Dissolved Solids (ppm) | Salinity (%) | Salt Specific Gravity (S.G.) | Fertility (ppm) |
|---|---|---|---|---|---|---|---|---|---|
| **SW1** | 28.3 | 6.93 | 254 | 261.0 | 52 | 26 | 0.00 | 1.000 | 1 |
| **SW2** | 28.1 | 6.38 | 182 | 303.7 | 46 | 23 | 0.00 | 1.000 | 1 |
| **SW3** | 28.1 | 6.43 | 165 | 285.6 | 38 | 22 | 0.00 | 1.000 | 1 |

Consequently, the field measurements complement the laboratory analyses by providing real-time baseline conditions against which the detailed physicochemical, microbiological, and heavy metal results can be interpreted. Together, the field and laboratory data provide a comprehensive assessment of the existing surface water quality and establish a robust baseline for evaluating any future environmental changes associated with the implementation of the proposed project.

Following the field measurements, all surface water samples were appropriately labelled, preserved, sealed, and transported to the accredited Ministry of Environment and Climate Change, Pollution Control Laboratory, Kano, for detailed physicochemical, microbiological, heavy metal, and organic analyses. The analytical results generated from both the in-situ measurements and laboratory investigations provide the baseline surface water quality conditions against which any future environmental changes associated with the implementation of the proposed 2 MW Solar Photovoltaic (PV) Power Project at the Federal University of Health Sciences, Otukpo (FUHSO), Benue State, can be evaluated.

The summary of the field in-situ measurements is presented in Table 4.14, while the detailed laboratory analytical results are presented in Table 4.15. The in-situ measurements provide real-time field information on water quality parameters that are susceptible to change during sample storage and transportation, whereas the laboratory analyses provide comprehensive characterization of the physicochemical, chemical, heavy metal, organic, and microbiological properties of the surface water. Together, these datasets establish a robust baseline for evaluating existing environmental conditions.

**Table 4.15: Laboratory Analytical Results for Surface Water Quality**

| S/N | Parameter | Unit | SW1 (Upstream) | SW2 (Midstream) | SW3 (Downstream) | FMEnv Limit |
|---|---|---|---|---|---|---|
| **A. PHYSICOCHEMICAL PARAMETERS** | | | | | | |
| **1** | Colour | TCU | Pale brown | Pale grayish | Pale grayish | Clear |
| **2** | Odour | – | Odourless | Odourless | Odourless | Unobjectionable |
| **3** | Taste | – | Tasteless | Tasteless | Tasteless | Unobjectionable |
| **4** | pH | – | 7.20 | 7.30 | 7.17 | 6.5–8.5 |
| **5** | Temperature | °C | 31.0 | 29.7 | 29.2 | Ambient |
| **6** | Electrical Conductivity | µS/cm | 60 | 50 | 58 | 1000 |
| **7** | Turbidity | NTU | 18 | 15 | 15 | 50 |
| **8** | Total Dissolved Solids (TDS) | mg/L | 30 | 30 | 29 | 500 |
| **9** | Total Suspended Solids (TSS) | mg/L | 4 | 6 | 8 | 20 |
| **10** | Dissolved Oxygen (DO) | mg/L | 3.9 | 4.1 | 4.0 | 2–8 |
| **11** | Biochemical Oxygen Demand (BOD) | mg/L | 2.2 | 2.5 | 2.5 | NS |
| **12** | Chemical Oxygen Demand (COD) | mg/L | 3 | 6 | 6 | 30 |
| **13** | Salinity | % | 0.00 | 0.00 | 0.00 | <1000 |
| **14** | Oxidation-Reduction Potential (ORP) | mV | 118 | 104 | 116 | 200–600 |
| **B. CHEMICAL PARAMETERS** | | | | | | |

| S/N | Parameter | Unit | SW1 (Upstream) | SW2 (Midstream) | SW3 (Downstream) | FMEnv Limit |
|---|---|---|---|---|---|---|
| **15** | Aluminium ($Al^{3+}$) | mg/L | 0.76 | 0.62 | 0.57 | NS |
| **16** | Calcium ($Ca^{2+}$) | mg/L | 5.77 | 6.21 | 5.63 | 200 |
| **17** | Magnesium ($Mg^{2+}$) | mg/L | 2.74 | 2.86 | 2.28 | 20 |
| **18** | Total Hardness | mg/L | 94 | 81 | 87 | 150 |
| **19** | Potassium ($K^{+}$) | mg/L | 4.3 | 5.2 | 4.7 | 20 |
| **20** | Nitrate ($NO_3^{-}$) | mg/L | 104.1 | 86.1 | 92.3 | 50 |
| **21** | Nitrite ($NO_2^{-}$) | mg/L | 0.175 | 0.201 | 0.186 | 0.02 |
| **22** | Chloride ($Cl^{-}$) | mg/L | 45.2 | 47.2 | 41.3 | 150 |
| **23** | Phosphate ($PO_4^{3-}$) | mg/L | 8.55 | 8.63 | 7.92 | NS |
| **24** | Sulphate ($SO_4^{2-}$) | mg/L | 48 | 37 | 42 | 100 |
| **25** | Fluoride ($F^{-}$) | mg/L | 3.50 | 3.62 | 2.96 | NS |
| **C. HEAVY METALS** | | | | | | |
| **26** | Copper ($Cu^{2+}$) | mg/L | 2.90 | 2.84 | 2.62 | 1.5 |
| **27** | Chromium (Cr) | mg/L | 0.55 | 0.47 | 0.43 | 0.05 |
| **28** | Cadmium (Cd) | µg/L | 0.246 | 0.384 | 0.394 | 0.000 |
| **29** | Lead ($Pb^{2+}$) | µg/L | 0.382 | 0.438 | 0.286 | 0.01 |
| **30** | Zinc ($Zn^{2+}$) | mg/L | 1.38 | 1.98 | 1.36 | 3.0 |
| **31** | Nickel ($Ni^{2+}$) | mg/L | 0.086 | 0.128 | 0.186 | 0.07 |
| **32** | Cobalt ($Co^{2+}$) | mg/L | 0.124 | 0.238 | 0.211 | 0.20 |
| **33** | Mercury (Hg) | µg/L | 0.143 | 0.298 | 0.199 | 0.001 |
| **34** | Iron ($Fe^{2+}$) | mg/L | 0.960 | 0.820 | 0.744 | 0.30 |
| **D. ORGANIC PARAMETERS** | | | | | | |
| **35** | Benzene | mg/L | 0.000 | 0.000 | 0.000 | 0.01 |
| **36** | Toluene | mg/L | 0.000 | 0.000 | 0.000 | 0.70 |
| **37** | Ethylbenzene | mg/L | 0.000 | 0.000 | 0.000 | 0.30 |
| **38** | Xylene | mg/L | 0.000 | 0.000 | 0.000 | 0.50 |
| **39** | Phenols | mg/L | 0.278 | 0.198 | 0.286 | 0.05 |
| **40** | Oil and Grease | mg/L | 0.000 | 0.000 | 0.000 | 10 |
| **E. MICROBIOLOGICAL PARAMETERS** | | | | | | |
| **41** | *Escherichia coli* (*E. coli*) | CFU/mL | 32 | 47 | 40 | Nil |
| **42** | Total Coliform | CFU/mL | 256 | 301 | 275 | 10 |

**Standard:** National Environmental (Surface and Groundwater Quality Control) Regulations, 2011, Federal Ministry of Environment (FMEnv), Nigeria.

**Analytical Methods:** American Public Health Association (APHA), American Water Works Association (AWWA), and Water Environment Federation (WEF). *Standard Methods for the Examination of Water and Wastewater*, 24th Edition (2022).

**Notes:**

- TCU = True Colour Unit.
- NTU = Nephelometric Turbidity Unit.
- µS/cm = Microsiemens per centimetre.
- mg/L = Milligram per litre.
- µg/L = Microgram per litre.
- CFU/mL = Colony Forming Units per millilitre.
- °C = Degree Celsius.
- mV = Millivolt.
- NS = No Standard Specified.
- Nil = Not Detectable

### 4.6.3 Surface Water Quality

The analysis and interpretation of the FUHSO surface-water results follow the structure adopted in the attached reference document, comprising detailed discussion of physicochemical characteristics, chemical constituents, heavy metals, organic parameters, microbiological quality and an overall compliance assessment. The reference format evaluates each parameter against the applicable regulatory limit and considers both environmental and project implications. The results presented in Tables 4.14 and 4.15 represent samples collected from the upstream, midstream and downstream sections of the Aloma River. As the river is located approximately 3.2 km from the proposed project site and outside the project's direct Area of Influence, the results represent the existing background condition of the nearest available control surface-water body rather than water quality directly influenced by the proposed FUHSO solar PV project.

#### 4.6.3.1 Comparison of In-Situ and Laboratory Measurements

The in-situ tests provided immediate measurements of parameters that may change during sample storage and transportation, particularly temperature, pH, oxidation-reduction potential, electrical conductivity and total dissolved solids. The laboratory analyses complemented the field measurements by providing controlled analytical determination of the physicochemical, chemical, heavy metal, organic and microbiological characteristics of the samples. The in-situ pH values ranged from 6.38 to 6.93, while the laboratory pH values ranged from 7.17 to 7.30. Both datasets indicate slightly acidic to slightly alkaline, near-neutral water. The differences are reasonable because pH may change following sample collection as a result of temperature variation, carbon dioxide exchange, aeration and continued chemical or biological reactions within the sample.

Field temperatures ranged from 28.1°C to 28.3°C, while the laboratory values ranged from 29.2°C to 31.0°C. The higher laboratory values likely reflect changes in ambient conditions during sample handling and analysis. The field measurements therefore provide the more representative record of river temperature at the time of sampling. Field electrical conductivity ranged from 38 to 52 µS/cm, compared with laboratory values of 50 to 60 µS/cm. Both sets of results indicate very low ionic mineralization. Similarly, field TDS concentrations ranged from 22 to 26 ppm, while laboratory TDS ranged from 29 to 30 mg/L. The close correspondence between conductivity and TDS confirms that the river is fresh and contains relatively low concentrations of dissolved ionic substances. The field ORP measurements ranged from 165 to 254 mV, while laboratory values ranged from 104 to 118 mV. All values were positive, indicating generally oxidizing rather than strongly reducing water conditions. However, the laboratory results were below the stated FMEnv range of 200–600 mV, while only SW1 complied with this range under field conditions. The difference demonstrates the sensitivity of ORP to aeration, temperature, holding time, microbial activity and electrode conditions, and reinforces the importance of the in-situ measurements.

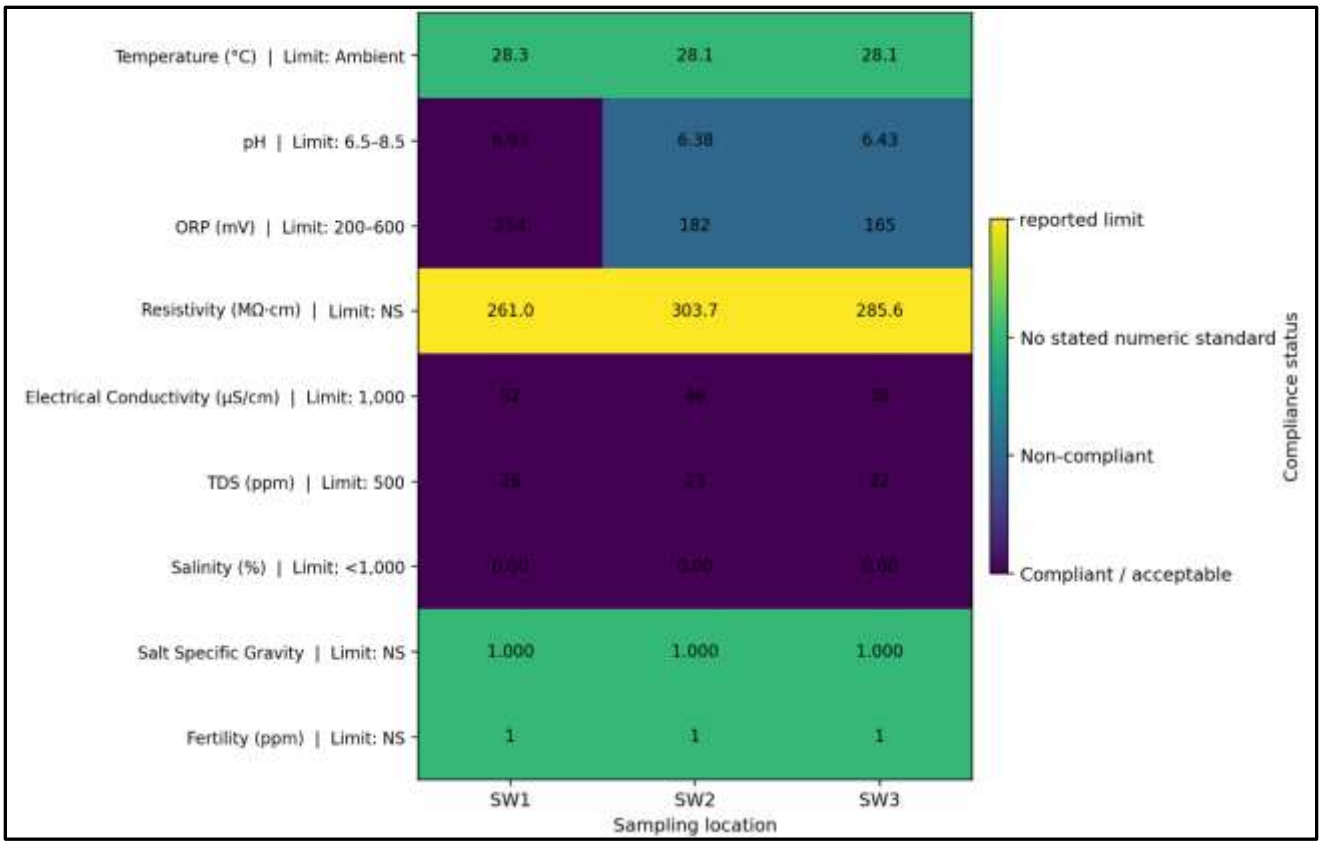



**Figure 4.10: Combined In-Situ Surface Water Results**

***Source:*** *Bolben Ltd. Fieldwork Survey, 2026*

**Table 4.16: Summary Comparison of In-Situ and Laboratory Measurements**

| Parameter | In-Situ Results | Laboratory Results | Interpretation |
|---|---|---|---|
| **Temperature** | 28.1–28.3°C | 29.2–31.0°C | Field values represent actual river conditions; laboratory increase likely reflects holding and analysis conditions. |
| **pH** | 6.38–6.93 | 7.17–7.30 | Slightly acidic to slightly alkaline and generally near neutral. |
| **ORP** | 165–254 mV | 104–118 mV | Positive oxidizing conditions, but laboratory results were below the stated regulatory range. |
| **Electrical Conductivity** | 38–52 µS/cm | 50–60 µS/cm | Very low ionic concentration and mineralization. |
| **TDS** | 22–26 ppm | 29–30 mg/L | Low dissolved-solid content and good agreement with conductivity. |
| **Salinity** | 0.00% | 0.00% | Freshwater conditions with no indication of salinization. |

#### 4.6.3.2 Surface Water Physicochemical Characteristics

Physicochemical characteristics provide an initial indication of the environmental condition, ecological functionality and potential suitability of surface water for domestic, agricultural, construction and other uses. The parameters evaluated provide information on visual quality, acid-base balance, thermal conditions, suspended and dissolved matter, oxygen balance, organic loading, mineralization and general aquatic health. This follows the parameter-by-parameter interpretive approach used in the reference report.

**a. Colour:** SW1 was pale brown, while SW2 and SW3 were pale grayish. All three samples differed from the stated FMEnv expectation of clear water. The discolouration is consistent with the visually turbid appearance of the river during sampling and may result from fine clay particles, organic matter, humic substances, bank erosion or recent stormwater runoff. The pale brown colour at SW1 suggests a slightly greater influence from suspended soil particles or natural organic materials at the upstream location. The pale grayish appearance at SW2 and SW3 may reflect differences in sediment composition or dilution along the river reach. Although the colour does not by itself establish chemical contamination, it indicates that untreated water would be aesthetically unsuitable for potable use and may require clarification or filtration before operational use.

**b. Odour:** All three samples were odourless and complied with the requirement that surface water should have an unobjectionable odour. The absence of objectionable odour indicates that there was no obvious field evidence of severe sewage contamination, petroleum pollution, sulphide generation or advanced anaerobic decomposition at the time of sampling.

**c. Taste:** All samples were reported as tasteless and met the stated unobjectionable criterion. However, taste assessment does not establish that the water is safe for drinking. The elevated nutrient, heavy metal, phenol and microbiological concentrations identified later in the analysis mean that direct consumption should not be permitted without adequate treatment and confirmation of potable-water compliance.

**d. pH:** The laboratory pH values were 7.20 at SW1, 7.30 at SW2 and 7.17 at SW3, all within the stated range of 6.5–8.5. The in-situ results were 6.93, 6.38 and 6.43, respectively. SW1 complied with the stated laboratory range under field conditions, while SW2 and SW3 were marginally below the lower limit. Nevertheless, both datasets indicate generally near-neutral water. The slightly lower field pH at SW2 and SW3 may reflect carbon dioxide enrichment, decomposition of organic material, rainfall influence or localized soil-water interaction. The near-neutral laboratory pH is favourable for most freshwater organisms and indicates that the river possesses some capacity to resist extreme acidification or alkalinization. However, the near-neutral condition may also allow several dissolved metals to remain environmentally available, depending on their chemical form and association with suspended particles.

**e. Temperature:** Field temperatures ranged narrowly from 28.1°C to 28.3°C, indicating uniform thermal conditions along the sampled river reach. Laboratory temperatures ranged from 29.2°C to 31.0°C and were recorded against an ambient criterion. The relatively small spatial variation indicates no evidence of localized thermal discharge or anthropogenic heating. The measured temperatures are typical of tropical surface-water environments. However, warm water naturally

retains less dissolved oxygen than cooler water and may enhance microbial activity and organic decomposition. Temperature should therefore be considered together with the dissolved oxygen, BOD and microbiological results.

**f. Electrical Conductivity:** Laboratory conductivity values were 60 µS/cm at SW1, 50 µS/cm at SW2 and 58 µS/cm at SW3, substantially below the stated limit of 1,000 µS/cm. Field values of 52, 46 and 38 µS/cm were similarly low. The results indicate that the water has a very low dissolved ionic content and is weakly mineralized. There is no evidence of saline intrusion, concentrated wastewater discharge or substantial dissolved-salt contamination. SW1 recorded the highest laboratory conductivity, but the spatial differences were minor. Low conductivity is generally favourable environmentally and also indicates a limited risk of salt-related corrosion or mineral scaling from the sampled water.

**g. Turbidity:** Turbidity values were 18 NTU at SW1 and 15 NTU at both SW2 and SW3, below the stated FMEnv limit of 50 NTU. Although the water appeared visibly coloured, the measured turbidity remained compliant. The higher value at SW1 is consistent with its pale brown colour and may reflect greater upstream bank erosion, runoff or fine suspended material. The moderate turbidity may reduce light penetration to some extent, but it is not sufficiently high to indicate severe sediment pollution. During implementation of the proposed solar PV project, erosion and sediment controls will remain important even though the Aloma River is outside the direct project area.

**h. Total Dissolved Solids:** Laboratory TDS values were 30 mg/L at SW1 and SW2 and 29 mg/L at SW3, substantially below the stated limit of 500 mg/L. The in-situ values of 26, 23 and 22 ppm showed the same low-concentration pattern. These results indicate fresh water with very low dissolved mineral content. Their close relationship with the low conductivity values demonstrates good internal consistency. The water presents little risk of dissolved-salt accumulation or scaling based on TDS alone.

**i. Total Suspended Solids:** TSS increased from 4 mg/L at SW1 to 6 mg/L at SW2 and 8 mg/L at SW3. All concentrations were below the stated limit of 20 mg/L. The downstream increase suggests progressive accumulation or resuspension of particulate material along the sampled reach. Potential influences include riverbank erosion, overland runoff, disturbance of bed sediments and the transport of fine organic debris. Despite this trend, the values indicate a relatively low suspended-sediment load at the time of sampling.

**j. Dissolved Oxygen:** DO concentrations were 3.9 mg/L at SW1, 4.1 mg/L at SW2 and 4.0 mg/L at SW3. Based on the stated laboratory range of 2–8 mg/L, all samples complied. The water was moderately oxygenated and capable of supporting aerobic biological processes. However, the concentrations were not particularly high for a flowing freshwater system. When interpreted together with the microbiological counts, nutrient enrichment and positive BOD values, the DO results indicate that oxygen was being consumed through biological decomposition. Continued organic loading could result in lower oxygen concentrations, especially during periods of reduced flow or higher water temperature.

**k. Biochemical Oxygen Demand:** BOD values were 2.2 mg/L at SW1 and 2.5 mg/L at both SW2 and SW3. No FMEnv limit was stated in the laboratory table. The relatively low values indicate a

limited to moderate biodegradable organic load. SW2 and SW3 showed slightly greater microbial oxygen demand than the upstream station. This corresponds with the higher *E. coli* and total-coliform counts at SW2 and the continued microbiological impairment at SW3. Although BOD itself was not unusually high, the results confirm that biologically degradable matter was present throughout the sampled reach.

**l. Chemical Oxygen Demand:** COD was 3 mg/L at SW1 and 6 mg/L at SW2 and SW3, all well below the stated limit of 30 mg/L. The low concentrations indicate that the total oxidizable organic and inorganic pollutant load was limited. The doubling of COD between SW1 and the two lower stations suggests some increase in oxidizable substances along the river reach. However, the absolute concentrations remained low and do not indicate severe chemical or organic pollution.

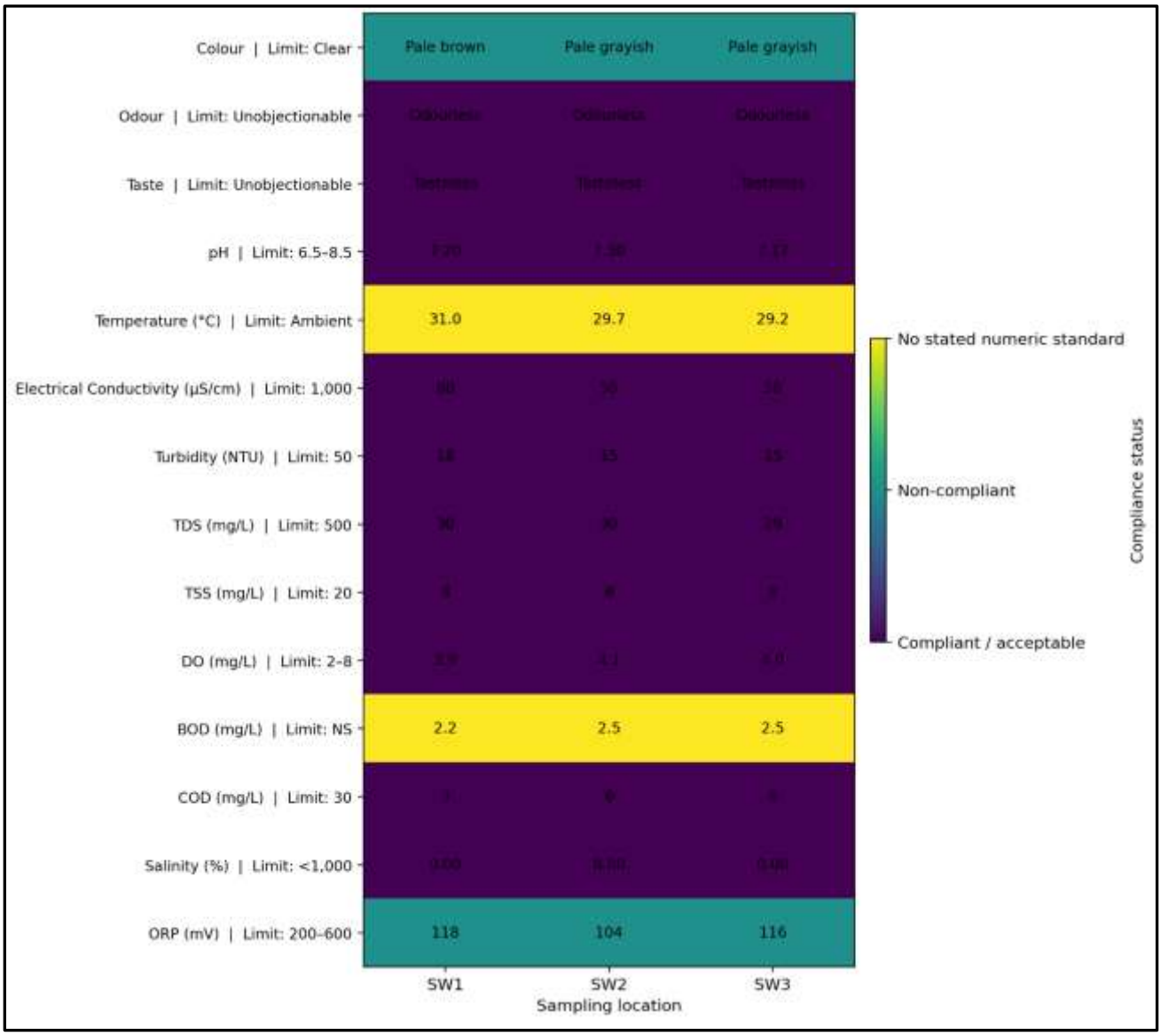



**Figure 4.11: Combined Laboratory Physicochemical Results**
***Source:*** *Bolben Ltd. Fieldwork Survey, 2026*

**m. Salinity:** Both in-situ and laboratory measurements recorded 0.00% salinity at all three locations. This confirms that the Aloma River is a freshwater system with no measurable saline influence. The result agrees with the low conductivity, chloride and TDS concentrations. Salinity therefore presents no ecological or engineering constraint.

**n. Oxidation-Reduction Potential:** Laboratory ORP values were 118 mV at SW1, 104 mV at SW2 and 116 mV at SW3, all below the stated FMEnv range of 200–600 mV. The field ORP values were higher at 254, 182 and 165 mV, respectively. SW1 fell within the stated range during field measurement, whereas SW2 and SW3 remained below it. All values were positive, indicating that the water was oxidizing rather than strongly anaerobic. Nevertheless, the relatively low ORP at SW2 and SW3 indicates weaker oxidizing conditions and may reflect microbial oxygen consumption, organic decomposition or interactions with reducing sediments. The lower ORP is consistent with the microbiological contamination and elevated nutrient concentrations recorded at the three locations.

**o. Resistivity, Salt Specific Gravity and Fertility:** Field electrical resistivity values were reported as 261.0 MΩ·cm at SW1, 303.7 MΩ·cm at SW2 and 285.6 MΩ·cm at SW3. Salt specific gravity was uniform at 1.000, supporting the finding of freshwater conditions and negligible salinity. Fertility was 1 ppm at all locations, indicating uniformly low readings for the instrument-specific fertility index. No regulatory criteria were provided for these parameters.

**Table 4.17: Summary of Surface-Water Physicochemical Characteristics**

| Parameter | Observation | Compliance Status | Environmental Interpretation | Engineering Implication |
|---|---|---|---|---|
| **Colour** | Pale brown to pale grayish | Non-compliant with "clear" criterion | Reflects fine sediment or natural organic matter. | Clarification or filtration required before practical use. |
| **Odour** | Odourless | Compliant | No obvious severe sewage, petroleum or anaerobic odour. | No odour-related constraint. |
| **Taste** | Tasteless | Compliant | No objectionable taste reported, but this does not establish potability. | Untreated use for consumption remains unsuitable. |
| **pH** | Near neutral; laboratory 7.17–7.30 | Compliant in laboratory; SW2 and SW3 marginally low in situ | Generally stable acid-base conditions. | Low pH-related corrosion risk. |
| **Temperature** | 28.1–31.0°C | Ambient | Typical tropical thermal regime. | No evidence of thermal pollution. |
| **Conductivity** | Very low, 50–60 µS/cm in laboratory | Compliant | Low ionic mineralization. | Low salt-related scaling and corrosion risk. |

| Parameter | Observation | Compliance Status | Environmental Interpretation | Engineering Implication |
|---|---|---|---|---|
| **Turbidity** | 15–18 NTU | Compliant | Moderate visual cloudiness but no severe sediment loading. | Maintain erosion and sediment controls. |
| **TDS** | 29–30 mg/L | Compliant | Fresh water with low dissolved mineral content. | Suitable for controlled non-potable use subject to other parameters. |
| **TSS** | 4–8 mg/L | Compliant | Low suspended-solid load, increasing downstream. | Low sediment-deposition risk. |
| **DO** | 3.9–4.1 mg/L | Compliant with stated 2–8 mg/L range | Moderately oxygenated but vulnerable to further organic loading. | Avoid discharges that increase oxygen demand. |
| **BOD** | 2.2–2.5 mg/L | No stated limit | Low to moderate biodegradable organic matter. | Continue monitoring and control wastewater inputs. |
| **COD** | 3–6 mg/L | Compliant | Low oxidizable pollutant load. | No major COD-related operational concern. |
| **Salinity** | 0.00% | Compliant | Freshwater conditions. | No salinity constraint. |
| **ORP** | 104–118 mV laboratory; 165–254 mV in situ | Mostly below stated range | Positive but relatively weak oxidizing conditions. | Monitor organic and microbial loading. |

#### 4.6.3.3 Chemical and Major-Ion Characteristics

Major ions and related chemical parameters provide information on water-rock interaction, nutrient enrichment, catchment processes and possible human influences. The reference laboratory analytical results similarly interprets ions in terms of natural hydrochemistry, nutrient cycling and potential contamination.

**a. Aluminium:** Aluminium concentrations were 0.76 mg/L at SW1, 0.62 mg/L at SW2 and 0.57 mg/L at SW3. No FMEnv limit was stated in the laboratory table. Concentrations decreased downstream, suggesting a greater upstream contribution from soil erosion, suspended clay minerals or natural weathering of aluminium-bearing materials. The pale brown colour at SW1

supports the possible influence of fine soil particles. Since no comparison criterion was provided, formal compliance cannot be determined. Aluminium should nevertheless be retained in future monitoring because its ecological availability may increase under acidic conditions.

**b. Calcium:** Calcium ranged from 5.63 to 6.21 mg/L, well below the stated limit of 200 mg/L. The low concentrations indicate limited calcium mineralization and agree with the relatively low conductivity and TDS values. Calcium is an essential natural constituent and does not represent a water-quality concern at the measured concentrations. Scaling potential associated with calcium is low.

**c. Magnesium:** Magnesium ranged from 2.28 to 2.86 mg/L, below the stated limit of 20 mg/L. The concentrations were low and likely reflect normal weathering of magnesium-bearing soils and minerals. No ecological or operational concern is indicated.

**d. Total Hardness:** Total hardness values were 94 mg/L at SW1, 81 mg/L at SW2 and 87 mg/L at SW3, all below the stated limit of 150 mg/L. The water may be characterized as moderately hard rather than highly mineralized. The results indicate that calcium and magnesium concentrations are sufficient to provide some buffering capacity but are unlikely to cause severe scale formation in pipes, pumps or panel-cleaning systems.

**e. Potassium:** Potassium concentrations were 4.3–5.2 mg/L and remained below the stated limit of 20 mg/L. SW2 had the highest concentration. The values are consistent with low-level natural mineral weathering, decomposition of vegetation and possible catchment runoff. No significant potassium-related contamination is indicated.

**f. Nitrate:** Nitrate concentrations were 104.1 mg/L at SW1, 86.1 mg/L at SW2 and 92.3 mg/L at SW3. All three exceeded the stated limit of 50 mg/L. SW1 recorded the highest concentration and exceeded the limit by approximately 108%, while SW2 and SW3 exceeded it by approximately 72% and 85%, respectively. The consistently elevated concentrations demonstrate substantial nitrate enrichment throughout the sampled reach rather than an isolated downstream occurrence. Possible sources include decomposition of organic matter, animal waste, agricultural runoff, fertilizer use, sanitation-related inputs and nitrogen-rich catchment runoff. Given that there were no operational university activities influencing this river, the nitrate enrichment represents an existing background condition associated with the wider Akwete-Akpa catchment. Elevated nitrate may stimulate excessive aquatic plant and algal growth and increase eutrophication risk.

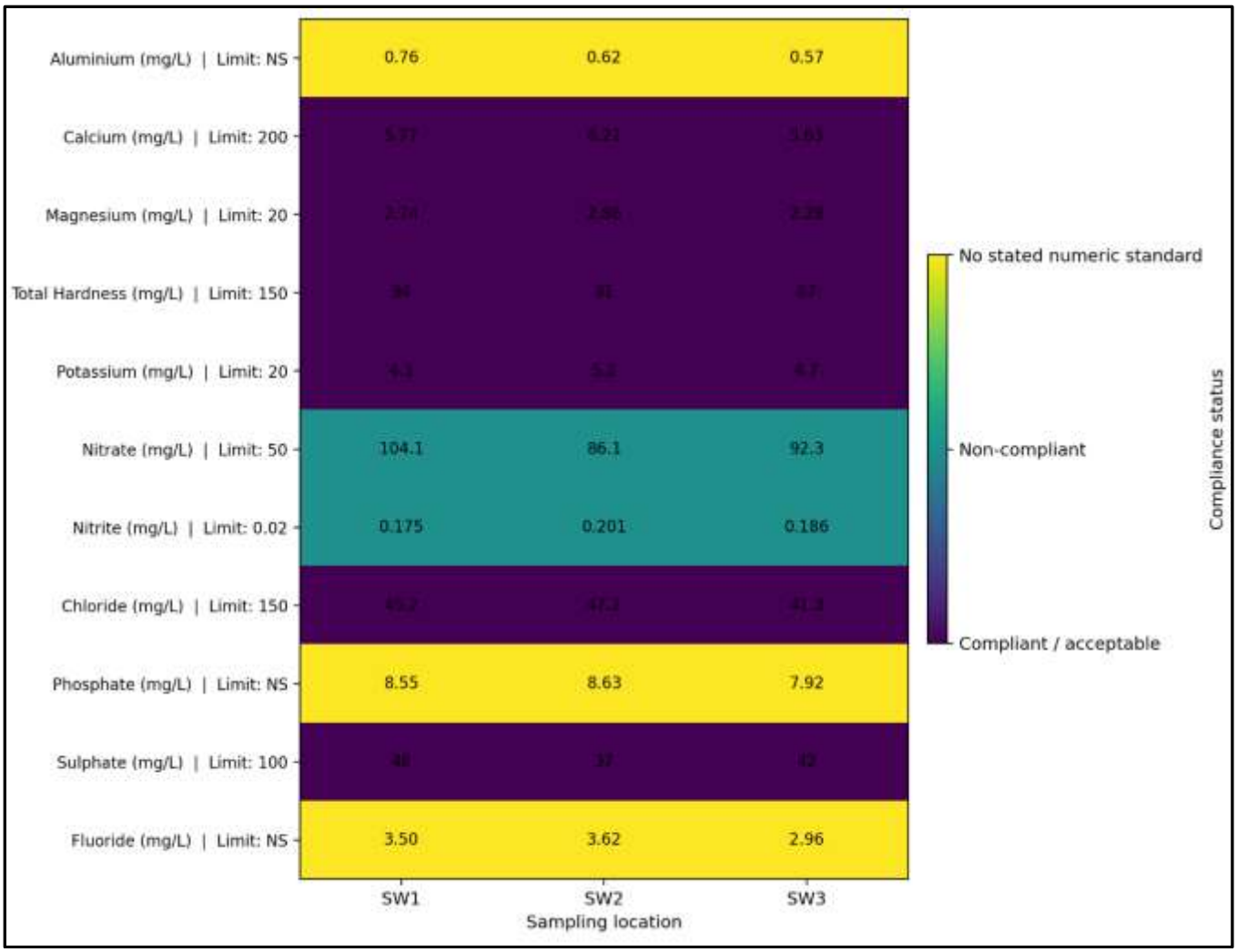



**Figure 4.12: Combined Laboratory Chemical Results**
***Source:*** *Bolben Ltd. Fieldwork Survey, 2026*

**g. Nitrite:** Nitrite concentrations ranged from 0.175 to 0.201 mg/L against a stated limit of 0.02 mg/L. All samples were substantially non-compliant. SW1 exceeded the limit by approximately 8.8 times, SW2 by approximately 10.1 times and SW3 by approximately 9.3 times. Nitrite is an intermediate product in nitrogen transformation and is generally unstable in well-oxygenated water. Its elevated occurrence indicates recent organic inputs, active microbial decomposition or incomplete conversion of ammonium to nitrate. The combination of high nitrate, elevated nitrite, microbiological contamination and relatively low ORP provides evidence of ongoing nitrogen cycling and catchment-derived organic contamination.

**h. Chloride:** Chloride concentrations ranged from 41.3 to 47.2 mg/L, well below the stated limit of 150 mg/L. The results indicate no significant saline intrusion or concentrated chloride-bearing effluent. The low chloride concentrations are favourable because they reduce salinity stress and chloride-induced corrosion risk.

**i. Phosphate:** Phosphate ranged from 7.92 to 8.63 mg/L. No standard was stated in the FUHSO laboratory table. Although formal compliance cannot be assigned, the concentrations indicate appreciable phosphorus availability. When considered with the nitrate and nitrite exceedances, the phosphate results point to nutrient enrichment and potential eutrophication risk. Potential sources include organic matter decomposition, agricultural runoff, detergents, animal waste or naturally phosphorus-rich soils.

**j. Sulphate:** Sulphate concentrations ranged from 37 to 48 mg/L, below the stated limit of 100 mg/L. The low to moderate values indicate no significant sulphate-rich industrial or wastewater discharge. From an engineering perspective, the concentrations indicate a low risk of sulphate-related corrosion or deterioration of concrete materials.

**k. Fluoride:** Fluoride concentrations ranged from 2.96 to 3.62 mg/L. No FMEnv limit was stated in the table. The values were relatively uniform and may reflect natural geological or soil-water interactions. Since no applicable comparison limit was provided, formal compliance cannot be determined. The concentrations should be retained in monitoring and evaluated against the intended use-specific standard before the water is considered for domestic consumption.

**Table 4.18: Summary of Surface-Water Chemical Characteristics**

| Parameter | Observation | Compliance Status | Environmental Interpretation | Engineering Implication |
|---|---|---|---|---|
| **Aluminium** | 0.57–0.76 mg/L; highest upstream | No stated limit | Likely associated with soil, clay and natural weathering. | May contribute to colour or deposits if used untreated. |
| **Calcium** | 5.63–6.21 mg/L | Compliant | Low natural mineral content. | Low calcium-scaling risk. |
| **Magnesium** | 2.28–2.86 mg/L | Compliant | Low natural concentration. | No significant scaling concern. |
| **Total Hardness** | 81–94 mg/L | Compliant | Moderately hard water. | Limited hardness-related operational effect. |
| **Potassium** | 4.3–5.2 mg/L | Compliant | Natural background or vegetation-related input. | No direct concern. |
| **Nitrate** | 86.1–104.1 mg/L | Non-compliant at all locations | Significant nutrient enrichment and possible agricultural, animal-waste or sanitation influence. | Requires source investigation and continued monitoring. |
| **Nitrite** | 0.175–0.201 mg/L | Non-compliant at all locations | Active nitrogen transformation and recent organic inputs. | Water unsuitable for untreated domestic use. |
| **Chloride** | 41.3–47.2 mg/L | Compliant | No saline or concentrated chloride pollution. | Low corrosion risk. |

| Parameter | Observation | Compliance Status | Environmental Interpretation | Engineering Implication |
|---|---|---|---|---|
| **Phosphate** | 7.92–8.63 mg/L | No stated limit | Nutrient enrichment and potential eutrophication risk. | Prevent additional nutrient-bearing discharges. |
| **Sulphate** | 37–48 mg/L | Compliant | No significant sulphate contamination. | Low sulphate-attack potential. |
| **Fluoride** | 2.96–3.62 mg/L | No stated limit | Likely geogenic; requires use-specific assessment. | Treatment assessment needed before potable use. |

***Source:*** *Bolben Ltd. Fieldwork Survey, 2026*

#### 4.6.3.4 Heavy Metals

Heavy metals are environmentally important because some are toxic at low concentrations, persistent in sediments and capable of bioaccumulation. Others, such as iron, zinc and copper, are essential in trace quantities but may cause ecological or operational effects when elevated. The discussion below compares the reported results directly with the limits stated in Table 4.18.

**a. Copper:** Copper concentrations were 2.90 mg/L at SW1, 2.84 mg/L at SW2 and 2.62 mg/L at SW3, exceeding the stated limit of 1.5 mg/L at all locations. The exceedances were approximately 1.9, 1.9 and 1.7 times the limit, respectively. The consistent elevation suggests a catchment-wide rather than isolated source. Possible influences include natural mineral weathering, agrochemicals, metallic waste, electrical materials, corrosion or contaminated runoff. At elevated concentrations, copper can adversely affect fish, aquatic invertebrates and microbial communities. Further monitoring should distinguish dissolved from particulate copper and investigate possible catchment sources.

**b. Chromium:** Chromium concentrations ranged from 0.43 to 0.55 mg/L against a limit of 0.05 mg/L. All stations were non-compliant, with concentrations approximately 8.6 to 11 times the stated limit. The highest value occurred upstream, suggesting that the enrichment was already present before the central and downstream sampling points. Potential sources include natural chromium-bearing minerals, metal-related waste, pigments, combustion residues or contaminated runoff. Since the analysis appears to represent total chromium rather than separate chromium species, the proportion present as the more toxic hexavalent form is unknown. Chromium speciation would improve future risk assessment.

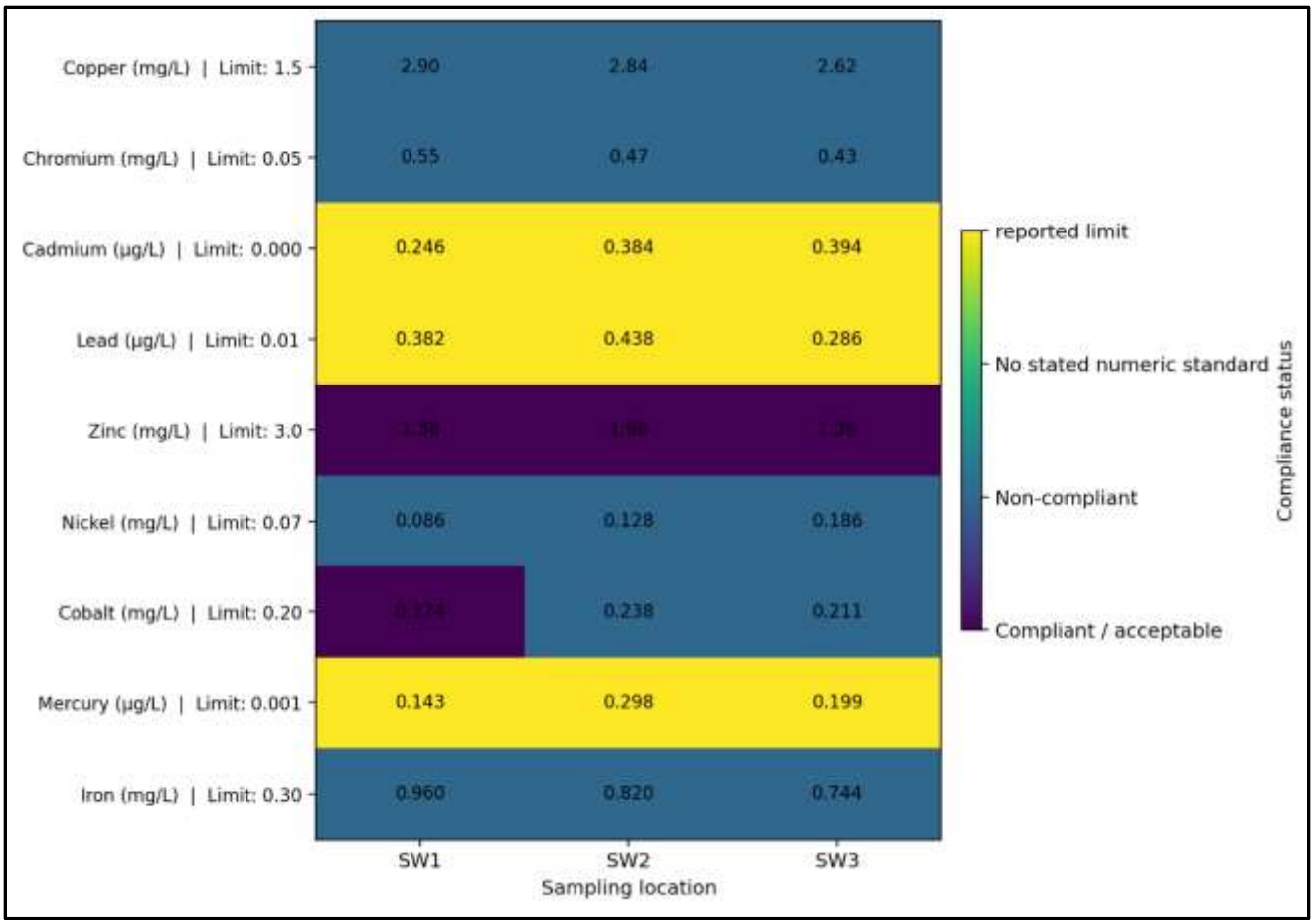



**Figure 4.13: Combined Laboratory Heavy Metal Results**
***Source:*** *Bolben Ltd. Fieldwork Survey, 2026*

**c. Cadmium:** Cadmium concentrations ranged from 0.246–0.394 µg/L, while the applicable regulatory limit is 0.003 mg/L, equivalent to 3 µg/L. After unit conversion, all measured concentrations are well below the permissible limit and therefore comply with the guideline. Cadmium is a highly toxic and persistent heavy metal that can bioaccumulate in aquatic organisms and poses significant ecological and human health risks following prolonged exposure. The low concentrations recorded indicate that the surface water is not impacted by cadmium contamination and does not present a cadmium-related environmental concern under the current baseline conditions.

**d. Lead:** Lead concentrations ranged from 0.286–0.438 µg/L, while the applicable regulatory limit is 0.01 mg/L, equivalent to 10 µg/L. After unit conversion, all measured concentrations are well below the permissible limit and therefore comply with the guideline. Lead is a toxic heavy metal that can adversely affect the nervous system, kidneys and other vital organs following prolonged exposure. The low concentrations recorded indicate that the surface water is not impacted by lead contamination and poses no significant lead-related environmental or public health concern under the current baseline conditions.

**e. Zinc:** Zinc concentrations ranged from 1.36 to 1.98 mg/L and complied with the stated limit of 3.0 mg/L. The highest value occurred at SW2, but it remained within the permissible concentration. The results indicate moderate background zinc without evidence of unacceptable contamination. Zinc is unlikely to produce significant ecological or operational effects at the reported concentrations, although its occurrence should be monitored with the other metals.

**f. Nickel:** Nickel concentrations were 0.086 mg/L at SW1, 0.128 mg/L at SW2 and 0.186 mg/L at SW3, exceeding the stated limit of 0.07 mg/L at all locations. The progressive downstream increase suggests cumulative input, mobilization or sediment interaction along the river reach. Potential sources include natural weathering, metallic wastes, batteries, machinery, combustion residues or agricultural runoff. The downstream concentration was approximately 2.7 times the stated limit. Nickel represents a baseline ecological concern requiring source investigation and future monitoring.

**g. Cobalt:** Cobalt concentrations were 0.124 mg/L at SW1, 0.238 mg/L at SW2 and 0.211 mg/L at SW3. SW1 complied with the limit of 0.20 mg/L, while SW2 and SW3 exceeded it. The higher concentrations at the midstream and downstream locations indicate localized enrichment along the sampled reach. Possible sources include natural geological materials, metallic waste, batteries, pigments and contaminated runoff. Although cobalt is an essential trace element, elevated concentrations may affect aquatic organisms.

**h. Mercury:** Mercury concentrations ranged from 0.143–0.298 µg/L, while the stated regulatory limit is 0.001 mg/L, equivalent to 1 µg/L. After unit conversion, all measured concentrations are well below the applicable limit and therefore comply with the guideline. Mercury is a highly toxic heavy metal with the potential to bioaccumulate and biomagnify through aquatic food chains. The low concentrations recorded indicate that the surface water is free from mercury contamination and does not present a mercury-related environmental or public health concern under the current baseline conditions.

**i. Iron:** Iron concentrations ranged from 0.744 to 0.960 mg/L and exceeded the stated limit of 0.30 mg/L at all locations. SW1 recorded the highest value at approximately 3.2 times the limit. The elevated iron may largely reflect natural weathering of iron-rich tropical soils, bank erosion and sediment interaction, particularly given the pale brown colour at SW1. Other possible influences include corrosion and contaminated runoff. Iron is primarily an aesthetic and operational concern at these concentrations, causing discolouration, staining, sediment deposition, pipe fouling and deposits on equipment or PV panels. It may also affect benthic habitats where precipitated iron accumulates.

**Table 4.19: Summary of Surface-Water Heavy Metals**

| Parameter | Observation | Compliance Status | Environmental Interpretation | Engineering Implication |
|---|---|---|---|---|
| **Copper** | 2.62–2.90 mg/L | Non-compliant at all locations | Widespread copper enrichment; potential ecological toxicity. | Investigate sources and avoid untreated discharge or use. |

| Parameter | Observation | Compliance Status | Environmental Interpretation | Engineering Implication |
|---|---|---|---|---|
| **Chromium** | 0.43–0.55 mg/L | Non-compliant at all locations | Significant total chromium enrichment; species not identified. | Speciation and source investigation recommended. |
| **Cadmium** | Detected at 0.246–0.394 µg/L | Compliance uncertain because limit is reported as 0.000 | Any confirmed cadmium requires attention due to persistence and toxicity. | Verify limit and unit with laboratory. |
| **Lead** | 0.286–0.438 µg/L | Compliance cannot be confirmed because of apparent unit mismatch | Toxic-metal risk depends on confirmation of units. | Verify certificate before final classification. |
| **Zinc** | 1.36–1.98 mg/L | Compliant | Moderate background concentration. | No significant direct constraint. |
| **Nickel** | 0.086–0.186 mg/L | Non-compliant at all locations | Increasing downstream; indicates baseline metal enrichment. | Source investigation and monitoring required. |
| **Cobalt** | 0.124–0.238 mg/L | SW1 compliant; SW2 and SW3 non-compliant | Localized enrichment at midstream and downstream points. | Include in routine monitoring. |
| **Mercury** | 0.143–0.298 µg/L | Compliance cannot be confirmed because of apparent unit mismatch | Potentially important due to bioaccumulation. | Confirm reporting units and regulatory limit. |
| **Iron** | 0.744–0.960 mg/L | Non-compliant at all locations | Likely natural soil and sediment influence, with possible runoff contribution. | Staining, fouling and deposition risk. |

***Source:*** *Bolben Ltd. Fieldwork Survey, 2026*

### 4.6.3.5 Organic Parameters

Organic analysis included benzene, toluene, ethylbenzene, xylene, phenols, and oil and grease. These parameters help identify petroleum-related contamination, solvents, industrial inputs and other organic pollutants.

**a. Benzene, Toluene, Ethylbenzene and Xylene:** Benzene, toluene, ethylbenzene and xylene were not detected in any of the three samples. All results complied with their respective stated limits. The absence of these compounds indicates no evidence of detectable BTEX contamination from fuel spills, petroleum storage, vehicle maintenance or hydrocarbon discharge at the time of sampling. This is a favourable baseline result.

**b. Phenols:** Phenol concentrations were 0.278 mg/L at SW1, 0.198 mg/L at SW2 and 0.286 mg/L at SW3, exceeding the stated limit of 0.05 mg/L at all locations. SW3 recorded the highest concentration at approximately 5.7 times the limit, while SW1 and SW2 exceeded the limit by approximately 5.6 and 4.0 times, respectively. Phenolic compounds may originate from decomposition of natural vegetation and humic materials, burning, pesticides, domestic wastes, industrial products or contaminated runoff.

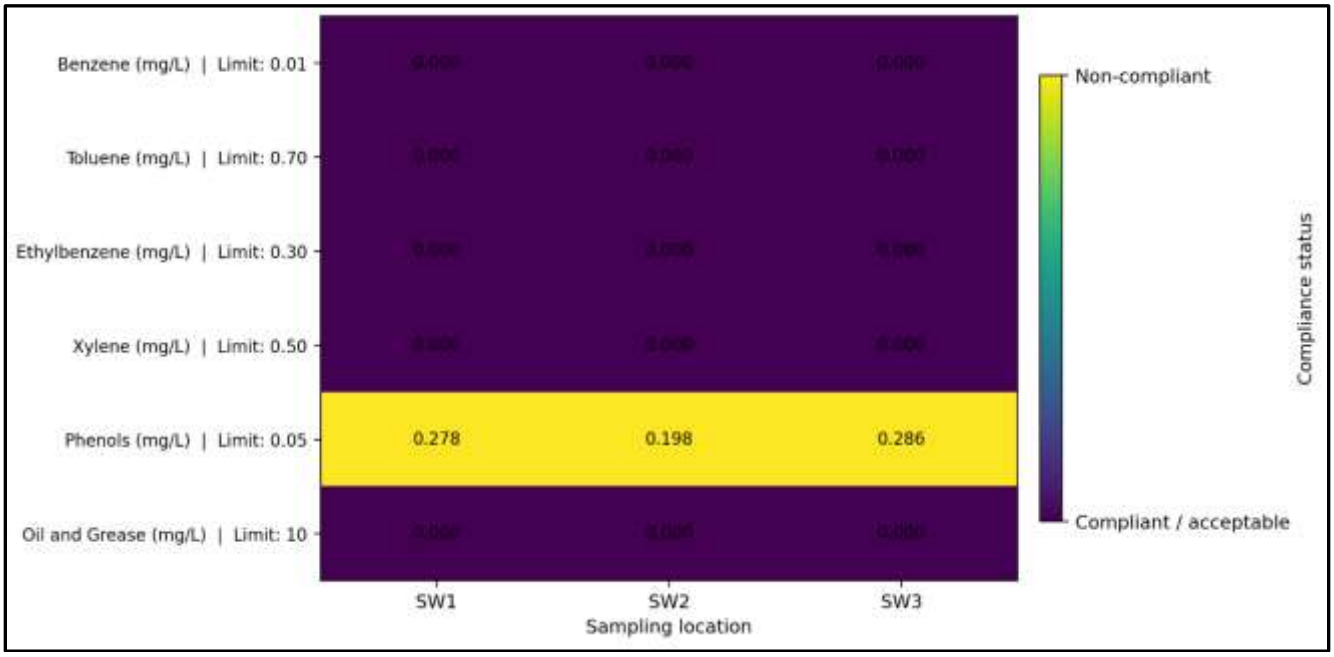



**Figure 4.14: Combined Laboratory Organics Result**
***Source:*** *Bolben Ltd. Fieldwork Survey, 2026*

Given the densely vegetated river environment, natural organic decomposition may contribute, but the consistently elevated concentrations warrant confirmation and source investigation. Phenols may affect aquatic organisms, create taste and odour problems and complicate treatment where chlorination is used. The results represent an important baseline water-quality concern.

**c. Oil and Grease:** Oil and grease were not detected in any sample and complied with the stated limit of 10 mg/L. The result indicates no evidence of petroleum films, lubricants or oily waste contamination at the time of sampling.

**Table 4.20: Summary of Surface-Water Organic Parameters**

| Parameter | Observation | Compliance Status | Environmental Interpretation | Engineering Implication |
|---|---|---|---|---|
| **Benzene** | Not detected | Compliant | No detectable petroleum-related benzene contamination. | No current constraint. |
| **Toluene** | Not detected | Compliant | No detectable solvent or fuel contamination. | No current constraint. |
| **Ethylbenzene** | Not detected | Compliant | No detectable petroleum-related contamination. | No current constraint. |
| **Xylene** | Not detected | Compliant | No detectable fuel or solvent contamination. | No current constraint. |
| **Phenols** | 0.198–0.286 mg/L | Non-compliant at all locations | Significant phenolic enrichment, potentially from natural organic decomposition or catchment inputs. | Confirm results, investigate sources and treat before use. |
| **Oil and Grease** | Not detected | Compliant | No evidence of oily contamination. | Maintain spill-prevention measures during project implementation. |

### 4.6.3.6 Microbiological Characteristics

Microbiological assessment provides an indication of sanitary condition and possible exposure to faecal or other biological contamination. Surface water is particularly vulnerable to microbial pollution through rainfall runoff, wildlife and livestock access, decaying vegetation, sanitation failures and sediment disturbance. This mirrors the reference document's emphasis on microbial results as indicators of sanitary and public-health risk.

**a. *Escherichia coli*:** *E. coli* counts were 32 CFU/mL at SW1, 47 CFU/mL at SW2 and 40 CFU/mL at SW3, whereas the stated limit was nil. All samples were therefore non-compliant. The highest count at SW2 indicates stronger faecal contamination at the midstream station. The detection of *E. coli* confirms recent contamination by human or animal faecal material and indicates the possible presence of other enteric pathogens. Potential sources include livestock and wildlife access, runoff from areas of open defecation, sanitation facilities, domestic wastes or contaminated soil. The water is unsuitable for drinking, food preparation, bathing or other direct-contact domestic uses without effective treatment and disinfection.

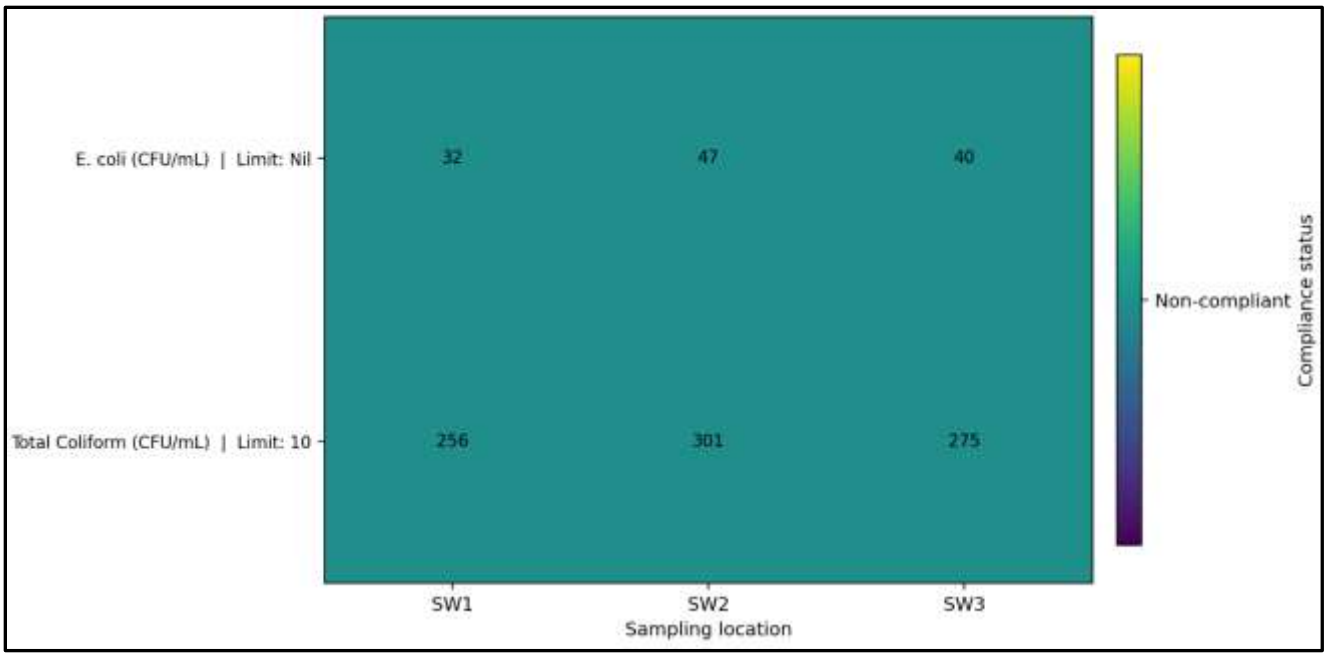



**Figure 4.15: Combined Laboratory Microbiological Results**
***Source:*** *Bolben Ltd. Fieldwork Survey, 2026*

**b. Total Coliform:** Total-coliform counts were 256 CFU/mL at SW1, 301 CFU/mL at SW2 and 275 CFU/mL at SW3, substantially exceeding the stated limit of 10 CFU/mL. SW1, SW2 and SW3 exceeded the limit by approximately 26, 30 and 28 times, respectively. The widespread elevation indicates substantial microbial impairment across the sampled river reach. The highest count at SW2 corresponds with the highest *E. coli* count and supports the conclusion that the central sampling location experienced the greatest sanitary contamination. The microbial results also help explain the observed BOD, nutrient concentrations and lower ORP. They demonstrate that, despite generally acceptable physical parameters, the river cannot be regarded as safe for untreated domestic use.

**Table 4.21: Summary of Surface-Water Microbiological Characteristics**

| Parameter | Observation | Compliance Status | Environmental Interpretation | Engineering Implication |
|---|---|---|---|---|
| ***E. coli*** | 32–47 CFU/mL | Non-compliant at all locations | Confirms faecal contamination and potential presence of enteric pathogens. | Untreated water unsuitable for potable or direct-contact domestic use. |
| **Total Coliform** | 256–301 CFU/mL | Non-compliant at all locations | Indicates widespread sanitary and general microbial contamination. | Treatment and disinfection required before any sensitive use. |

***Source:*** *Bolben Ltd. Fieldwork Survey, 2026*

#### 4.6.3.7 Spatial Interpretation of the Sampling Stations

SW1 represents the upstream background station. It recorded the highest colour intensity, conductivity, nitrate, copper, chromium and iron concentrations. This indicates that several of the identified concerns were already present before the river reached the central sampling station and are therefore associated with the wider upstream catchment rather than the proposed FUHSO project. SW2 recorded the highest laboratory pH, calcium, magnesium, potassium, nitrite, chloride, phosphate, fluoride, zinc, cobalt, mercury, *E. coli* and total-coliform concentrations. It therefore represents the most microbiologically impaired station and shows the greatest combined nutrient and sanitary influence. SW3 recorded the highest TSS, nickel, cadmium and phenol concentrations, while nitrate, nitrite, copper, chromium, iron and microbiological indicators remained elevated. This suggests that contamination persisted downstream and that some particulate, metal and organic constituents accumulated or remained mobilized along the flow path. The absence of a consistent increase from SW1 through SW3 for all parameters indicates that the river quality is controlled by multiple diffuse catchment influences rather than one distinct point-source discharge. Because the river lies outside the proposed project's direct Area of Influence, these conditions constitute pre-project background water-quality characteristics.

**Table 4.22: Summary of Overall Surface-Water Quality Assessment**

| Assessment Aspect | Overall Status | Key Findings | Implications |
|---|---|---|---|
| **Overall Water Quality** | Impacted | Basic physical quality was generally acceptable, but nutrient, metal, phenol and microbial exceedances were recorded. | Establishes a pre-project background condition requiring continued monitoring. |
| **Physicochemical Quality** | Fair | Near-neutral laboratory pH, low conductivity, low solids, moderate DO and low COD; colour and ORP were concerns. | Generally suitable for environmental baseline purposes, but untreated use is restricted. |
| **Chemical and Nutrient Quality** | Poor | Nitrate and nitrite exceeded limits at all stations; phosphate was appreciable. | Indicates nutrient enrichment and potential eutrophication risk. |
| **Heavy-Metal Quality** | Poor | Copper, chromium, nickel and iron exceeded stated limits; cobalt exceeded at SW2 and SW3. | Source investigation and repeat monitoring are required. |
| **Organic Quality** | Moderate | BTEX and oil and grease were absent, but phenols exceeded the limit at all stations. | Phenolic contamination requires confirmation and source assessment. |

| Assessment Aspect | Overall Status | Key Findings | Implications |
|---|---|---|---|
| **Microbiological Quality** | Poor | *E. coli* and total coliform were substantially above limits at all stations. | Water is unsuitable for untreated potable and domestic use. |
| **Ecological Condition** | Moderate to Poor | Water remained moderately oxygenated, but nutrient, microbial, phenolic and metal stressors were present. | Aquatic conditions may deteriorate if pollution loading increases. |
| **Human-Health Risk** | High for untreated use | Faecal contamination and multiple chemical exceedances were identified. | Direct consumption, food preparation and unrestricted domestic contact are not recommended. |
| **Engineering Suitability** | Limited without treatment | Low salts and moderate hardness are favourable, but iron, microbes, phenols and other contaminants are problematic. | Treatment is required before construction use, panel washing or other operational applications. |
| **Project Relationship** | Background/control condition | The sampled river is approximately 3.2 km from FUHSO and outside the direct project AoI. | Existing exceedances should not be attributed to the proposed project; future results should be compared with this baseline. |
| **Project Monitoring Requirement** | High | Baseline contamination already exists within the wider environment. | Implement the ESMP, runoff control, spill prevention, sanitation management and periodic water-quality monitoring. |

***Source:*** *Bolben Ltd. Fieldwork Survey, 2026*

The surface-water assessment established that the Aloma River is a low-mineralization freshwater system with generally acceptable temperature, laboratory pH, conductivity, turbidity, dissolved and suspended solids, dissolved oxygen, COD, salinity, hardness and several major-ion characteristics. The absence of BTEX compounds and oil and grease also indicates that petroleum-related contamination was not evident at the time of sampling. Nevertheless, the river was affected by significant pre-existing water-quality concerns. These included elevated nitrate and nitrite, multiple metal exceedances, phenols and pronounced microbiological contamination. The detection of *E. coli* at all stations and total-coliform concentrations far above the stated limit demonstrates that the river is unsuitable for direct drinking or unrestricted domestic use without treatment and disinfection. The results indicate that the observed contamination is associated with

existing natural and catchment-related conditions rather than the proposed FUHSO solar PV development. The river is outside the project's direct Area of Influence and functions solely as the nearest representative control surface-water source. Accordingly, the dataset should be retained as a background reference for future monitoring rather than interpreted as evidence of project-related impact.

## 4.7 Site-Specific Micro-Climate

The micro-climatic conditions at the proposed project area, located within the Federal University of Health Sciences, Otukpo (FUHSO), were assessed through direct field measurements. The monitoring exercise covered fifteen locations within the project area and two control locations. The field data comprised ambient temperature, relative humidity and the air-quality parameters required to establish the baseline environmental condition of the site. The recorded conditions indicate a warm and moderately humid environment during the monitoring period. The variations observed among the sampling locations reflect differences in exposure, shade, surface characteristics and the time at which each reading was taken.

### 4.7.1 Temperature and Relative Humidity

The collected data revealed a clear inverse relationship between ambient temperature and relative humidity across the monitoring locations. As temperature increased at several points, relative humidity generally declined, while the cooler monitoring points recorded comparatively higher humidity values. Ambient temperatures ranged from 85.0°F (29.4°C) at AQ6 to 93.5°F (34.2°C) at AQ15, with an overall mean of 89.9°F (32.2°C). Relative humidity ranged from 50.7% at AQ15 to 66.3% at AQ6, with a mean value of 56.9%. These values indicate warm, moderately humid conditions within the FUHSO project environment at the time of assessment.

The ambient condition of ground-level air quality within the project area was examined using the instrument-reported Air Quality Index (AQI) and direct measurements of gaseous pollutants and particulate matter. The results of the field measurements are presented in Table 4.22. The AQI values were interpreted using the standard descriptive rating bands presented later in this section. AQI = (Pollution Concentration) / (Pollution Standard Level) × 100. The detection limits of the meters used for measuring air-quality parameters will be provided in Table 2 when the equipment names, model numbers, measurement ranges and calibration details are available.
***See Plate 4.11 for pictorial evidence of Air Quality Sampling Activities AND;***
***See Plate 4.12 for pictorial evidence of Nosie Level Sampling Activities.***

*For more pictures for different sampling locations for Air Quality and Noise level see Appendix VII.*

*Detection Limits for Air Quality and noise level Instruments are presented in Appendix IX*

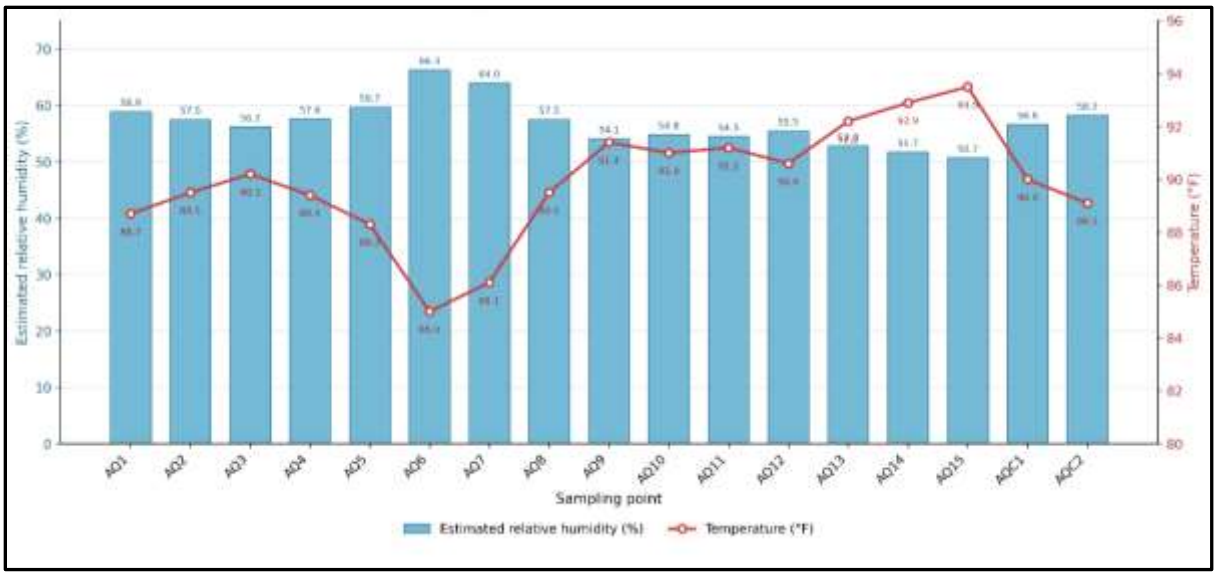



**Figure 4.16: Relative Humidity and Temperature Measured in the Project Area**
***Source:*** *Bolben Ltd. Fieldwork Survey, 2026*

## Table 4.24: Ambient Air Quality Level Around the Project Area

| CODE | SAMPLING LOCATION | AQI | Temperature (°F) | Relative humidity (%) | HCHO (mg/m³) | TVOC (mg/m³) | $PM_{2.5}$ (µg/m³) | $PM_{10}$ (µg/m³) | No. of particles (per/L) | $CO_2$ | $O_2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **PROPOSED SITE AND SURROUNDINGS** | | | | | | | | | | | |
| **AQ1** | PROPOSED SITE AREA | 53 | 88.7 | 58.9 | 0.07 | 0.31 | 13.2 | 22.3 | 1999 | 402 | 20.9 |
| **AQ2** | PROPOSED SITE AREA | 52 | 89.5 | 57.5 | 0.03 | 0.06 | 14.3 | 22.7 | 2060 | 417 | 20.9 |
| **AQ3** | PROPOSED SITE AREA | 47 | 90.2 | 56.2 | 0.05 | 0.24 | 11.3 | 19.7 | 1741 | 416 | 20.9 |
| **AQ4** | PROPOSED SITE AREA | 49 | 89.4 | 57.6 | 0.01 | 0.03 | 12.0 | 22.4 | 1936 | 402 | 20.9 |
| **AQ5** | PROPOSED SITE AREA | 61 | 88.3 | 59.7 | 0.01 | 0.08 | 17.1 | 31.7 | 2637 | 404 | 20.9 |
| **AQ6.** | PROPOSED SITE AREA | 56 | 85.0 | 66.3 | 0.04 | 0.17 | 15.2 | 26.7 | 2282 | 407 | 20.9 |
| **AQ7** | PROPOSED SITE AREA | 58 | 86.1 | 64.0 | 0.02 | 0.08 | 14.4 | 25.3 | 2188 | 411 | 20.9 |
| **AQ8** | PROPOSED SITE AREA | 58 | 89.5 | 57.5 | 0.01 | 0.08 | 15.9 | 27.0 | 2362 | 412 | 20.9 |
| **AQ9** | PROPOSED SITE AREA | 56 | 91.4 | 54.1 | 0.01 | 0.03 | 14.6 | 25.2 | 2169 | 693 | 20.9 |
| **AQ10** | PROPOSED SITE AREA | 56 | 91.0 | 54.8 | 0.01 | 0.08 | 14.1 | 24.4 | 2191 | 407 | 20.9 |
| **AQ11** | CAMPUS MAIN JUNCTION AREA | 52 | 91.2 | 54.5 | 0.01 | 0.08 | 12.9 | 23.2 | 1953 | 412 | 20.9 |
| **AQI2** | PROPOSED ADMINISTRATIVE BUILDING | 65 | 90.6 | 55.5 | 0.02 | 0.08 | 19.0 | 33.1 | 2884 | 408 | 20.9 |
| **AQ13** | PROPOSED LECTURE THEATRE | 62 | 92.2 | 52.8 | 0.01 | 0.03 | 17.5 | 31.2 | 2754 | 405 | 20.9 |
| **QA14** | ADJACENT PROPOSED ADMINISTRATIVE BUILDING | 52 | 92.9 | 51.7 | 0.01 | 0.03 | 12.7 | 22.3 | 1992 | 407 | 20.9 |
| **AQ15** | BEHIND PROPOSED LECTURE THEATRE | 62 | 93.5 | 50.7 | 0.01 | 0.04 | 16.4 | 29.2 | 2533 | 412 | 20.9 |
| **CONTROL** | | | | | | | | | | | |
| **AQC1** | SCHOOL ENTRANCE | 53 | 90.0 | 56.6 | 0.01 | 0.03 | 13.4 | 34.2 | 2105 | 409 | 20.9 |
| **AQC2** | FUHSO CHECK POINT | 53 | 89.1 | 58.2 | 0.02 | 0.08 | 13.2 | 22.3 | 1881 | 517 | 20.9 |
| **FMEnv. Limit** | | | | | | | 250.00 | 250.00 | | | |
| **WHO Guideline Value** | | | | | | | 25.00 | 50.00 | | | |
| **USE-EPA Guideline Value** | | | | | | | | | | 1000.00 | |

***Source:*** *Bolben Ltd. Fieldwork Survey, 2026*

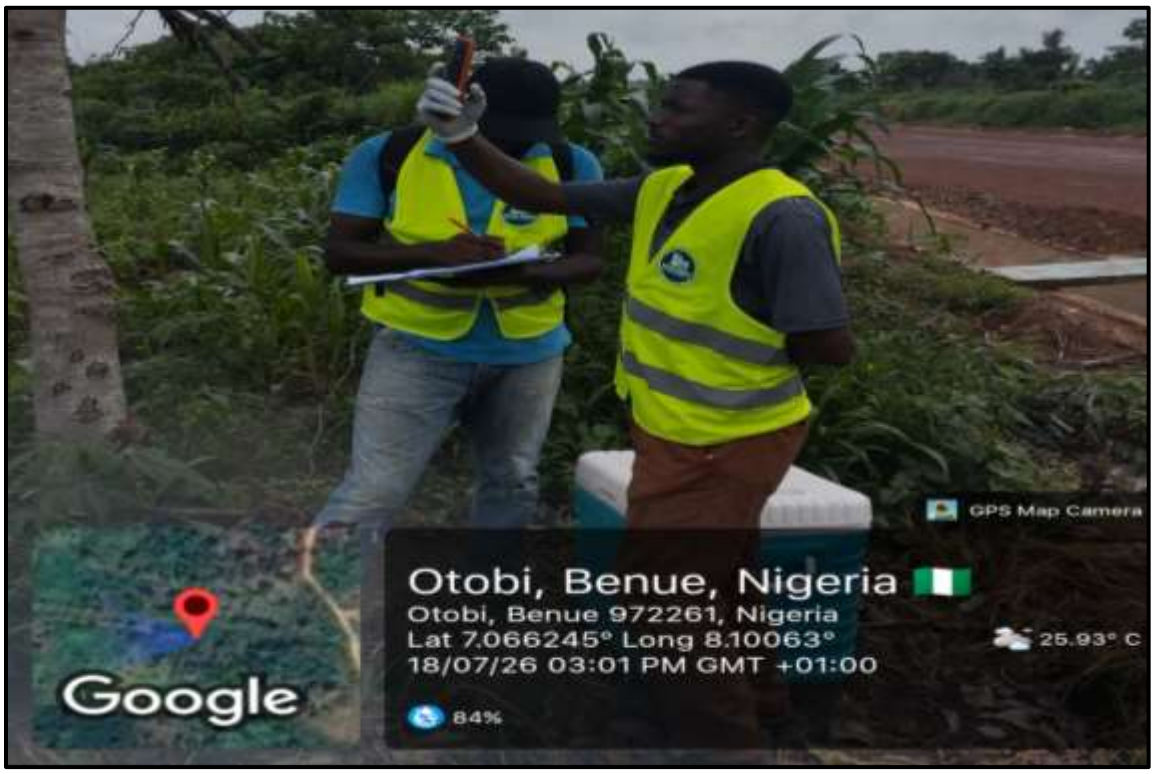



**Plate 4.11: Air Quality Sampling Activities**
***Source:*** *Bolben Ltd. Fieldwork Survey, 2026*




**Plate 4.12: Nosie Level Sampling Activities**
***Source:*** *Bolben Ltd. Fieldwork Survey, 2026*

## 4.7.2 Results of Air Quality Measurements

### 4.7.2.1 Gaseous Pollutants and Volatile Organics

Direct measurements of ambient trace gases indicated a generally clean atmospheric profile across the FUHSO project environment. Formaldehyde (HCHO): Baseline concentrations ranged from 0.01 mg/m³ to 0.07 mg/m³, with an overall mean of 0.021 mg/m³. The highest recorded concentration occurred at AQ1. Total Volatile Organic Compounds (TVOC): Measured concentrations ranged from 0.03 mg/m³ to 0.31 mg/m³, with a mean value of 0.090 mg/m³. AQ1 recorded the highest TVOC concentration, while several locations recorded the minimum value of 0.03 mg/m³. Oxygen and Carbon Dioxide: Oxygen remained uniform at 20.9% at all sampling locations. Carbon dioxide ranged from 402 ppm to 693 ppm, with an overall mean of 431.8 ppm. The highest concentration was recorded at AQ9; however, it remained below the 1,000 ppm guideline indicated on the supplied field-results sheet. The measured gaseous-pollutant profile indicates that the project area was not subject to substantial atmospheric contamination at the time of monitoring. The baseline nevertheless provides an important reference for construction-phase control of exhaust emissions, fuel combustion and unnecessary equipment idling.

### 4.7.2.2 Particulate Matter

Particulate matter is a key indicator of ambient air quality because of its relevance to human health and environmental quality. Fine particulate matter ($PM_{2.5}$) and coarse particulate matter ($PM_{10}$) were measured at all monitoring locations. The ambient concentration of $PM_{2.5}$ ranged from 11.3 to 19.0 µg/m³, with a mean concentration of 14.5 ± 2.08 µg/m³. All measured $PM_{2.5}$ concentrations were below the 25 µg/m³ reference value presented in the result table. AQ12 recorded the highest value, while AQ3 recorded the lowest. $PM_{10}$ concentrations ranged from 19.7 to 34.2 µg/m³, with a mean concentration of 26.1 ± 4.37 µg/m³. The measurements were below the 50 µg/m³ reference value indicated in the results. Particle counts ranged from 1,741 to 2,884 particles per litre. During project construction, particulate concentrations may increase temporarily as a result of site clearing, excavation, material handling and vehicular movement. The present baseline therefore provides a reference for evaluating change and for implementing dust-suppression measures where required.

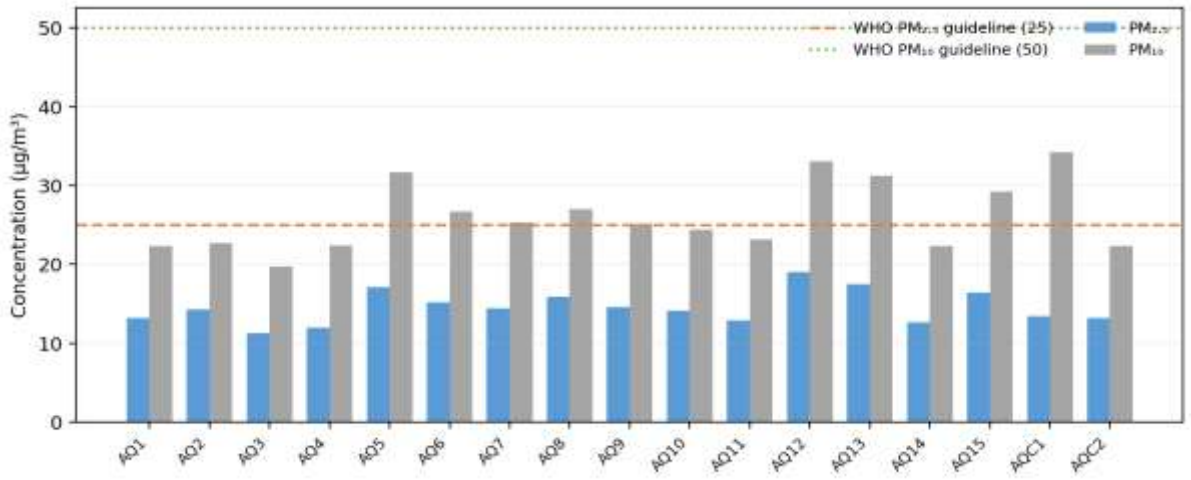



**Figure 4.17: Particulate matter concentrations within the project area**
***Source:*** *Bolben Ltd. Fieldwork Survey, 2026*

### 4.7.2.3 Result of Noise Level Measurement

Ambient noise-level measurements were conducted at fifteen locations within the FUHSO project area and at two control locations to establish the baseline acoustic environment. Minimum and maximum sound-pressure levels were recorded in decibels on the A-weighted scale [dB(A)]. Ambient noise levels ranged from 33.0 dB(A) to 80.5 dB(A). Minimum readings ranged from 33.0 to 56.1 dB(A), with a mean of 42.2 dB(A), while maximum readings ranged from 52.0 to 80.5 dB(A), with a mean of 66.2 dB(A). The highest maximum noise level was recorded at NL11.

**Table 4.25: Ambient Noise Levels around the Project Area**

| Sampling Code | Minimum Reading [dB(A)] | Maximum Reading [dB(A)] |
|---|---|---|
| NL1 | 44.2 | 73.8 |
| NL2 | 40.6 | 61.3 |
| NL3 | 56.1 | 64.1 |
| NL4 | 48.3 | 66.6 |
| NL5 | 55.9 | 77.5 |
| NL6 | 40.4 | 68.3 |
| NL7 | 41.3 | 64.4 |
| NL8 | 34.6 | 64.7 |
| NL9 | 38.6 | 63.4 |
| NL10 | 36.5 | 66.0 |
| NL11 | 33.0 | 80.5 |
| NL12 | 42.9 | 64.8 |
| NL13 | 44.9 | 62.3 |
| NL14 | 35.7 | 64.6 |
| NL15 | 36.4 | 52.0 |
| **CONTROL** | | |
| NLC1 | 38.7 | 64.8 |
| NLC2 | 48.5 | 66.2 |

***Source:*** *Bolben Ltd. Fieldwork Survey, 2026*

The variation between the minimum and maximum readings indicates the influence of intermittent activities and short-duration noise events rather than continuously elevated background noise. Although several maximum readings exceeded the commonly applied 55 dB(A) daytime screening value for sensitive institutional environments, the recorded peaks remained below 90 dB(A). Construction-phase noise should be managed through daytime scheduling, preventive equipment maintenance, restriction of unnecessary horn use and periodic monitoring at sensitive receptors.

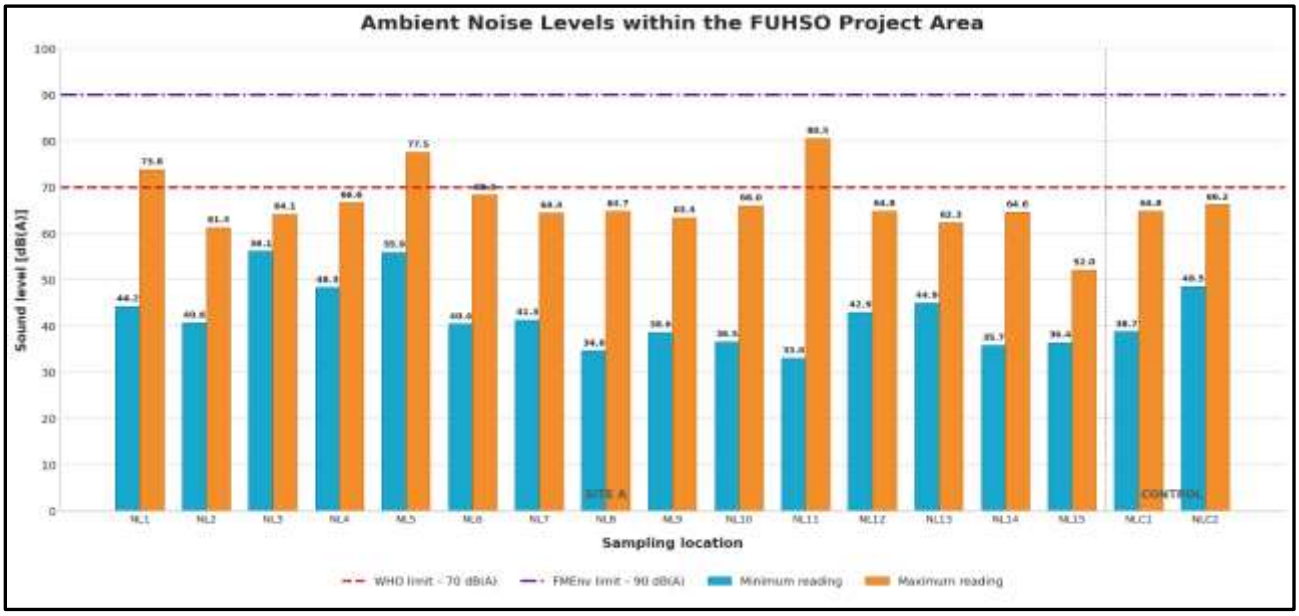



**Figure 4.18: Ambient noise levels within the project area**
***Source:*** *Bolben Ltd. Fieldwork Survey, 2026*

### 4.7.2.4 Air Quality Index (AQI)

The instrument-reported AQI values indicate the broad condition at each sampling point. The rating bands and associated health implications are presented in Table 4, while the supplied AQI values are summarized in Table 4.26 a and b. The reported index should be treated as an instrument-generated screening indicator because the specific pollutant and averaging period used by the meter were not stated in the supplied field sheet.

**Table 4.26a: Air Quality Rating Table**

| Good | Moderate | Unhealthy for sensitive groups | Unhealthy | Very unhealthy | Hazardous |
|---|---|---|---|---|---|
| 0–50 | 51–100 | 101–150 | 151–200 | 201–300 | 301–500 |

**Table 4.26b: Air Quality Index of the Project Area**

| Sampling Code | Instrument AQI | Level of Health Concern |
|---|---|---|
| AQ1 | 53 | Moderate |
| AQ2 | 52 | Moderate |
| AQ3 | 47 | Good |
| AQ4 | 49 | Good |
| AQ5 | 61 | Moderate |
| AQ6 | 56 | Moderate |

| Sampling Code | Instrument AQI | Level of Health Concern |
|---|---|---|
| AQ7 | 58 | Moderate |
| AQ8 | 58 | Moderate |
| AQ9 | 56 | Moderate |
| AQ10 | 56 | Moderate |
| AQ11 | 52 | Moderate |
| AQ12 | 65 | Moderate |
| AQ13 | 62 | Moderate |
| AQ14 | 52 | Moderate |
| AQ15 | 62 | Moderate |
| AQC1 | 53 | Moderate |
| AQC2 | 53 | Moderate |

***Source:*** *Bolben Ltd. Fieldwork Survey, 2026*

The instrument-reported AQI ranged from 47 to 65. Two of the seventeen monitoring locations were within the "Good" category (0–50), while the remaining fifteen locations were "Moderate" (51–100). Overall, the baseline air quality was acceptable at the time of measurement, with no location falling within the unhealthy categories.

## 4.8 Terrestrial Ecology (Flora and Fauna)

### 4.8.1 Vegetation Characteristics

A reconnaissance ecological survey of the proposed Solar PV Project site was undertaken to establish the existing terrestrial flora, fauna and habitat conditions through direct field observations and photographic documentation. The survey indicates that the project area comprises a greenfield site characterized by secondary vegetation interspersed with cultivated farmland and fallow agricultural land. The vegetation has been substantially modified by long-term farming activities and natural regeneration, resulting in a mosaic of cultivated crops, shrubs, herbs, climbers and scattered mature trees.

The proposed project site is predominantly covered by dense herbaceous vegetation with patches of shrubs and regenerating woody species. Vegetation density varies across the site, becoming denser in less disturbed portions where shrubs, climbers and young trees have regenerated naturally. Several mature indigenous trees occur within the landscape alongside economically important tree crops. No primary forest, protected forest, riparian vegetation, wetland or other ecologically sensitive plant communities were observed within the proposed project footprint.

**Table 4.27: Major Habitat Types within the Project Area**

| Habitat Type | Description | Ecological Significance |
|---|---|---|
| **Cultivated Farmland** | Areas cultivated with cassava, maize, yam, banana and other seasonal crops. | Provides agricultural production but supports limited natural vegetation. |
| **Secondary Vegetation** | Dense regenerating shrubs, herbs, grasses, climbers and young trees. | Supports natural regeneration, erosion control and habitat for common fauna. |
| **Scattered Mature Trees** | Indigenous trees and oil palms dispersed throughout the landscape. | Provide shade, carbon sequestration, microclimate regulation and wildlife habitat. |
| **Fallow Land** | Previously cultivated areas undergoing natural regeneration. | Enhances vegetation recovery and ecological connectivity. |

***Source:*** *Bolben Ltd. Fieldwork Survey, 2026*

### 4.8.2 Habitat Description

Based on field observations, the vegetation within and around the project area can be classified into the following habitat types:

**a. Cultivated Farmland:** Cultivated farmland constitutes the dominant land cover within the project area. The fields contain food crops including cassava (*Manihot esculenta*), maize (*Zea mays*), yam (*Dioscorea* spp.) and banana (*Musa* spp.), reflecting active subsistence agriculture. Farming activities have significantly modified the original vegetation structure.

**b. Secondary Vegetation:** Areas not under active cultivation support secondary vegetation comprising regenerating woody species, shrubs, herbs, grasses and climbing plants. These communities represent vegetation recovering following previous land clearing and farming activities.

**c. Scattered Mature Trees:** Several mature indigenous trees occur as isolated individuals throughout the site together with oil palm (*Elaeis guineensis*) and guava (*Psidium guajava*). These trees contribute to landscape diversity, provide shade and support local ecological functions.

### 4.8.3 Floral Composition

The vegetation recorded during the survey represents a typical secondary vegetation/agricultural mosaic common within southern Nigeria. Field observations identified a mixture of indigenous woody species, cultivated crops, shrubs, herbs, climbers and grasses.

**a. Trees**
- Oil Palm (*Elaeis guineensis*)
- Guava (*Psidium guajava*)
- Various indigenous tree species

**b. Shrubs**
- Mixed secondary woody shrubs
- Regenerating shrub species
- Seasonal bush vegetation

**c. Herbaceous Vegetation**
- Grasses
- Broadleaf herbs
- Climbers and creepers

- Agricultural weeds

**d. Cultivated Crops**

- Cassava (*Manihot esculenta*)
- Maize (*Zea mays*)
- Yam (*Dioscorea* spp.)
- Banana (*Musa* spp.)
- Other seasonal food crops

**Table 4.28: Dominant Flora Recorded During the Field Survey**

| Vegetation Category | Species/Type Observed | Scientific Name |
|---|---|---|
| Tree | Oil Palm | *Elaeis guineensis* |
| Tree | Guava | *Psidium guajava* |
| Tree | Indigenous Trees | Various species |
| Shrub | Secondary Woody Shrubs | Various species |
| Shrub | Regenerating Shrubs | Various species |
| Shrub | Seasonal Bush Vegetation | Various species |
| Herbaceous Vegetation | Grasses | Various species |
| Herbaceous Vegetation | Broadleaf Herbs | Various species |
| Herbaceous Vegetation | Climbers/Creepers | Various species |
| Herbaceous Vegetation | Agricultural Weeds | Various species |
| Cultivated Crop | Cassava | *Manihot esculenta* |
| Cultivated Crop | Maize | *Zea mays* |
| Cultivated Crop | Yam | *Dioscorea* spp. |
| Cultivated Crop | Banana | *Musa* spp. |
| Cultivated Crop | Other Seasonal Food Crops | Various species |



**Plate 4.13: Observed Flora within the Proposed Project Site** ***(From the right: Guinea Grass (Megathyrsus maximus), Banana (Musa paradisiaca), Cassava (Manihot esculenta), Teak (Tectona grandis) and Oil Palm (Elaeis guineensis)).***
***Source:*** *Bolben Ltd. Fieldwork Survey, 2026*

### 4.8.4 Faunal Composition

Faunal observations during the ecological survey were limited. No reptiles, mammals or amphibians were directly observed within the proposed project site. Likewise, no burrows, nests, breeding sites or wildlife corridors were identified during the survey. Although no birds were visually observed, vocalizations of common bird species were heard from the surrounding vegetation. Similarly, the sounds of insects typical of secondary vegetation and cultivated farmland were recorded throughout the survey area, indicating the presence of common invertebrate communities. These observations suggest that the project area supports only common fauna associated with disturbed agricultural habitats and that no species of conservation concern were encountered during the field survey.

**Table 4.29: Fauna Observed During the Field Survey**

| Faunal Group | Observation | Ecological Importance |
|---|---|---|
| Birds | Calls of common bird species heard; no direct sightings | Contribute to seed dispersal, pollination and insect population regulation. |
| Insects | Common insects detected by sound; no detailed identification undertaken | Important for pollination, decomposition and nutrient cycling. |
| Mammals | None observed | No evidence of resident mammalian fauna during the survey. |
| Reptiles | None observed | No reptiles recorded within the project area during the survey. |
| Amphibians | None observed | No amphibians recorded during the survey. |

### 4.8.5 Ecological Condition

The vegetation and faunal communities within the project area have been substantially influenced by long-term farming activities and other anthropogenic disturbances. Consequently, the habitat is considered to be of **low to moderate ecological sensitivity**. The site is dominated by secondary vegetation and cultivated farmland, with no rare, threatened or endangered plant or animal species observed during the field survey. No protected forests, wetlands, critical habitats or other areas of high conservation importance were identified within the proposed development footprint. The vegetation nevertheless provides localized ecosystem services including erosion control, carbon sequestration, soil stabilization and habitat for common fauna, while the faunal community reflects a typical disturbed agricultural ecosystem. Overall, the ecological value of the project area is considered **low to moderate**, and potential impacts from vegetation clearance are expected to be localized and readily mitigated through appropriate vegetation management and site restoration measures.

## 4.9 Socio-economic and Health Conditions of the Study Area

The socio-economic and health assessment was conducted to establish the baseline conditions of the proposed project area and its immediate area of influence. The assessment provides information on the demographic, social, economic, and health characteristics of the host community and the Federal University of Health Sciences, Otukpo (FUHSO), which serves as the basis for evaluating the potential impacts of the proposed 2 MW Solar Photovoltaic (PV) Power Project and developing appropriate mitigation and enhancement measures.

***See pictorial evidence of socio-economics questionnaire sample in Appendix I…***

### 4.9.1 Sampled Population/Socioeconomic Characteristics

This assessment examines the economic and human dimensions of the host institution, with particular emphasis on sources of power and other relevant socioeconomic variables. The parameters considered include gender and age distribution, ethnic affiliation, religion, literacy level, occupation, household size and duration of stay within the project area, income level and general health status.

These key socioeconomic characteristics provide valuable insight into the structure and dynamics of the university community and are essential for effective stakeholder engagement.

The information will support the project proponent and facility operators in designing appropriate communication, employment and participation strategies during both the construction and operational phases of the proposed project. In addition, the findings will assist the beneficiary school authority in informed decision-making, planning and management related to the proposed development.

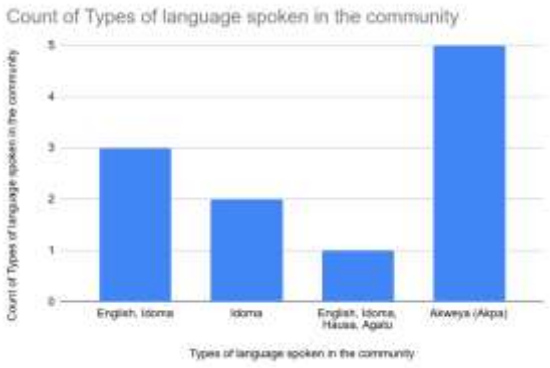
A total of 50 questionnaires were prepared for the socio-economic survey. However, the institution has not yet moved to its permanent site (the proposed project location) and academic activities have not commenced there due to ongoing construction works, the absence of a reliable power supply, and incomplete supporting infrastructure. Although the institution currently operates from temporary campuses scattered across Otukpo, these locations are outside the 5 km project area of influence and were therefore excluded from the survey.

To ensure that the socio-economic baseline adequately captured the communities likely to be affected by the proposed project, the neighboring host community (Akwete-Akpa), which lies within the project's area of influence, was also included in the socio-economic exercise. Furthermore, as the institution was not in academic session during the survey period and only a few management staff were present at the permanent site, 11 questionnaires were successfully administered and retrieved from institutional staff and the community members around.

### 4.9.2 Respondent's Socio-Economics Characteristics

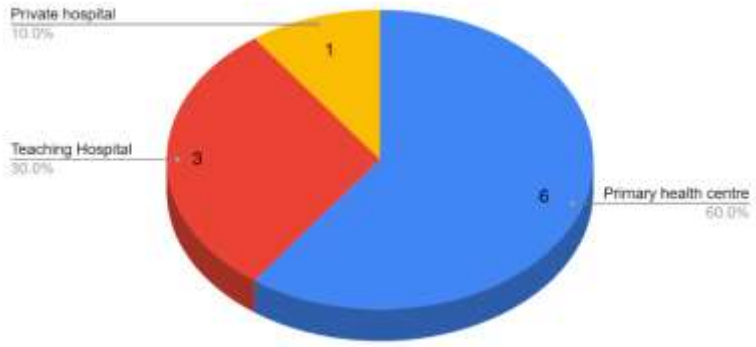
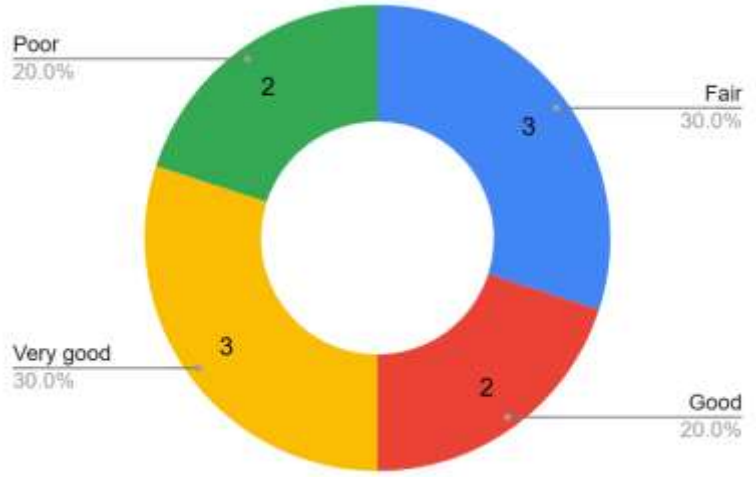
<table>
<tr><th colspan="3">Category</th><th>Findings</th></tr>
<tr><td colspan="3">Gender</td><td rowspan="5">The respondents were mostly male, with 90.9% (10) males and 9.1% (1) female. This reflects the composition of the respondents available during the survey period. Although female participation was limited, the responses provide useful insights for assessing the potential social and environmental impacts of the proposed project and support gender-responsive planning during both the construction and operational phases.</td></tr>
<tr><td>Options</td><td>Frequency</td><td>Percent</td></tr>
<tr><td>Male</td><td>10</td><td>90.9</td></tr>
<tr><td>Female</td><td>1</td><td>9.1</td></tr>
<tr><td>Total Response</td><td>11</td><td>100</td></tr>
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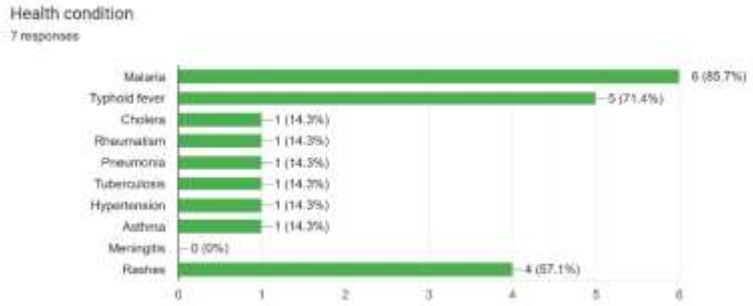
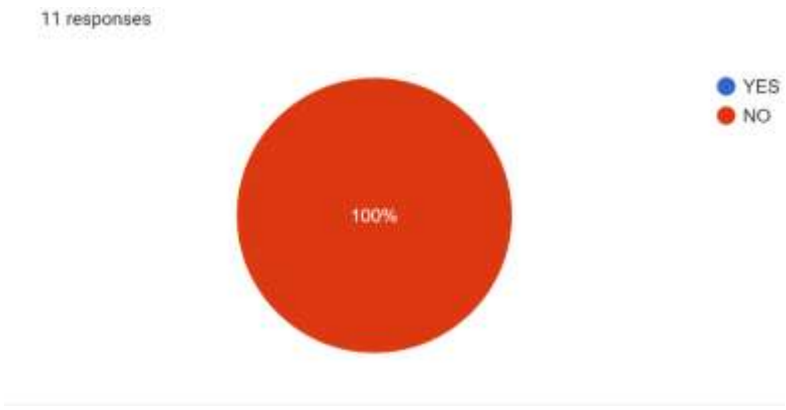
| Category | | | Findings |
|---|---|---|---|
| **Age of Respondents** | | | Most respondents 6 (54.5%) were aged 31–45 years, followed by 27.3% (3) aged 55 years and above, and 18.2% (2) aged 46–54 years. No respondents were within the 18–30 years age group. The findings indicate that the respondents were predominantly mature adults occupying active professional and managerial roles. |
| Options | Frequency | Percent | |
| 18-30 years | - | - | |
| 31-45 years | 6 | 54.5 | |
| 46-54 years | 2 | 18.2 | |
| 55 years and above | 3 | 27.3 | |
| **Total Response** | **11** | **100** | |
| **Religion** | | | |
| Options | Frequency | Percent | Majority of respondents were Christians 8 (72.7%), while 18.2% (2) were Muslims and 9.1% (1) practiced Traditional religion. Religious diversity highlights the need for inclusive stakeholder engagement that respects different cultural and religious backgrounds during project implementation. |
| Christianity | 8 | 72.7 | |
| Isam | 2 | 18.2 | |
| Traditional | 1 | 9.1 | |
| **Total Response** | **11** | **100** | |
| **Education** | | | |
| Options | Frequency | Percent | Respondents were generally well educated. Half of the respondents 5 (50.0%) possessed HND/B.Sc. qualifications, while 20.0% (2) each had Secondary School and Ph.D. qualifications. Only 10.0% (1) had Primary School education. The generally high educational attainment is expected within a tertiary institution and is likely to facilitate effective communication and understanding of project objectives, benefits, and environmental and safety requirements. |
| Primary School | 1 | 10 | |
| Secondary school | 2 | 20 | |
| NCE/ND | - | - | |
| HND/B.Sc | 5 | 50 | |
| Ph.D | 2 | 20 | |
| **Total Response** | **10** | **100** | |
| **Occupation** | | | |
| Options | Frequency | Percent | The largest proportion of respondents were non-academic staff 5 (45.5%), followed by students 2 (18.2%) and farmers 2 (18.2%). Academic staff 1 (9.1%) and traders 1 (9.1%) each accounted for a smaller proportion of respondents. This reflects a mix of institutional personnel and members of the neighboring host community included in the socio-economic exercise. |
| Academic Staff | 1 | 9.1 | |
| Non- academic Staff | 5 | 45.5 | |
| Trading | 1 | 9.1 | |
| Student | 2 | 18.2 | |
| Farmer | 2 | 18.2 | |
| **Total Response** | **11** | **100** | |
| **Monthly Income** | | | |
| Options | Frequency | Percent | The largest proportion of respondents 4 (36.4%) earned ₦120,000 and above per month. Meanwhile, 27.3% (3) earned between ₦0 and ₦30,000, while 18.2% (2) each earned |
| ₦0 to ₦30,000 | 3 | 27.3 | |
| ₦31,000 to ₦70,000 | 2 | 18.2 | |
| ₦70,000 to ₦90,000 | 2 | 18.2 | |

| Category | | | Findings |
|---|---|---|---|
| ₦120,000 + | 4 | 36.4 | ₦31,000–₦70,000 and ₦70,000–₦90,000. The income distribution reflects a combination of salaried employees and lower-income earners from the surrounding community. |
| **Total Response** | **11** | **100** | |
| **Duration of stay in the institution/Community** | | | Respondents were evenly distributed between those who had stayed 1–5 years 5 (50.0%) and those who had stayed 20 years and above 5 (50.0%). This indicates the presence of both relatively recent occupants and long-term residents. |
| Options | Frequency | Percent | |
| 1-5yrs | 5 | 50 | |
| 6-10yrs | - | - | |
| 11-19yrs | - | - | |
| 20 and above | 5 | 50 | |
| **Total Response** | **10** | **100** | |
| **Types of language spoken in the institution/community** | | | |
|  | | | Most respondents spoke Aweye (Akpa), followed by English, Hausa, and Agatu. This reflects the predominance of the indigenous Akpa language within the host community, while English serves as the official language for communication and Hausa functions as a common lingua franca for interaction with people from diverse backgrounds.<br><br>The multilingual nature of the institution suggests that while English remains the official language, awareness and stakeholder engagement activities should consider the linguistic diversity of the university community where necessary. |

***Source:*** *Bolben Ltd. Fieldwork Survey, 2026*

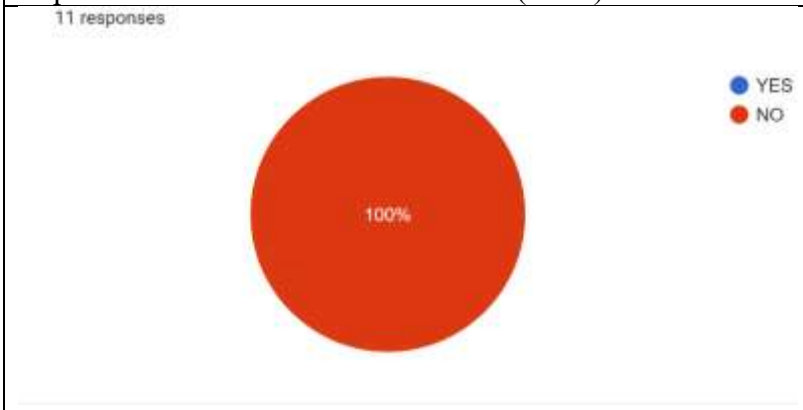
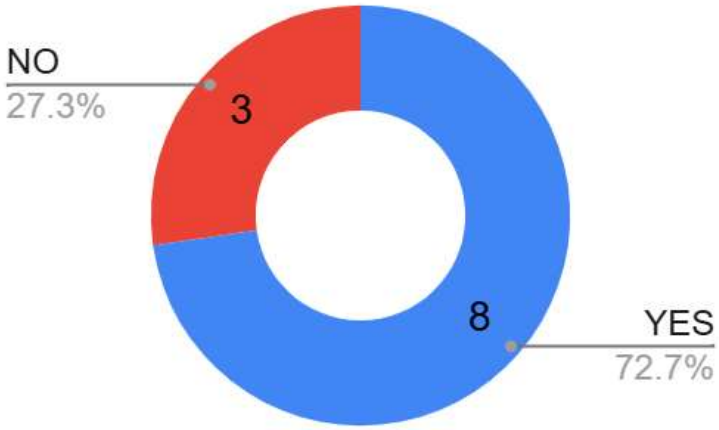
### 4.9.2.1 Health Status

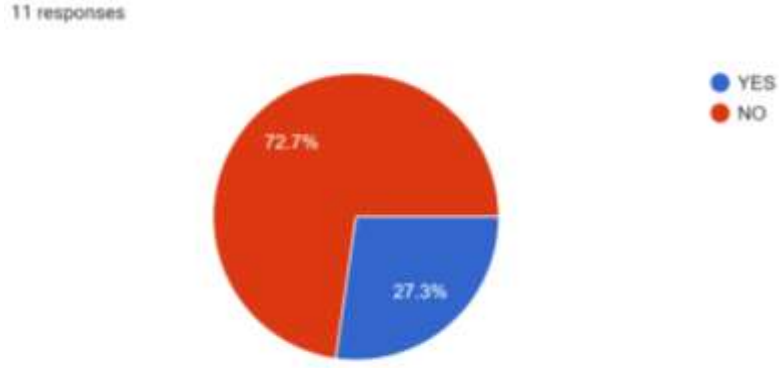
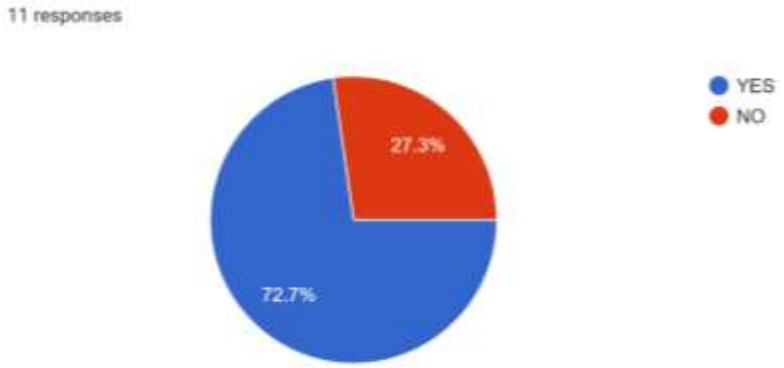
| Category | Key Observations |
|---|---|
| Available Health Facility in the Institution/Community | |
|  | Majority of respondents (60.0%) indicated that they access Primary Health Centres, followed by Teaching Hospitals (30.0%), while Private Hospitals accounted for 10.0%.<br><br>This suggests that respondents primarily rely on public healthcare facilities for their medical needs, with specialized and private healthcare services serving as secondary options. |
| Condition of Health Facility Within the Institution/Community | |
|  | Respondents generally rated the available healthcare facilities positively. About 30.0% rated the facilities as Very Good, while another 30.0% considered them Fair.<br><br>Additionally, 20.0% rated the facilities as Good, whereas 20.0% considered them Poor. Overall, the findings indicate that although healthcare services are available, improvements in infrastructure, equipment, and service delivery could enhance users' satisfaction. |
| Common Health Conditions Within the Institution/Community | |

| Category | Key Observations |
|---|---|
|  | Malaria was identified as the most prevalent health condition, affecting 85.7% of respondents, followed by Typhoid fever (71.4%) and Rashes (57.1%). Other reported health conditions including Cholera, Rheumatism, Pneumonia, Tuberculosis, Hypertension, and Asthma were each reported by 14.3% of respondents, while no cases of Meningitis were reported. These findings highlight the continued burden of vector-borne and water-related diseases which calls need for sustained environmental sanitation, improved water quality, effective drainage, and community health awareness programmes. |
| Perceived Negative Impact of Project | |
|  | All respondents (100%) indicated that they do not anticipate any negative impacts arising from the proposed project. This demonstrates a high level of public acceptance and confidence in the project. |

***Source:*** *Bolben Ltd. Fieldwork Survey, 2026*

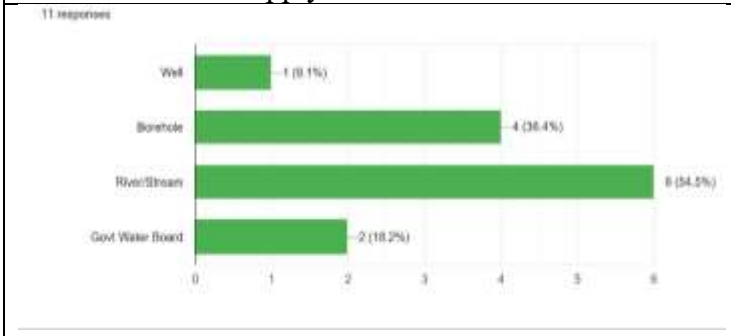
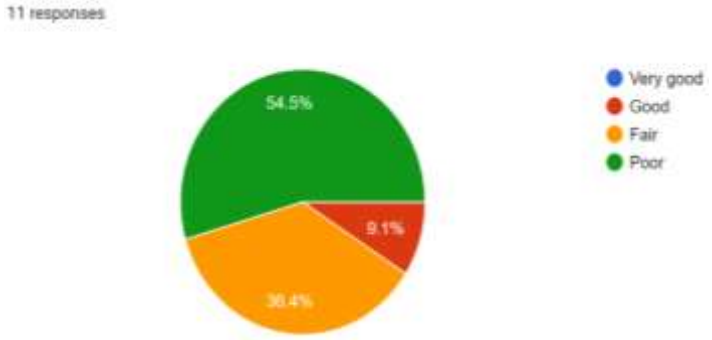
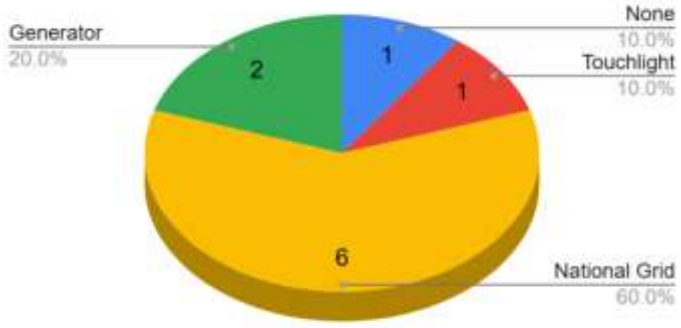
### 4.9.2.3 Gender-Based Violence and Gender Equality Indicators

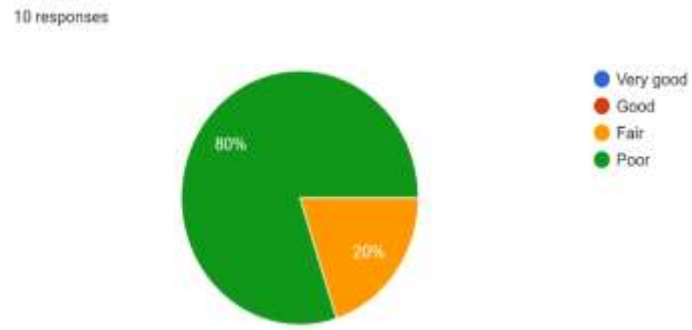
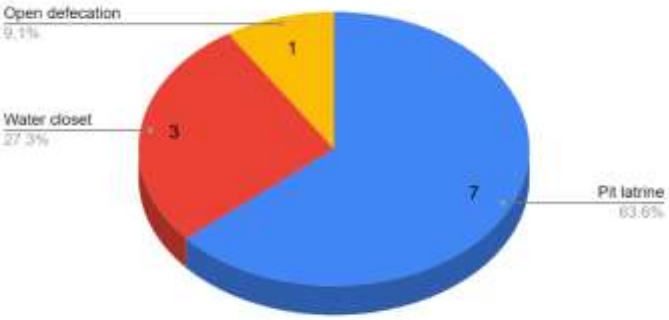
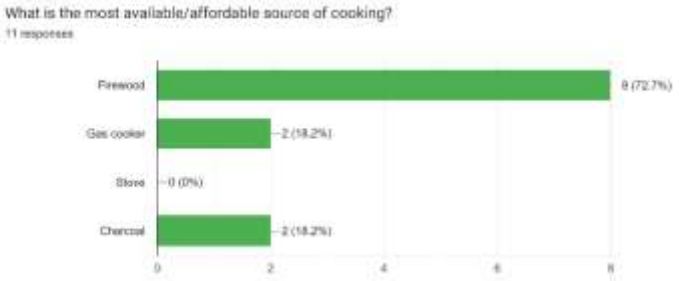
| Category | Key Observations |
|---|---|
| Experience of Gender-Based Violence (GBV) | |
|  | None of the respondents (100%) reported that they or any member of their household had experienced Gender-Based Violence (GBV). This indicates that no GBV incidents were reported among the surveyed respondents during the study period. Nevertheless, the absence of reported cases does not shut out the need for preventive measures, awareness creation, and accessible reporting mechanisms during project implementation. |
| Do you think men and women have equal access to economic opportunities in your institution/community? | |
|  | Majority of respondents (72.7%) believed that men and women have equal access to economic opportunities within the institution and community, while 27.3% felt that equal access does not exist. This suggests that respondents generally perceive the community as inclusive, although there remains a need to promote equal opportunities for all genders throughout project implementation. |
| Do you believe that cultural norms in your community/institution influence the prevalence of GBV? | |

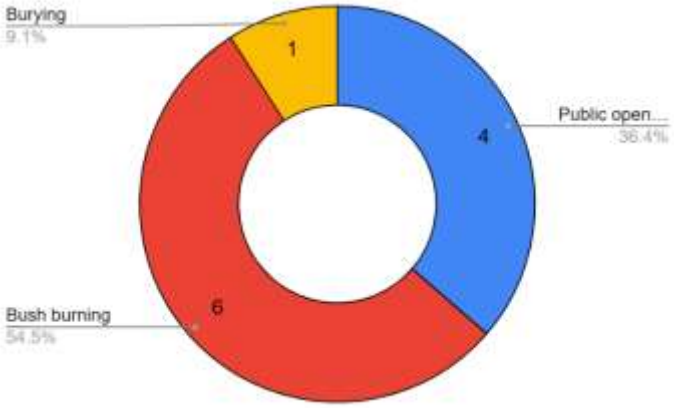
| Category | Key Observations |
|---|---|
|  | Most respondents (72.7%) believed that cultural norms do not influence the prevalence of GBV, whereas 27.3% believed they do. Although the majority perceived limited cultural influence, the differing opinions highlight the importance of continued awareness and sensitization programs addressing gender equality, harmful social norms, and GBV prevention. |
| Availability of Support Services for GBV Survivors | |
|  | Most respondents (72.7%) indicated that support services for GBV survivors are available within the institution or surrounding community, while 27.3% believed such services were unavailable.<br><br>This finding suggests that support mechanisms exist; however, increased awareness, accessibility, and public sensitization are necessary to ensure that all institution/community members know how to access available GBV response services when needed. |

***Source:*** *Bolben Ltd. Fieldwork Survey, 2026*

### 4.9.2.4 Community/Institutional Utilities and Services Profile

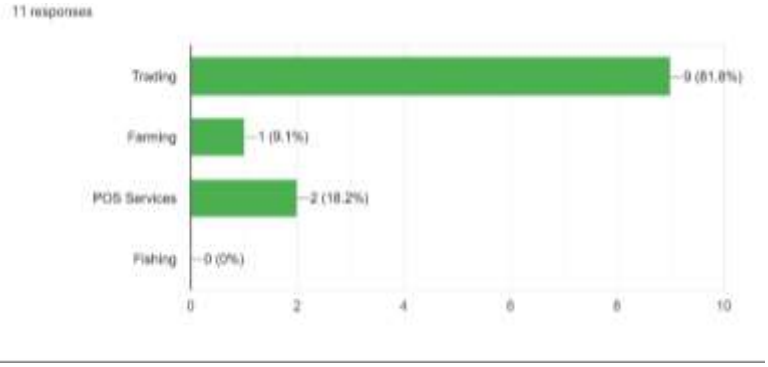
| Category | Key Observations |
|---|---|
| Source of Water Supply | |
|  | The main source of water supply is rivers/streams, identified by 54.5% of respondents, followed by boreholes (36.4%). A smaller proportion relies on the Government Water Board (18.2%) and wells (9.1%). Since respondents could select more than one source, the findings indicate that households depend on a combination of surface water and groundwater sources to meet their domestic water needs. |
| Condition of Potable Water | |
|  | The condition of potable water was generally rated as unsatisfactory. More than half of the respondents (54.5%) rated the quality as Poor, while 36.4% considered it Fair and only 9.1% rated it Good. No respondent rated the water quality as Very Good, suggesting the need for improved access to safe and reliable potable water. |
| Available Source of Electricity | |
|  | The National Grid is the primary source of electricity, used by 60.0% of respondents. This is supplemented by generators (20.0%), while touch lights (10.0%) are used as alternative lighting during power outages. Another 10.0% indicated having no electricity source.<br><br>These findings reflect limited and unreliable electricity supply within the project area, highlighting the potential benefits of the proposed solar PV project. |
| Condition of Public Electricity | |

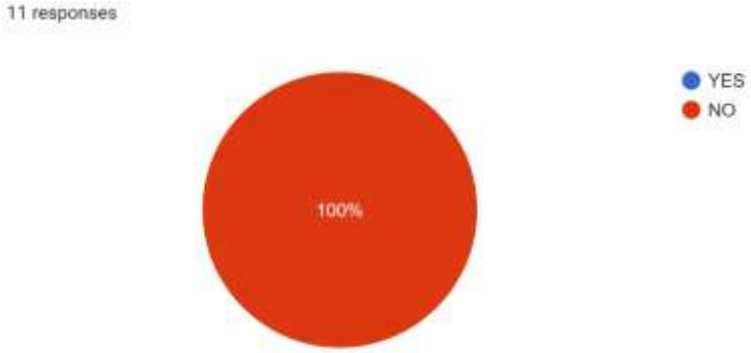
| Category | Key Observations |
|---|---|
|  | Respondents generally expressed dissatisfaction with the condition of public electricity supply. 80.0% rated the electricity supply as Poor, while the remaining 20.0% rated it Fair. None of the respondents rated the electricity supply as Good or Very Good, indicating frequent outages and unreliable power supply in the area. |
| Sanitation Facilities | |
|  | Pit latrines are the most common sanitation facility, used by 63.6% of respondents. This is followed by water closets (27.3%), while 9.1% of respondents still practice open defecation. These indicate that although improved sanitation facilities exist, there remains a need to promote access to hygienic sanitation systems and eliminate open defecation practices. |
| Cooking Fuel | |
|  | Firewood is the dominant cooking fuel, used by 72.7% of respondents. Gas cookers and charcoal are each used by 18.2%, while no respondent reported using electric stoves. This indicates a continued dependence on traditional biomass fuels, which may contribute to indoor air pollution and environmental degradation. |
| Educational Institutions | |
|  | Primary schools are the most commonly available educational facilities, identified by 63.6% of respondents. Secondary schools and tertiary institutions were each reported by 18.2% of respondents, indicating that access to basic education is more widespread than |

| Category | Key Observations |
|---|---|
| | access to higher levels of education within the project area. |
| Waste Disposal Method | |
|  | The results indicate that bush burning is the most common waste disposal method, practiced by 54.5% of respondents. However, 36.4% dispose of waste through public open dumps, while only 9.1% adopt waste burying. These findings indicate that informal waste disposal practices remain prevalent in the project area community, highlighting the need for improved waste management systems, public awareness on proper waste disposal, and increased access to organized waste collection services. |

***Source:*** *Bolben Ltd. Fieldwork Survey, 2026*

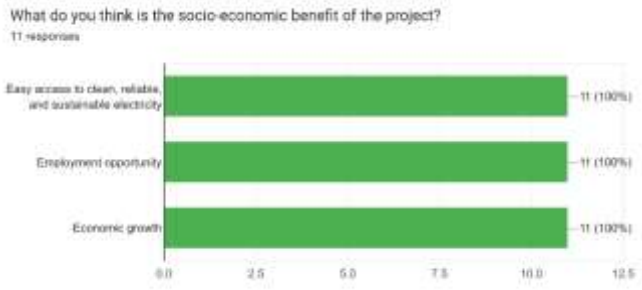
### 4.9.2.5 Traditional Practices and Cultural Heritage

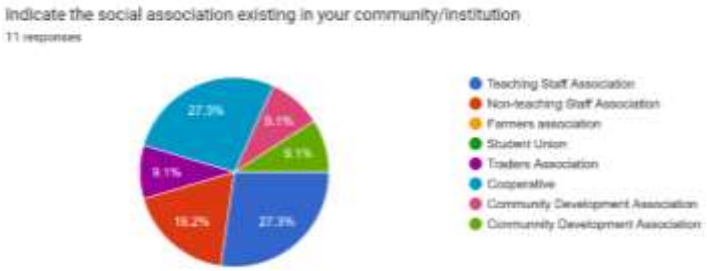
| Category | Key Observations |
|---|---|
| Traditional Economic Activities Practiced | |
|  | Trading is the main economic activity 9 (81.8%), followed by POS services 2 (18.2%) and farming 1 (9.1%). Fishing was not reported (0%).<br>The community is therefore predominantly commercial, with limited agricultural activities. |
| Will Proposed Project Affect any Valued Resources/Cultural Assets/Archeological Site Within the Institution/Community? | |

| Category | Key Observations |
|---|---|
|  | All respondents 11 (100%) stated that the proposed project will not affect any valued cultural resources or archaeological sites. However, a Chance Find Procedure (CFP) should be implemented during construction to manage any unexpected archaeological or cultural discoveries. |

***Source:*** *Bolben Ltd. Fieldwork Survey, 2026*

### 4.9.2.6 Community Awareness, Perceived Benefits, and Social Associations

| Category | Key Observations |
|---|---|
| Awareness of Proposed Project | |
|  | All respondents 11 (100%) are aware of the proposed project, indicating that stakeholder engagement and information dissemination have been effective within the institution and surrounding community. |
| What do you think is the socio-economic benefit of the project? (11 responses) | |
|  | All respondents 11 (100%) identified employment opportunities, economic growth, and access to clean, reliable, and sustainable electricity as the key socio-economic benefits of the project, demonstrating unanimous support for its anticipated positive impacts. |
| Count of Indicate the social association existing in your community/institution | |

| Category | Key Observations |
|---|---|
|  | The institution/community has diverse social associations, including Teaching Staff Associations (27.3%), Cooperatives (27.3%), Non-teaching Staff Associations (18.2%), and Farmers, Student, Traders, and Community Development Associations (9.1% each). These groups provide effective platforms for stakeholder engagement, information dissemination, and community participation. |
| Which neighboring institution/communities do you think will benefit from the proposed project? | |
| Respondents identified Akwete-Akpa/Akweya communities as the neighbouring community most likely to benefit from the proposed project through improved electricity access and associated socio-economic opportunities. | |

***Source:*** *Bolben Ltd. Fieldwork Survey, 2026*

## 4.10 Health, Safety and Environmental (HSE) Baseline Conditions

The Health, Safety and Environmental (HSE) assessment undertaken during the baseline survey evaluated existing site conditions that may influence the safe execution of the proposed project and future construction activities. The assessment considered site accessibility, terrain stability, drainage characteristics, occupational hazards and the prevailing security situation within the project area.

The proposed project site is accessible through the institution's access road and is situated on relatively elevated terrain characterized by stable ground conditions and good natural drainage. No active erosion features, unstable slopes, contaminated land, abandoned infrastructure or other significant environmental hazards capable of constraining the proposed development were observed during the field investigation. Vegetation within the project area is typical of secondary Guinea Savannah vegetation and presents only routine occupational risks associated with vegetation clearing, manual handling, and earthworks. A twin-cell reinforced concrete culvert located along the access route to the proposed project site was observed to be under construction during the field survey. The drainage structure is designed to convey stormwater runoff into a natural drainage channel situated behind the proposed project site. Localized waterlogging was observed within the downstream drainage corridor receiving runoff from the culvert. However, the proposed project footprint occupies relatively higher ground and remained dry during the site investigation, indicating favourable drainage conditions. Existing drainage pathways should be preserved and incorporated into the project design to prevent localized flooding and erosion during construction and operation.

The most significant HSE issue identified during the baseline survey relates to the prevailing regional security situation. The wider area has experienced recurring incidents of insurgency and banditry, which have reportedly disrupted and slowed ongoing infrastructure development within

the institution's permanent site. Owing to these security concerns, the ESIA field team conducted all site investigations under official security escort provided by military and law enforcement personnel. The security personnel accompanied the survey team throughout field mobilization, environmental sampling and ecological assessments to ensure the safety of personnel and equipment. No security incident occurred during the survey; however, the requirement for armed security escort reflects the elevated security risk currently associated with the wider project environment.

From an occupational health and safety perspective, the project site itself presents no unusual physical hazards beyond those commonly associated with construction activities. Nevertheless, future project implementation should incorporate a comprehensive HSE Management Plan that addresses site safety, emergency preparedness, journey management, access control, contractor induction, environmental protection and security risk management. Particular attention should be given to coordinating construction activities with relevant security agencies to safeguard personnel, project assets and surrounding communities throughout the construction phase.

Overall, the HSE baseline indicates that the proposed project site is environmentally suitable for development, with favourable terrain, stable ground conditions and adequate natural drainage. The principal baseline constraint is the prevailing external security situation rather than any inherent environmental or occupational hazard within the project footprint.

**Table 4.30: Summary of Health, Safety and Environmental (HSE) Baseline Conditions**

| HSE Component | Baseline Observation | Project Implication |
|---|---|---|
| **Site Accessibility** | Accessible through the institution's access road | Suitable for construction access and mobilization |
| **Terrain Stability** | Stable, gently elevated terrain with no erosion or slope instability | Favourable for civil works and foundation construction |
| **Surface Drainage** | Triple-cell culvert under construction conveys runoff to a natural drainage channel behind the project site | Existing drainage should be maintained and integrated into project stormwater management |
| **Flood Risk** | Localized waterlogging observed downstream; proposed project footprint remained dry | Low flood susceptibility within the proposed development area |
| **Environmental Hazards** | No contaminated land, hazardous waste, unstable ground or abandoned structures observed | No significant environmental constraints identified |
| **Occupational Health Hazards** | Routine hazards associated with vegetation clearing and earthworks | Standard construction HSE measures required |
| **Security Conditions** | Regional insurgency and banditry reported; ESIA survey undertaken under continuous military and police security escort | Comprehensive security management, journey management, emergency response procedures and coordination with security agencies will be required during project implementation |
| **Overall HSE Status** | Site environmentally suitable for development; security is the primary external constraint | Implement robust HSE and security management throughout project execution |

## 4.11 Summary of Baseline Environmental Conditions

The baseline environmental survey established the existing physical, biological and environmental characteristics of the proposed project area prior to project implementation. The study confirmed that the proposed development site is generally characterized by well-drained upland terrain underlain by lateritic soils, with no evidence of active erosion or flooding within the project footprint. Existing drainage is facilitated through a twin-cell reinforced concrete culvert located along the access road, which conveys stormwater runoff into a natural drainage channel situated behind the proposed project site. Although the downstream drainage corridor exhibited localized waterlogged conditions during the field survey, the proposed project footprint occupies a relatively higher elevation and remained comparatively dry, stable and suitable for the proposed development.

The baseline physicochemical characteristics of the soils indicate generally favourable conditions for construction, with no evidence of widespread contamination by petroleum hydrocarbons, heavy metals or hazardous substances. Ambient air quality monitoring further demonstrated a generally clean atmospheric environment, with measured concentrations of particulate matter ($PM_{2.5}$ and $PM_{10}$), gaseous pollutants and volatile organic compounds remaining within applicable guideline values. Similarly, ambient noise measurements reflected a relatively quiet institutional environment characterized by low background noise levels and only occasional short-duration peak noise events. Overall, the baseline physical environment presents no significant environmental constraints to the implementation of the proposed project.

The biological environment is dominated by secondary vegetation comprising scattered trees, shrubs, grasses and cultivated crops, while the wildlife assemblage is typical of a disturbed Guinea Savannah ecosystem and was represented primarily by common bird species and insects detected during the survey. No reptiles or mammals were observed within the proposed project area, and no critical habitats, protected species or environmentally sensitive ecological features were identified within the project footprint. Furthermore, no residential settlements, host communities or permanent human populations were observed within the project site or its immediate area of influence; consequently, a detailed socio-economic baseline survey was not undertaken.

It is noteworthy that the field investigation was undertaken under prevailing security challenges within the wider area arising from reported incidents of insurgency and banditry, which have reportedly affected ongoing construction activities at the University's permanent site. Consequently, the ESIA field team conducted all environmental sampling and site investigations under continuous security escort provided by military and police personnel to ensure the safety of personnel and equipment throughout the exercise. Although no security incident occurred during the survey, the prevailing security situation represents an important external consideration for project planning, logistics and contractor Health, Safety, Security and Environmental (HSSE) management during project implementation.

The baseline information generated from the physical, biological and environmental assessments provides the reference conditions against which the potential environmental and social impacts of the proposed 2 MW Solar Photovoltaic (PV) Power Project and Associated Infrastructure will be evaluated in the subsequent chapters of this ESIA. These baseline data will guide the identification and evaluation of project impacts, formulation of mitigation measures, preparation of the

Environmental and Social Management Plan (ESMP), environmental monitoring programme and other management measures, thereby ensuring that project implementation is undertaken in an environmentally sustainable, socially responsible and safe manner.

**Table 4.31: Summary of Baseline Environmental Conditions**

| Environmental Component | Baseline Condition | Implication for Project |
|---|---|---|
| **Topography** | Gently undulating, relatively elevated terrain with stable ground conditions. | Favourable for infrastructure development and natural surface drainage. |
| **Soils** | Lateritic soils with no evidence of significant contamination or erosion. | Suitable for foundation construction with routine erosion and sediment control measures. |
| **Surface Water** | No natural surface water body occurs within the project site. Stormwater is conveyed through an existing twin-cell culvert to a natural drainage channel behind the site, while the project footprint remains relatively well-drained. | Existing drainage pathways should be maintained and integrated into the project's stormwater management system. |
| **Groundwater** | No operational groundwater source was available within the project site during the baseline survey; consequently, groundwater sampling could not be undertaken. | Future groundwater monitoring may be undertaken once operational boreholes become available. |
| **Ambient Air Quality** | Warm, moderately humid atmospheric conditions with generally good air quality. Measured gaseous pollutants, $PM_{2.5}$ and $PM_{10}$ concentrations were within applicable guideline values, while AQI ratings ranged from Good to Moderate. | Existing air quality is suitable for development. Temporary dust and exhaust emissions during construction should be controlled through standard mitigation measures. |
| **Noise Environment** | Ambient noise levels represent a generally quiet institutional environment with occasional short-duration peak noise events. Maximum noise levels remained below occupational exposure limits. | Construction activities are expected to constitute the principal temporary source of noise and should be managed through good construction practices. |
| **Terrestrial Ecology (Flora and Fauna)** | Secondary vegetation comprising cultivated crops, shrubs and scattered indigenous trees with common bird and insect species. No protected species, critical habitats or significant wildlife populations were recorded. | Vegetation clearance impacts are expected to be localized and readily mitigated through appropriate environmental management measures. |
| **Socio-economic Environment** | No residential settlements, host communities or permanent residents occur within the project site or its immediate area of influence. | No displacement, resettlement or livelihood impacts are anticipated. |
| **Health, Safety and Security** | The project site presents favourable environmental and occupational conditions for development. However, prevailing regional insecurity required the ESIA field team to conduct all site investigations under continuous military and police escort. | A comprehensive HSE and Security Management Plan, including coordination with security agencies, emergency preparedness and controlled site access, should be implemented throughout project execution. |

# CHAPTER FIVE
# POTENTIAL AND ASSOCIATED IMPACTS

## 5.1 Introduction

This chapter identifies and evaluates the potential environmental and social impacts and risks associated with the proposed 2 MW Solar Photovoltaic (PV) Hybrid Power Project and Associated Infrastructure at the Permanent Site of the Federal University of Health Sciences, Otukpo (FUHSO), Benue State. The assessment covers the project's pre-construction, construction, operation and maintenance, and decommissioning phases. It considers both beneficial and adverse impacts arising from site preparation, civil works, equipment installation, electricity generation and distribution, routine maintenance, waste management and eventual project closure.

The assessment was based on:

- The project description and activities presented in Chapter Three;
- The physical, biological, environmental and Health, Safety, Security and Environmental baseline conditions established in Chapter Four;
- Laboratory analytical results for soil and surface water;
- Ambient air quality and noise monitoring results;
- Terrestrial ecology and land-use findings;
- Stakeholder consultation outcomes;
- Applicable environmental standards and regulatory requirements; and
- Professional judgement and experience from comparable solar photovoltaic projects.

The baseline assessment established that the proposed project site is a largely undeveloped greenfield area within the FUHSO Permanent Campus. The site comprises secondary Guinea Savannah vegetation, scattered cultivated crops and relatively well-drained lateritic soils. No permanent settlements, residential structures, critical habitats, protected species or surface water bodies occur within the proposed project footprint. Ambient air quality and noise levels were generally acceptable, while the soil baseline showed no evidence of significant petroleum or heavy-metal contamination.

The wider project area is nevertheless subject to security concerns associated with reported incidents of insurgency and banditry. These conditions are relevant to the movement of personnel, equipment and construction materials and have therefore been considered within the project risk assessment and Health, Safety and Security management requirements.

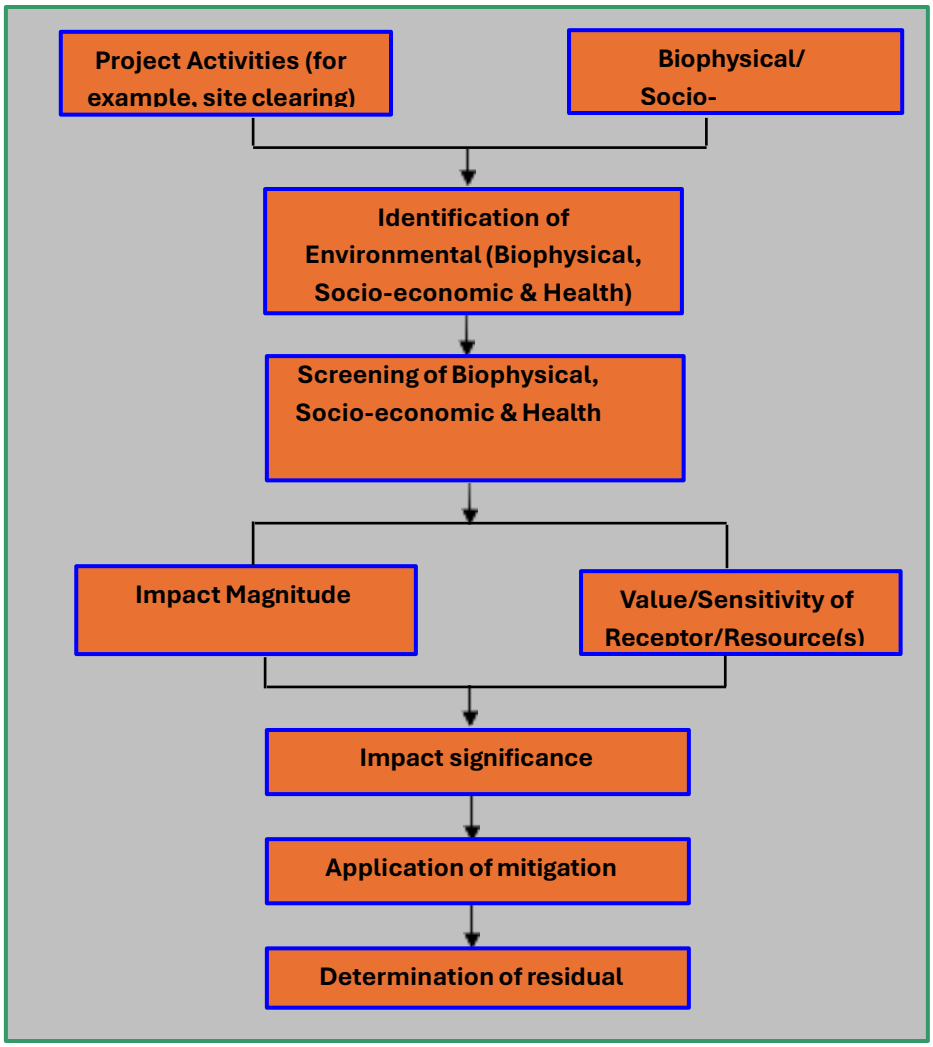



**Figure 5.1: Overview of the Impact Assessment Process**

The impact assessment seeks to:

- Identify interactions between project activities and environmental or social receptors;
- Determine the nature, magnitude, duration and extent of potential impacts;
- Evaluate the sensitivity of affected receptors;
- Determine the significance of each impact before mitigation;
- Identify positive impacts that may be enhanced;
- Establish appropriate mitigation measures for adverse impacts;
- Evaluate residual impacts after mitigation; and
- Assess cumulative environmental and social effects.

Impact significance is classified as **Major, Moderate, Minor or Negligible**, while beneficial impacts are identified as **Positive**. The ratings presented in this chapter represent impacts before the application of additional mitigation measures, except where environmental protection measures have already been incorporated into the project design. The mitigation measures required

to reduce adverse impacts to as low as reasonably practicable are presented in Chapter Six, while implementation responsibilities and monitoring requirements are detailed in Chapter Seven.

## 5.2 Impact Methodology Description

The impact assessment methodology provides a systematic framework for identifying project–environment interactions and determining the significance of the resulting environmental and social impacts. A potential impact exists where a project activity or environmental aspect has the capacity to interact with a physical, biological, social, economic, health or safety receptor. For example, vegetation clearance may result in habitat loss, excavation may disturb soil, and movement of construction vehicles may generate dust, noise and traffic-safety risks.

The impact assessment process comprised the following stages:

1. Identification of project activities and environmental aspects;
2. Identification of potentially affected receptors;
3. Screening of activity–receptor interactions;
4. Characterization of identified impacts;
5. Evaluation of impact magnitude;
6. Evaluation of receptor sensitivity;
7. Determination of impact significance;
8. Identification of mitigation or enhancement measures; and
9. Evaluation of residual and cumulative impacts.

A modified **Leopold Interaction Matrix** was adopted to screen the project activities against the environmental and social receptors identified within the project area. This approach is consistent with the methodology used in comparable REA environmental assessments, where project activities are matched against potentially affected resources to determine whether an interaction and impact may occur.

**Table 5.1: Examples of Project Activities, Environmental Aspects and Potential Impacts**

| Project Activity | Environmental or Social Aspect | Potential Impact |
|---|---|---|
| Site clearing and preparation | Removal of vegetation | Loss of secondary vegetation and disturbance of fauna |
| Earthworks and excavation | Exposure and disturbance of soil | Soil compaction, erosion and sediment generation |
| Movement of equipment and materials | Vehicular emissions and noise | Temporary deterioration of air quality and increased noise |
| Cable trenching | Soil excavation | Localized soil disturbance and disruption of drainage |
| Installation of PV modules and BESS | Electrical and lifting activities | Occupational injury and electrical safety risks |
| Construction workforce employment | Demand for labour | Temporary employment and income opportunities |
| Routine maintenance | Generation of spent electrical components | Electronic and hazardous waste-management risks |
| Solar electricity generation | Reduced diesel combustion | Lower greenhouse gas emissions, air pollution and noise |

### 5.2.1 Environmental and Social Indicators

Environmental and social indicators were selected to provide measurable or observable evidence of potential changes resulting from project activities. The indicators were derived from the baseline studies presented in Chapter Four and reflect the receptors that may be affected within the project footprint and wider Area of Influence. The principal receptors and impact indicators considered are presented in Table 5.2.

**Table 5.2: Environmental and Social Receptors and Impact Indicators**

| Receptor/Medium | Existing Condition | Principal Impact Indicators |
|---|---|---|
| **Ambient air quality** | Generally good, with no major industrial pollution sources | Increased dust, particulate matter and exhaust emissions |
| **Ambient noise** | Generally low and suitable for an institutional environment | Increase in noise and vibration above baseline conditions |
| **Soil** | Slightly acidic to near neutral, non-saline and without significant contamination | Erosion, compaction, contamination, loss of topsoil and changes in soil properties |
| **Groundwater** | Existing campus boreholes were non-operational during the baseline study | Groundwater abstraction, accidental contamination and changes in availability |
| **Drainage and runoff** | Project site is relatively elevated and well drained; downstream corridor shows localized waterlogging | Increased runoff, erosion, sediment transport and obstruction of drainage |
| **Surface water** | No surface water occurs within the project footprint; Aloma River is approximately 3.2 km away | Off-site sediment or contaminant migration during abnormal conditions |
| **Topography and landscape** | Gently undulating greenfield terrain | Changes in landform, visual character and drainage patterns |
| **Terrestrial flora** | Secondary Guinea Savannah vegetation with scattered crops and common plant species | Vegetation loss, habitat alteration and introduction of invasive species |
| **Terrestrial fauna** | Common birds and insects; no mammals or reptiles observed during the survey | Disturbance, displacement, injury or mortality of common fauna |
| **Land use** | University-owned institutional greenfield land | Conversion of undeveloped land to energy infrastructure |
| **Infrastructure and access** | Campus infrastructure under construction; access through Otukpo–Igumale Road | Traffic increase, road deterioration and access disruption |
| **Employment and income** | Limited permanent activity at the undeveloped campus | The proposed project forms part of the Rural Electrification Agency's Nigeria Electrification Project Phase II (NEP II) – Desert to Power Programme, implemented by the Federal Government of Nigeria with development partner support. The project comprises the engineering, procurement, construction, installation, testing, commissioning, |

| Receptor/Medium | Existing Condition | Principal Impact Indicators |
|---|---|---|
| | | operation and maintenance of a 2 MW Solar Photovoltaic Hybrid Power System and associated infrastructure within the Federal University of Health Sciences, Otukpo. The Engineering, Procurement and Construction (EPC) Contractor will be competitively selected by the Rural Electrification Agency in accordance with applicable procurement procedures, while long-term operation and maintenance will be undertaken by qualified personnel to ensure safe and sustainable performance throughout the project lifespan. |
| **Gender and vulnerable groups** | No resident population within the project footprint | Unequal employment access, harassment, discrimination and GBV risks |
| **Workers' health and safety** | No existing project workforce | Injuries, electrocution, falls, fire, equipment accidents and exposure to dust or noise |
| **Public and institutional safety** | Campus largely unoccupied but under construction | Traffic accidents, unauthorized access, electrical hazards and security risks |
| **Security** | Wider regional insecurity reported | Threats to personnel, equipment, logistics and construction continuity |

The selection of these receptors reflects the actual FUHSO baseline. In particular, no permanent residential community or sensitive social facility occurs within the project footprint, while the biological receptors are of generally low ecological sensitivity because no critical habitat, protected area or threatened species was identified. The baseline soil, air and noise conditions also indicate capacity to accommodate temporary project-related changes, provided that construction activities are controlled and applicable environmental limits are maintained.

### 5.2.2 Impact Identification and Characterization Technique

The identification of potential environmental and social impacts was undertaken through a systematic assessment of interactions between the proposed project activities and the environmental and social receptors identified within the Project Area of Influence (AoI). The assessment considered the entire project lifecycle, including the pre-construction, construction, operation and maintenance, and decommissioning phases.

Impact identification was based on:

- Review of the project design and implementation activities;
- Findings from the baseline environmental and social studies presented in Chapter Four;
- Laboratory analytical results for soil and surface water quality;
- Ambient air quality and noise monitoring data;

- Ecological field surveys;
- Stakeholder consultations and field observations;
- Applicable environmental legislation, standards and guidelines; and
- Professional judgement based on experience from similar solar photovoltaic projects.

A modified **Leopold Interaction Matrix** was adopted to identify potential interactions between project activities and environmental receptors. Under this approach, project activities were evaluated against the identified physical, biological, socio-economic, health and safety receptors to determine whether a direct or indirect interaction could occur. Where an interaction was identified, the associated environmental or social impact was evaluated for its significance. Table 5.3 presents examples of the relationship between project activities, environmental aspects and their potential impacts.

**Table 5.3: Relationship between Project Activities, Environmental Aspects and Potential Impacts**

| Project Activity | Environmental/Social Aspect | Potential Impact |
|---|---|---|
| **Site clearing** | Removal of vegetation | Loss of vegetation and habitat disturbance |
| **Earthworks and excavation** | Soil disturbance | Soil compaction, erosion and sediment generation |
| **Movement of construction vehicles** | Exhaust emissions and noise | Temporary deterioration of air quality and increase in ambient noise |
| **Installation of PV modules and electrical equipment** | Construction activities | Occupational health and safety risks |
| **Installation of underground cables** | Excavation and trenching | Localized soil disturbance and temporary disruption of drainage |
| **Construction workforce** | Labour demand | Employment opportunities and increased local economic activities |
| **Operation of the solar facility** | Renewable electricity generation | Improved energy reliability and reduction in greenhouse gas emissions |
| **Routine maintenance** | Generation of maintenance waste | Electronic waste and hazardous waste management requirements |

Potential impacts identified during the assessment were subsequently characterized based on their environmental and social attributes. The principal characteristics considered are described below.

### Impact Characteristics

The identified impacts were characterized using the following criteria:

- **Positive:** Impacts that result in beneficial environmental, social or economic outcomes.
- **Negative:** Impacts that result in adverse environmental or social effects.
- **Direct:** Impacts resulting directly from project activities.
- **Indirect:** Impacts occurring as a consequence of project activities but through secondary pathways.
- **Temporary:** Impacts occurring for a limited period and reversible after completion of the activity.
- **Short-term:** Impacts lasting only during a specific project phase.
- **Long-term:** Impacts persisting throughout the operational life of the project.

- **Permanent:** Impacts that remain after project completion or cannot be readily reversed.
- **Site-specific:** Impacts confined to the project footprint.
- **Local:** Impacts extending beyond the project site but limited to the immediate surrounding environment.
- **Regional:** Impacts affecting a wider geographical area beyond the immediate project vicinity.
- **Reversible:** Impacts that can be restored through natural recovery or mitigation measures.
- **Irreversible:** Impacts that cannot be fully restored to baseline conditions.
- **Cumulative:** Impacts resulting from the combined effect of the proposed project together with other past, present or reasonably foreseeable activities.
- **Residual:** Impacts remaining after implementation of mitigation measures.

The characterization of impacts provided the basis for evaluating impact magnitude, receptor sensitivity and overall impact significance, as described in the following section.

### 5.2.3 Determination of Impact Significance

The significance of each identified environmental and social impact was determined by considering two principal factors:

- **Impact Magnitude**; and
- **Sensitivity (or value) of the affected receptor.**

Impact significance was determined before the application of additional mitigation measures, except where mitigation has been incorporated into the project design. The assessment methodology adopted for this study is consistent with internationally accepted Environmental and Social Impact Assessment (ESIA) practice and considers both quantitative and qualitative information obtained during the baseline studies.

The following factors were considered in assigning impact magnitude:

- Nature of the impact (beneficial or adverse);
- Spatial extent;
- Duration;
- Frequency of occurrence;
- Intensity or severity;
- Reversibility; and
- Likelihood of occurrence.

Similarly, receptor sensitivity was assessed based on:

- Environmental importance;
- Ecological value;
- Existing baseline condition;
- Social importance;
- Regulatory protection status; and
- Ability of the receptor to recover from disturbance.

The overall significance of each impact was determined by combining the impact magnitude with receptor sensitivity using a significance matrix. Based on the assessment, impacts were classified as:

- **Major**
- **Moderate**
- **Minor**

- **Negligible**
- **Positive (Beneficial)**

The significance ratings provide the basis for identifying impacts requiring mitigation and for prioritizing environmental management measures. Impacts assessed as **Major** or **Moderate** require specific mitigation measures to reduce their significance to **As Low As Reasonably Practicable (ALARP)**, while **Minor** and **Negligible** impacts generally require standard environmental management practices and routine monitoring.

## 5.3 Impact Methodology Description

The assessment of potential environmental and social impacts was undertaken by relating the activities associated with the proposed project to the baseline environmental and social conditions established in Chapter Four. The methodology was designed to identify the likely interactions between project activities and environmental receptors, determine the significance of the resulting impacts, and provide a basis for developing appropriate mitigation and monitoring measures. The assessment covered both planned activities and reasonably foreseeable accidental events during the pre-construction, construction, operation and maintenance, and decommissioning phases of the project.

The principal steps applied were:

1. Identification of project activities likely to interact with the environment;
2. Identification of physical, biological, social, health, safety and security receptors;
3. Screening of activity–receptor interactions using a modified Leopold Interaction Matrix;
4. Characterization of each identified impact;
5. Determination of impact magnitude;
6. Evaluation of receptor sensitivity;
7. Assignment of impact significance;
8. Identification of mitigation or enhancement measures;
9. Assessment of residual impacts following mitigation; and
10. Evaluation of cumulative impacts and project-specific risks.

### 5.3.1 Sources of Information

The impact assessment was based on information obtained from:

- The project description and implementation activities presented in Chapter Three;
- Baseline physical, biological and environmental data presented in Chapter Four;
- Soil and surface-water laboratory analytical results;
- Ambient air quality and noise measurements;
- Terrestrial flora and fauna observations;
- Existing land-use, drainage and infrastructure conditions;
- Stakeholder consultation findings;
- Applicable environmental standards and regulatory limits; and
- Professional judgement and experience from similar solar PV projects.

The baseline findings established that the project site is a predominantly undeveloped greenfield area within the FUHSO Permanent Campus. The site has relatively level to gently undulating terrain, well-drained lateritic soils, acceptable ambient air and noise conditions, secondary Guinea Savannah vegetation and no permanent settlements, critical habitats or protected species within

the project footprint. These conditions were taken into account when determining receptor sensitivity and impact significance.

### 5.3.2 Impact Screening

A modified Leopold Interaction Matrix was used to screen project activities against relevant environmental and social receptors. An interaction was recorded where a project activity was considered capable of causing a measurable or observable change in the affected receptor.

The screening covered the following receptor groups:

- Physical environment;
- Biological environment;
- Land use and infrastructure;
- Employment and economic activities;
- Gender and vulnerable groups;
- Occupational health and safety;
- Public and institutional safety; and
- Security.

**Table 5.4: Summary of Project Activities Considered in the Impact Assessment**

| Project Phase | Principal Activities |
|---|---|
| **Pre-Construction** | Detailed design, site demarcation, limited vegetation clearing, mobilisation of personnel, equipment and materials |
| **Construction** | Earthworks, excavation, foundations, access roads, drainage works, installation of PV modules, BESS, electrical equipment, cables and associated infrastructure |
| **Commissioning** | Inspection, testing, energisation and performance verification |
| **Operation and Maintenance** | Electricity generation and distribution, panel cleaning, vegetation control, equipment inspection, maintenance and waste management |
| **Decommissioning** | Shutdown, dismantling, material recovery, waste removal and site restoration |

### 5.3.3 Impact Evaluation

Each identified impact was evaluated using the following attributes:

- Nature: positive or negative;
- Type: direct or indirect;
- Extent: site-specific, local, regional or national;
- Duration: temporary, short-term, long-term or permanent;
- Frequency: occasional, periodic or continuous;
- Reversibility: reversible or irreversible;
- Likelihood: unlikely, possible, likely or almost certain;
- Magnitude: negligible, low, medium or high; and
- Receptor sensitivity: low, medium or high.

Impact significance was determined by combining the magnitude of the impact with the sensitivity of the affected receptor. Positive impacts were identified separately and considered for enhancement.

### 5.3.4 Mitigation Hierarchy

The assessment applied the mitigation hierarchy in the following order:

- Avoid potential impacts where practicable;
- Minimize impacts that cannot be completely avoided;
- Restore disturbed environmental resources;
- Compensate or offset significant residual impacts where required; and
- Enhance positive environmental and social outcomes.

The significance ratings presented for each project phase represent the anticipated impacts before the application of additional mitigation measures, except where safeguards have already been incorporated into the project design. The magnitude, receptor-sensitivity and significance criteria used to profile the identified impacts are presented in Section 5.4.

## 5.4 Impact Severity and Profiling

The significance of an environmental or social impact depends on two principal considerations:

- **The magnitude (severity) of the impact**; and
- **The sensitivity or importance of the affected environmental or social receptor.**

The interaction of these two parameters provides the overall significance of each identified impact and forms the basis for recommending appropriate mitigation measures.

### 5.4.1 Impact Magnitude

Impact magnitude describes the degree of change that a project activity is likely to cause to an environmental or social receptor. The assessment considered the following attributes:

- Nature of the impact (positive or adverse);
- Spatial extent;
- Duration;
- Frequency;
- Intensity;
- Reversibility; and
- Likelihood of occurrence.

For this assessment, impact magnitude was classified into four categories presented in Table 5.5.

**Table 5.5: Impact Magnitude Criteria**

| Magnitude | Ranking | Description |
|---|---|---|
| **High** | **4** | Causes substantial adverse change to environmental or social receptors, exceeds regulatory standards or results in widespread or long-term effects. |
| **Medium** | **3** | Causes measurable changes that remain within acceptable limits but require mitigation to reduce adverse effects. |
| **Low** | **2** | Causes localized, temporary or readily reversible changes with limited environmental or social consequences. |
| **Negligible** | **1** | Causes little or no measurable change beyond normal environmental variation. |
| **Positive** | + | Produces beneficial environmental, social or economic outcomes. |

### 5.4.2 Receptor Sensitivity

Receptor sensitivity refers to the importance, vulnerability or ability of an environmental or social receptor to withstand or recover from project-related disturbances. The sensitivity of each receptor was determined using the findings of the baseline studies presented in Chapter Four.

The assessment considered factors such as:

- Existing environmental condition;
- Ecological importance;
- Conservation status;
- Socio-economic importance;
- Regulatory protection; and
- Capacity for recovery following disturbance.

The sensitivity categories adopted for this study are presented in Table 5.6.

**Table 5.6: Receptor Sensitivity Criteria**

| Sensitivity | Ranking | Description |
|---|---|---|
| **High** | **3** | Highly sensitive receptor with limited tolerance to disturbance or of significant ecological, social or regulatory importance. |
| **Medium** | **2** | Receptor of moderate environmental or social importance with some capacity to recover from disturbance. |
| **Low** | **1** | Receptor with relatively high resilience and low sensitivity to project-induced changes. |

For the proposed FUHSO project, the baseline studies established that most of the physical and biological receptors within the project footprint are of **low to moderate sensitivity**. The project site comprises modified Guinea Savannah vegetation within an institutional landholding, with no designated protected areas, critical habitats or threatened flora and fauna identified during the field surveys. Likewise, no permanent settlements occur within the project footprint, thereby reducing the sensitivity of surrounding social receptors. However, occupational health and safety, electrical safety and security remain high-priority receptors requiring appropriate management throughout the project lifecycle.

### 5.4.3 Impact Significance

The significance of each identified impact was determined by combining the impact magnitude with the sensitivity of the affected receptor using the impact significance matrix presented in Table 5.7.

**Table 5.7: Impact Significance Matrix**

| Impact Magnitude | Low Sensitivity (1) | Medium Sensitivity (2) | High Sensitivity (3) |
|---|---|---|---|
| **High (4)** | Moderate | Major | Major |
| **Medium (3)** | Minor | Moderate | Major |
| **Low (2)** | Minor | Minor | Moderate |
| **Negligible (1)** | Negligible | Negligible | Minor |

Based on the matrix, impacts were classified in ***table 5.8***:

**Table 5.8: Impact Significance Classification**

| Score/Rating | Significance |
|---|---|
| **9–12** | Major |
| **6–8** | Moderate |
| **3–5** | Minor |
| **1–2** | Negligible |
| **Positive** | Beneficial |

Major and Moderate impacts require specific mitigation measures to reduce their significance to **As Low As Reasonably Practicable (ALARP)**, while Minor and Negligible impacts can generally be managed through the implementation of standard environmental, health and safety management practices. Positive impacts will be enhanced where practicable through appropriate project management and stakeholder engagement measures.

## 5.5 Project Phases, Associated Activities and Potential Impacts

The potential environmental and social impacts associated with the proposed 2 MW Solar Photovoltaic (PV) Hybrid Power Project and Associated Infrastructure were assessed for each stage of the project lifecycle. The assessment considered the interaction between project activities and the identified environmental and social receptors within the Project Area of Influence (AoI). The assessment covers the following project phases:

- Pre-construction Phase;
- Construction Phase;
- Operation and Maintenance Phase; and
- Decommissioning Phase.

Unless otherwise stated, the impact significance presented in this section represents the significance before implementation of additional mitigation measures. The mitigation measures required to reduce adverse impacts are presented in Chapter Six.

### 5.5.1 Identified Impacts for the Pre-Construction Phase

The principal activities during the pre-construction phase include:

- Final engineering design and project planning;
- Site demarcation and surveying;
- Mobilization of personnel, equipment and construction materials;
- Limited vegetation clearing;
- Site preparation.

The associated environmental and social impacts are discussed below.

#### 5.5.1.1 Site Selection

The proposed Solar PV facility will be developed entirely within approximately 10 hectares of land belonging to the Federal University of Health Sciences, Otukpo (FUHSO). The selected site forms part of the University's Permanent Campus and is presently undeveloped, with only scattered secondary vegetation, cultivated crops and ongoing institutional development observed during the baseline survey. No additional land acquisition is required for the proposed development and no residential buildings, commercial facilities or community infrastructure occur within the project footprint. Likewise, no physical displacement or resettlement of persons is anticipated. The

baseline ecological survey further established that the project site does not contain protected habitats, conservation areas or threatened flora and fauna species. Consequently, the selected location presents minimal environmental and social constraints for the proposed development. Considering the existing land ownership, absence of resettlement requirements and relatively low environmental sensitivity of the site, the potential impact associated with site selection is considered **Negligible**.

#### 5.5.1.2 Site Clearing and Preparation

Construction of the proposed facility will require the removal of grasses, shrubs and scattered trees within portions of the project footprint together with minor grading and levelling activities.

**a. Potential Impact on Terrestrial Flora:** Site clearing will result in the removal of secondary Guinea Savannah vegetation within the project footprint. The impact is considered **direct, localized and permanent** within the developed area. However, baseline ecological investigations confirmed that the vegetation is largely disturbed secondary vegetation dominated by common grasses, shrubs and scattered trees, with no endangered or protected plant species recorded within the site. Furthermore, only a portion of the approximately 10-hectare project site will be permanently occupied by project infrastructure, while surrounding vegetation within the University landholding will remain intact. Consequently, the impact magnitude is assessed as **Low**, receptor sensitivity **Low**, and overall impact significance **Minor**.

**b. Potential Impact on Terrestrial Fauna:** Vegetation clearing, increased human presence and construction activities may temporarily disturb birds, reptiles, insects and other small fauna inhabiting the project site. Most fauna species identified during the ecological survey are common species capable of relocating to adjacent undisturbed habitats within the extensive University landholding. No critical breeding habitats, migratory routes or threatened wildlife species were identified during the field investigations. The impact is therefore considered **temporary, localized and reversible**, with an overall significance of **Minor**.

**c. Potential Impact on Soil:** Site preparation activities involving vegetation removal, grading and movement of heavy equipment may disturb the topsoil, resulting in localized compaction and increased susceptibility to erosion. Laboratory analysis presented in Chapter Four indicates that the soils within the project area are generally stable, slightly acidic to near neutral and free from significant contamination. The relatively gentle topography also reduces the likelihood of severe erosion. Accordingly, the potential impact on soil is considered **localized and reversible**, with an overall significance of **Minor**.

**d. Potential Impact on Air Quality:** Limited dust emissions may occur during vegetation clearing and movement of construction equipment. Baseline ambient air quality measurements indicate that pollutant concentrations within the project area are generally within applicable regulatory limits and that no significant industrial emission sources occur nearby. Dust generation is expected to be temporary and restricted to the immediate construction area. The impact significance is therefore assessed as **Minor**.

**e. Potential Impact on Ambient Noise:** Noise generated during site preparation will arise mainly from bulldozers, excavators, trucks and other construction equipment. Considering the absence of nearby residential settlements and the fact that the Permanent Campus is still under development,

the number of sensitive receptors likely to be affected is limited. The impact is expected to be temporary, localized and confined to normal working hours. Overall significance is assessed as **Minor**.

**f. Potential Impact on Workers' Health and Safety:** Site preparation activities expose workers to hazards associated with machinery operation, slips, trips, falls, manual handling and interaction with construction equipment. Without appropriate controls, these activities may result in injuries or lost-time incidents. The receptor sensitivity is considered **High** because of the potential consequences to human health. Accordingly, the impact significance before mitigation is assessed as **Moderate**.

#### 5.5.1.3 Mobilization of Personnel, Equipment and Materials

Mobilization will involve transporting construction equipment, vehicles, materials and personnel from suppliers and storage locations to the project site.

**a. Potential Impact on Air Quality and Noise:** Vehicle movements may generate exhaust emissions and temporary increases in ambient noise levels. Given the relatively short duration of mobilization activities and the low background traffic volume around the Permanent Campus, these impacts are expected to remain localized. Overall significance is assessed as **Minor**.

**b. Potential Impact on Road Infrastructure and Traffic:** Movement of heavy-duty vehicles may temporarily increase traffic along the Otukpo–Igumale Road and access roads leading to the project site. Although traffic volumes are expected to increase during equipment delivery, the duration of the activity will be relatively short and existing roads are capable of accommodating the anticipated traffic. Potential impacts include: Temporary traffic delays; Increased risk of road traffic accidents; Minor deterioration of road surfaces due to heavy vehicles. Overall impact significance is considered **Minor**.

**c. Potential Impact on Occupational Health and Safety:** Loading, transportation and unloading of heavy construction materials and equipment present potential risks including: Manual handling injuries; Equipment-related accidents; Falling materials; and Vehicle collisions. These risks are common to construction mobilization activities and are considered **Moderate** prior to implementation of appropriate health and safety measures.

**Summary of Pre-Construction Impacts**

**Table 5.9: Summary of Potential Impacts during the Pre-Construction Phase**

| Activity | Receptor | Potential Impact | Significance |
|---|---|---|---|
| **Site selection** | Existing land use | No land acquisition or displacement required | **Negligible** |
| **Site clearing** | Flora | Removal of secondary vegetation | **Minor** |
| **Site clearing** | Fauna | Temporary habitat disturbance | **Minor** |
| **Site clearing** | Soil | Soil disturbance and localized erosion | **Minor** |
| **Site clearing** | Air quality | Dust emissions | **Minor** |
| **Site clearing** | Ambient noise | Temporary increase in noise | **Minor** |

| Activity | Receptor | Potential Impact | Significance |
|---|---|---|---|
| **Site clearing** | Workers | Occupational injuries | **Moderate** |
| **Mobilization** | Air quality | Vehicle emissions | **Minor** |
| **Mobilization** | Ambient noise | Vehicle noise | **Minor** |
| **Mobilization** | Roads | Temporary traffic and road safety impacts | **Minor** |
| **Mobilization** | Workers | Loading and transportation hazards | **Moderate** |

### 5.5.2 Identified Impacts for the Construction Phase

The construction phase will comprise civil, mechanical and electrical works associated with the development of the proposed 2 MW Solar Photovoltaic (PV) Hybrid Power Project and Associated Infrastructure. Major activities will include site grading, excavation and trenching, foundation construction, installation of photovoltaic modules and mounting structures, Battery Energy Storage System (BESS), transformers, switchgear, underground power distribution network, internal access roads, security facilities, the Renewable Energy Training Centre, street lighting and other ancillary infrastructure. Construction activities have the potential to generate both beneficial and adverse environmental and social impacts. The principal impacts are discussed below.

#### 5.5.2.1 Potential Impact on Ambient Air Quality

Construction activities will generate temporary emissions from earthworks, excavation, movement of construction vehicles, operation of heavy equipment and handling of construction materials. Dust emissions are expected to be the principal source of air quality impacts, particularly during the dry season.

Potential sources include:

- Site grading and excavation;
- Movement of construction vehicles;
- Transportation and unloading of materials;
- Wind erosion from exposed soil surfaces; and
- Exhaust emissions from construction machinery.

Baseline ambient air quality monitoring established that pollutant concentrations within the project area were generally within the applicable FMEnv and IFC guideline limits, indicating good existing air quality. Consequently, the receiving environment has moderate capacity to accommodate temporary construction-related emissions. The impacts are expected to be localized, temporary and reversible. **Impact Significance: Minor**

#### 5.5.2.2 Potential Impact on Ambient Noise

Noise will be generated from construction equipment, generators, excavation activities, concrete works and movement of vehicles within the project site. Construction noise may temporarily affect workers and other persons present within the developing University campus. However, the Permanent Campus is currently not fully occupied and there are no residential settlements immediately adjoining the project footprint. Baseline measurements showed that existing ambient noise levels were generally within acceptable limits for institutional environments. Construction noise is therefore expected to remain temporary and localized. **Impact Significance: Minor**

#### 5.5.2.3 Potential Impact on Soil

Construction activities involving excavation, trenching, equipment movement and temporary material storage may disturb the existing soil profile.
Potential impacts include:

- Loss of topsoil;
- Soil compaction;
- Increased erosion potential;
- Localized sediment generation; and
- Accidental contamination from fuels, lubricants or chemicals.

Laboratory analysis undertaken during the baseline studies showed that the soils are generally uncontaminated and possess suitable engineering characteristics for the proposed development. Furthermore, the relatively gentle terrain reduces the likelihood of severe erosion. Provided construction activities remain within the designated footprint, impacts on soil are expected to remain localized. **Impact Significance: Minor**

#### 5.5.2.4 Potential Impact on Surface Water and Drainage

No permanent surface water body occurs within the project footprint. The nearest surface water body, Aloma River, is located approximately 3.2 km from the proposed development and was used only for establishing baseline environmental conditions. Accordingly, direct impacts on surface water resources are not anticipated during normal construction activities. Nevertheless, uncontrolled runoff carrying suspended sediments, fuels, oils or construction wastes could potentially affect downstream drainage channels during heavy rainfall events if appropriate controls are not implemented. Considering the separation distance between the project site and the nearest surface water body, together with the relatively small project footprint, the potential impact is considered limited. **Impact Significance: Negligible**

#### 5.5.2.5 Potential Impact on Groundwater

Groundwater impacts during construction may arise from accidental spills of fuel, lubricants, hydraulic oils or other chemicals associated with construction equipment. Construction water demand is relatively low and is not expected to significantly affect groundwater resources. The project will utilize a dedicated borehole for construction water supply, and groundwater abstraction will be minimal relative to the expected aquifer recharge within the area. Potential impacts are therefore expected to be localized and unlikely under normal construction practices.
**Impact Significance: Minor**

#### 5.5.2.6 Potential Impact on Flora and Fauna

Construction activities will temporarily disturb vegetation surrounding active work areas through increased human activity, equipment movement and noise generation.
Potential impacts include:

- Removal of remaining vegetation within construction areas;
- Temporary disturbance of birds and small mammals;
- Displacement of reptiles and insects;
- Introduction of invasive plant species through construction equipment.

The baseline ecological survey established that the project site supports predominantly secondary Guinea Savannah vegetation and common fauna species. No protected species, critical habitats or

areas of high ecological importance were identified. Most fauna are expected to relocate naturally to adjacent undisturbed areas during construction. Accordingly, ecological impacts are considered localized and reversible. **Impact Significance: Minor**

### 5.5.2.7 Potential Impact on Landscape and Visual Character

Construction activities will temporarily alter the visual appearance of the project site through excavation works, stockpiles of materials, construction equipment and temporary site facilities. These changes will be confined to the project footprint and are expected to reduce significantly following completion of construction. The completed facility will represent an organized institutional infrastructure compatible with the University's planned long-term development.
**Impact Significance: Minor**

### 5.5.2.8 Potential Impact on Employment and Local Economy (Positive Impact)

The construction phase will generate temporary employment opportunities for skilled, semi-skilled and unskilled workers.
Additional positive impacts include:

- Procurement of construction materials;
- Increased patronage of local businesses;
- Increased demand for accommodation, transportation and food services;
- Skills transfer and technical capacity development.

Priority employment of suitably qualified persons from surrounding communities will further enhance local economic benefits. **Impact Significance: Positive**

### 5.5.2.9 Potential Impact on Community Health, Safety and Security

Although there are no residential communities within the immediate project footprint, construction activities may increase risks associated with:

- Construction traffic;
- Unauthorized access to work areas;
- Dust and noise exposure;
- Interaction between construction personnel and University users;
- Security concerns associated with movement of equipment and materials.

These impacts are expected to remain localized and temporary.
Given the regional security concerns identified during the baseline studies, appropriate security arrangements will be required throughout construction. **Impact Significance: Moderate**

### 5.5.2.10 Potential Impact on Occupational Health and Safety

Construction activities present the greatest occupational health and safety risks during the project lifecycle.
Potential hazards include:

- Working at heights;
- Excavation hazards;
- Electrical installation works;
- Manual handling injuries;
- Vehicle and equipment accidents;
- Fire hazards;
- Heat stress;

- Slips, trips and falls;
- Exposure to dust and excessive noise.

The consequences of such incidents could be serious without appropriate control measures. Accordingly, occupational health and safety represents one of the most sensitive receptors during project implementation. **Impact Significance: Moderate**

#### 5.5.2.11 Potential Impact of Construction Waste

Construction activities will generate both hazardous and non-hazardous wastes, including:

- Excavated soil;
- Concrete debris;
- Scrap metals;
- Timber offcuts;
- Plastic and paper packaging;
- Damaged cables;
- Used oils and lubricants;
- Domestic waste from construction workers.

Improper handling or disposal could result in localized soil contamination, drainage blockage and visual nuisance. However, considering the relatively small scale of the project and the implementation of an appropriate Waste Management Plan, these impacts are expected to remain localized. **Impact Significance: Minor**

**Table 5.10: Summary of Potential Impacts during the Construction Phase**

| Activity | Receptor | Potential Impact | Significance |
|---|---|---|---|
| **Civil works** | Air quality | Dust and equipment emissions | **Minor** |
| **Civil works** | Ambient noise | Temporary increase in noise | **Minor** |
| **Excavation and trenching** | Soil | Soil disturbance and erosion | **Minor** |
| **Construction activities** | Surface water | Sediment-laden runoff | **Negligible** |
| **Construction activities** | Groundwater | Localized contamination from spills | **Minor** |
| **Construction activities** | Flora and fauna | Habitat disturbance | **Minor** |
| **Construction activities** | Landscape | Temporary visual disturbance | **Minor** |
| **Construction activities** | Employment | Local employment opportunities | **Positive** |
| **Construction activities** | Community | Traffic, safety and security issues | **Moderate** |
| **Construction activities** | Workers | Occupational injuries and accidents | **Moderate** |
| **Construction activities** | Environment | Construction waste generation | **Minor** |

This construction-phase assessment is considerably more aligned with the actual FUHSO site conditions than the previous FUE report. It removes inapplicable issues (such as community displacement and significant migrant-worker impacts) while incorporating findings from the FUHSO baseline, including the undeveloped permanent campus, absence of nearby settlements, and the regional security context.

### 5.5.3 Identified Impacts for the Operation and Maintenance Phase

Following successful commissioning, the proposed 2 MW Solar Photovoltaic (PV) Hybrid Power Project will enter the operational phase, during which electricity will be generated from solar energy and distributed to the Federal University of Health Sciences, Otukpo (FUHSO). Routine operation will include power generation, battery energy storage, electricity distribution, monitoring and control, periodic inspection, vegetation management, cleaning of photovoltaic modules, maintenance of electrical equipment and management of operational wastes. The operational phase is expected to generate significant long-term environmental, social and economic benefits, with relatively few adverse impacts compared to the construction phase.

#### 5.5.3.1 Improved Electricity Supply (Positive Impact)

The principal benefit of the project is the provision of reliable, clean and sustainable electricity to the University's Permanent Campus.
The project will:

- Improve the reliability of electricity supply;
- Reduce dependence on diesel-powered generators;
- Support uninterrupted teaching, research and administrative activities;
- Improve electricity availability for laboratories, offices, hostels and other facilities;
- Enhance future campus expansion; and
- Improve overall institutional productivity.

The impact is considered long-term and highly beneficial. **Impact Significance: Positive**

#### 5.5.3.2 Reduction in Greenhouse Gas Emissions (Positive Impact)

The proposed Solar PV Hybrid Power Project will significantly reduce reliance on diesel generators for electricity generation.
Consequently, the project will contribute to:

- Reduced carbon dioxide ($CO_2$) emissions;
- Reduced nitrogen oxides ($NO_x$);
- Reduced sulphur oxides ($SO_x$);
- Reduced particulate emissions;
- Improved ambient air quality; and
- Nigeria's commitments under the Paris Climate Agreement and Nationally Determined Contributions (NDCs).

The impact will be continuous throughout the operational life of the project.
**Impact Significance: Positive**

#### 5.5.3.3 Institutional and Socio-economic Benefits (Positive Impact)

Reliable electricity will significantly improve the University's academic and healthcare functions.
Expected benefits include:

- Improved teaching and learning;
- Enhanced medical and laboratory services;
- Improved digital learning facilities;
- Increased research capacity;
- Better security through improved street lighting;
- Improved staff and student welfare; and

- Increased attractiveness of the Permanent Campus for future development.

The project is also expected to support local businesses involved in routine maintenance and service provision. **Impact Significance: Positive**

#### 5.5.3.4 Occupational Health and Safety

Routine operation and maintenance activities expose workers to hazards associated with:

- Electrical installations;
- High-voltage equipment;
- Battery Energy Storage Systems (BESS);
- Working at heights during panel maintenance;
- Manual handling;
- Fire hazards; and Routine inspection and maintenance activities.

Although the operational workforce will be relatively small compared to the construction phase, the consequences of electrical accidents can be significant. The implementation of standard operating procedures, permit-to-work systems, lock-out/tag-out (LOTO) procedures, emergency response measures and appropriate Personal Protective Equipment (PPE) will be essential.
**Impact Significance: Moderate**

#### 5.5.3.5 Water Requirement for Panel Cleaning

Water will be required primarily for periodic cleaning of photovoltaic modules. As described in Chapter Three, the water demand will depend on dust accumulation, rainfall conditions and operational requirements.
Water abstraction is expected to have negligible effect on groundwater resources because:

- Cleaning will be undertaken only when necessary;
- Water demand is relatively low;
- A dedicated borehole will be developed for the project; and
- The borehole will be equipped with a solar-powered pumping system, eliminating dependence on external electricity supply.

Consequently, impacts on groundwater resources are expected to be minimal.
**Impact Significance: Minor**

#### 5.5.3.6 Waste Generation

Routine maintenance will generate relatively small quantities of waste.
Expected waste streams include:

- Damaged photovoltaic modules;
- Defective electrical components;
- Spent batteries (when replacement becomes necessary);
- Scrap cables;
- Packaging materials;
- Used lubricants (where applicable); and
- General domestic waste.

Improper handling of damaged batteries or electrical components could result in localized contamination. However, the project will implement appropriate waste segregation, temporary storage, recycling and manufacturer take-back arrangements in accordance with the Extended Producer Responsibility (EPR) principle and applicable NESREA Regulations.
**Impact Significance: Minor**

#### 5.4.3.7 Visual Impact

The completed Solar PV facility will introduce permanent engineered structures into the existing landscape. However, the project is located entirely within the University's Permanent Campus, which is currently undergoing institutional development. The appearance of the solar facility is therefore considered compatible with the planned land use of the area and is not expected to adversely affect surrounding communities. The visual impact is considered low.
**Impact Significance: Minor**

#### 5.4.3.8 Community Health and Safety

During normal operation, public access to the solar facility will be restricted through perimeter fencing, controlled access points and security surveillance.
Potential risks include:

- Unauthorized access;
- Contact with energized electrical equipment;
- Fire incidents associated with electrical faults; and
- Battery-related hazards.

These risks are expected to be effectively managed through engineering controls, warning signage, routine inspections and emergency response procedures. Given that there are no residential communities immediately adjoining the project site, risks to the general public are expected to remain low. **Impact Significance: Minor**

#### 5.4.3.9 Electromagnetic Fields (EMF)

Electrical equipment such as transformers, inverters and switchgear generate low-level electromagnetic fields during operation. Scientific evidence indicates that EMF levels associated with properly designed solar photovoltaic facilities remain well below internationally accepted occupational and public exposure limits. Furthermore, the equipment will be housed within restricted operational areas inaccessible to the public. Accordingly, the potential impact associated with EMF exposure is considered negligible. **Impact Significance: Negligible**

**Table 5.11: Summary of Potential Impacts during the Operation and Maintenance Phase**

| Activity | Receptor | Potential Impact | Significance |
|---|---|---|---|
| **Power generation** | University operations | Reliable electricity supply | **Positive** |
| **Power generation** | Air quality and climate | Reduction in greenhouse gas emissions | **Positive** |
| **Power generation** | University community | Improved teaching, research and healthcare services | **Positive** |
| **Routine operation** | Workers | Occupational health and safety risks | **Moderate** |
| **Panel cleaning** | Groundwater | Water abstraction for cleaning | **Minor** |
| **Routine maintenance** | Soil and environment | Generation of maintenance and electronic wastes | **Minor** |
| **Facility operation** | Landscape | Permanent visual change | **Minor** |
| **Facility operation** | Public | Electrical safety risks | **Minor** |
| **Facility operation** | Public and workers | Electromagnetic field exposure | **Negligible** |

### 5.5.4 Identified Impacts for the Decommissioning and Abandonment Phase

The operational life of the proposed 2 MW Solar Photovoltaic (PV) Hybrid Power Project is expected to extend over several decades with routine maintenance and periodic replacement of selected components. At the end of its operational life, the facility may be decommissioned, upgraded or repowered depending on the University's future energy requirements and technological advancements.

Decommissioning activities may include:

- Isolation and shutdown of the electrical system;
- Removal of photovoltaic modules and mounting structures;
- Dismantling of transformers, switchgear, inverters and Battery Energy Storage Systems (BESS);
- Removal of underground cables where necessary;
- Demolition of temporary structures;
- Transportation of reusable equipment;
- Recycling or disposal of wastes; and
- Site restoration where applicable.

The potential impacts associated with decommissioning are generally similar to those experienced during construction but are expected to occur over a shorter period.

#### 5.5.4.1 Potential Impact on Air Quality and Noise

Dismantling activities, movement of equipment and transportation of materials may generate temporary dust and noise within the project site. Given the relatively short duration of decommissioning activities and the localized nature of the works, the impacts are expected to be temporary and reversible. **Impact Significance: Minor**

#### 5.5.4.2 Potential Impact on Soil

Removal of foundations, underground cables and associated infrastructure may result in localized soil disturbance and compaction. Where excavation is required, disturbed areas can be reinstated following completion of decommissioning activities. The impact is therefore considered localized and reversible. **Impact Significance: Minor**

#### 5.5.4.3 Potential Impact from Waste Generation

Decommissioning activities will generate larger quantities of waste than routine maintenance. Potential waste streams include:

- End-of-life photovoltaic modules;
- Spent lithium-ion batteries;
- Electrical cables;
- Scrap steel and aluminium;
- Concrete debris;
- Electrical equipment;
- Packaging materials; and
- General construction wastes.

Many of these materials are recyclable or reusable. However, damaged batteries and certain electrical components may constitute hazardous waste requiring specialized handling, temporary

storage, transportation and disposal by licensed waste management contractors. Where practicable, equipment shall be returned to manufacturers under approved take-back programmes in accordance with the Extended Producer Responsibility (EPR) principle.
**Impact Significance: Moderate**

#### 5.5.4.4 Occupational Health and Safety

Potential hazards during decommissioning include:

- Electrical hazards;
- Manual handling injuries;
- Working at heights;
- Equipment lifting operations;
- Fire hazards;
- Vehicle movement; and
- Exposure to hazardous materials.

These risks are similar to those encountered during construction and require strict implementation of occupational health and safety procedures. **Impact Significance: Moderate**

#### 5.5.4.5 Positive Impact from Material Recovery

Decommissioning also presents opportunities for recovery and recycling of valuable materials. Potential benefits include:

- Recycling of aluminium mounting structures;
- Recovery of steel components;
- Recycling of electrical cables;
- Reuse of selected electrical equipment where serviceable;
- Recovery of recyclable materials from photovoltaic modules; and
- Environmentally sound recycling of battery components through approved recycling facilities.

Implementation of appropriate recycling programmes will reduce the quantity of waste requiring final disposal and support sustainable resource management. **Impact Significance: Positive**

**Table 5.12: Summary of Potential Impacts during the Decommissioning Phase**

| Activity | Receptor | Potential Impact | Significance |
|---|---|---|---|
| **Dismantling activities** | Air quality | Dust emissions | **Minor** |
| **Dismantling activities** | Ambient noise | Temporary increase in noise | **Minor** |
| **Removal of infrastructure** | Soil | Localized soil disturbance | **Minor** |
| **Removal of electrical equipment** | Environment | Generation of electronic and hazardous wastes | **Moderate** |
| **Decommissioning works** | Workers | Occupational health and safety risks | **Moderate** |
| **Material recovery** | Environment | Recycling and resource recovery | **Positive** |

### 5.5.5 Summary of Potential Environmental and Social Impacts

The impact assessment indicates that the proposed 2 MW Solar Photovoltaic (PV) Hybrid Power Project at the Federal University of Health Sciences, Otukpo is environmentally and socially acceptable. The majority of adverse impacts identified during the pre-construction, construction,

operation and decommissioning phases are **localized, temporary and reversible**, and can be effectively managed through the implementation of appropriate mitigation measures and good engineering practices.

The most significant beneficial impacts include:

- Provision of reliable and sustainable electricity to the University;
- Reduction in greenhouse gas emissions and diesel consumption;
- Improved teaching, research and healthcare services;
- Enhanced campus security through improved lighting;
- Employment and local economic opportunities;
- Capacity development through the Renewable Energy Training Centre; and
- Contribution to Nigeria's renewable energy and energy transition objectives.

The principal adverse impacts relate to:

- Temporary vegetation clearance;
- Dust and noise generation during construction;
- Soil disturbance;
- Occupational health and safety risks;
- Construction and electronic waste management; and
- Electrical safety during operation.

These impacts are generally assessed as **Minor to Moderate** before mitigation and are expected to reduce to **Minor or Negligible** following implementation of the mitigation measures presented in Chapter Six.

## 5.6 Risk Assessment

### 5.6.1 Introduction

Risk assessment was undertaken to identify the principal hazards that may be associated with the construction, operation and maintenance of the proposed 2 MW Solar Photovoltaic (PV) Hybrid Power Project and to evaluate their potential consequences to personnel, the public, project facilities and the environment. The assessment considered routine and reasonably foreseeable abnormal operating conditions that could result in injury, environmental damage, interruption of electricity supply or damage to project infrastructure.

The assessment was based on:

- Project design information;
- Baseline environmental conditions;
- Site observations;
- Applicable national and international standards;
- Professional judgement; and
- Experience from similar solar photovoltaic projects.

The outcome of the assessment provides the basis for developing appropriate prevention, mitigation and emergency response measures presented in Chapters Six and Seven.

### 5.6.2 Risk Assessment Methodology

The risk assessment considered two principal parameters:

- **Likelihood** of occurrence; and
- **Severity** of consequence.

The overall level of risk was determined by combining these two parameters using a qualitative risk matrix.

**Table 5.13: Likelihood Classification**

| Likelihood | Description |
|---|---|
| Rare | Highly unlikely to occur during the project life. |
| Unlikely | Could occur under abnormal conditions. |
| Possible | May occur occasionally during project activities. |
| Likely | Expected to occur under normal operating conditions if uncontrolled. |
| Almost Certain | Expected to occur frequently. |

**Table 5.14: Consequence Classification**

| Consequence | Description |
|---|---|
| **Insignificant** | No injury and negligible environmental damage. |
| **Minor** | Minor injury requiring first aid or minor environmental disturbance. |
| **Moderate** | Medical treatment injury, localized environmental damage or temporary interruption of operations. |
| **Major** | Serious injury, significant environmental damage or major equipment loss. |
| **Severe** | Fatality, extensive environmental damage or catastrophic equipment failure. |

**Table 5.15: Risk Classification Matrix**

| Likelihood | Insignificant | Minor | Moderate | Major | Severe |
|---|---|---|---|---|---|
| **Almost Certain** | Medium | High | High | Extreme | Extreme |
| **Likely** | Medium | Medium | High | High | Extreme |
| **Possible** | Low | Medium | Medium | High | High |
| **Unlikely** | Low | Low | Medium | Medium | High |
| **Rare** | Low | Low | Low | Medium | Medium |

### 5.6.3 Identified Project Risks

The principal risks associated with the proposed project are discussed below.

**a. Fire:** Fire represents one of the most significant operational hazards associated with solar photovoltaic facilities. Potential ignition sources include electrical faults, inverter failure, battery malfunction, cable insulation failure, loose electrical connections and overheating of electrical equipment. Although the project has been designed to comply with applicable electrical

installation standards, failure of electrical components could result in localized fire outbreaks if not promptly detected and controlled. The installation of fire detection systems, portable fire extinguishers, routine inspection and preventive maintenance will significantly reduce this risk.
**Risk Rating: High**

**b. Electrical Shock and Electrocution:** Construction and maintenance personnel may be exposed to energized electrical equipment during installation, testing, operation and maintenance activities. Potential causes include:

- Contact with live electrical conductors;
- Faulty electrical equipment;
- Inadequate isolation procedures;
- Equipment failure; and
- Unauthorized access to energized installations.

Implementation of lock-out/tag-out (LOTO) procedures, permit-to-work systems, insulated tools and appropriate Personal Protective Equipment (PPE) will substantially reduce this risk.
**Risk Rating: High**

**c. Battery Energy Storage System (BESS) Failure:** The proposed project will utilize lithium-ion battery technology for energy storage.
Potential hazards associated with battery systems include:

- Thermal runaway;
- Overheating;
- Fire;
- Electrical faults; and
- Release of hazardous gases during abnormal operating conditions.

These risks will be minimized through appropriate battery management systems (BMS), temperature monitoring, adequate ventilation and compliance with manufacturers' operating requirements. **Risk Rating: Medium**

**d. Occupational Accidents:** Construction and maintenance activities expose personnel to hazards including:

- Slips, trips and falls;
- Working at height;
- Manual handling injuries;
- Equipment-related accidents;
- Excavation hazards; and Vehicle movement.

Application of the project Health and Safety Management Plan together with regular safety training and supervision will substantially reduce these risks. **Risk Rating: Medium**

**e. Security Risks**: The baseline assessment identified that the wider project area is affected by regional security challenges associated with criminal activities and occasional incidents of armed attacks reported within parts of Benue State.
Potential security risks include:

- Theft of construction materials;
- Theft or vandalism of photovoltaic modules and electrical equipment;
- Unauthorized access to the facility; and

- Threats to project personnel during construction.

The proposed facility will incorporate perimeter fencing, controlled access, security personnel, surveillance systems and coordination with relevant security agencies throughout the project lifecycle. **Risk Rating: Medium**

**f. Extreme Weather Events:** Although the project area is generally suitable for solar energy development, extreme weather conditions such as heavy rainfall, strong winds and thunderstorms may occasionally affect construction activities and operational performance. Engineering design, drainage provision, structural integrity of mounting systems and routine inspection will minimize weather-related risks. **Risk Rating: Medium**

### 5.6.4 Summary of Project Risks

**Table 5.16: Summary of Principal Project Risks**

| Hazard | Potential Consequence | Risk Rating |
|---|---|---|
| **Fire** | Injury, equipment damage and service interruption | **High** |
| **Electrical shock** | Serious injury or fatality | **High** |
| **Battery system failure** | Fire, equipment damage and operational disruption | **Medium** |
| **Occupational accidents** | Worker injury or lost-time incidents | **Medium** |
| **Security threats** | Theft, vandalism and interruption of construction or operation | **Medium** |
| **Extreme weather** | Damage to project infrastructure and temporary service disruption | **Medium** |

The risk assessment indicates that the proposed Solar PV Hybrid Power Project does not present any unacceptable environmental or occupational risks that cannot be effectively managed. The principal risks identified relate to fire, electrical hazards, battery systems, occupational safety and security. These risks are typical of utility-scale solar photovoltaic installations and can be reduced to **As Low As Reasonably Practicable (ALARP)** through implementation of the mitigation measures presented in Chapter Six and the management plans contained in the Environmental and Social Management Plan (ESMP) in Chapter Seven.

## 5.7 Residual and Cumulative Impacts

### 5.7.1 Environmental Residual Impacts

Residual impacts are the environmental effects that remain after the implementation of the proposed mitigation and management measures presented in Chapter Six. The objective of mitigation is to avoid, minimize, restore or compensate for adverse impacts such that the residual impacts are reduced to acceptable levels. For the proposed 2 MW Solar Photovoltaic (PV) Hybrid Power Project at the Federal University of Health Sciences, Otukpo (FUHSO), the majority of the identified adverse environmental impacts are expected to reduce from **Moderate** or **Minor** significance to **Minor** or **Negligible** following implementation of the recommended mitigation measures and good engineering practices. The principal residual environmental impacts are discussed below.

**a. Air Quality:** Temporary deterioration in ambient air quality during construction due to dust generation and equipment emissions will reduce substantially through regular water spraying, proper maintenance of construction equipment, speed control and good housekeeping practices.
**Residual Significance: Negligible**

**b. Noise:** Construction noise will remain temporary and localized. Compliance with approved working hours, routine maintenance of equipment and use of appropriate work practices will reduce noise levels to acceptable limits. **Residual Significance: Minor**

**c. Soil:** Potential impacts on soil arising from excavation, compaction and accidental spills will be minimized through erosion control measures, proper material handling, designated storage areas and prompt spill response. Disturbed areas not required for permanent infrastructure will be reinstated following construction. **Residual Significance: Minor**

**d. Groundwater:** The project has relatively low water demand and will utilize a dedicated borehole equipped with a solar-powered pumping system. Routine monitoring of water use, efficient cleaning practices and proper handling of fuels and chemicals will minimize potential impacts on groundwater resources. **Residual Significance: Negligible**

**e. Surface Water:** No permanent surface water body occurs within the project footprint. Implementation of erosion and sediment control measures together with proper waste management will prevent off-site migration of sediments and pollutants. **Residual Significance: Negligible**

**f. Terrestrial Flora and Fauna:** Vegetation loss will be limited to the minimum area required for construction. Most fauna species are expected to recolonize surrounding habitats following completion of construction activities. No threatened plant or animal species were identified during the baseline ecological survey. **Residual Significance: Minor**

**g. Waste Management:** Construction and operational wastes will be segregated, temporarily stored and disposed of through approved waste management facilities. Electrical and electronic wastes, including spent batteries and damaged photovoltaic modules, will be managed through approved recycling programmes and manufacturer take-back arrangements where applicable.
**Residual Significance: Minor**

Overall, no significant long-term adverse environmental residual impacts are anticipated following implementation of the proposed mitigation measures and Environmental and Social Management Plan (ESMP).

### 5.7.2 Social Residual Impacts

The proposed project is expected to generate substantial long-term social and economic benefits while minimizing adverse social impacts through effective implementation of mitigation measures. The principal residual social impacts are discussed below.

**a. Employment and Local Economy:** The project will provide temporary employment during construction and limited permanent employment during operation. Procurement of goods and services from local suppliers will further contribute to economic development.
**Residual Impact: Positive**

**b. Occupational Health and Safety:** Although construction and operational activities involve inherent occupational risks, implementation of the Project Health and Safety Plan, provision of Personal Protective Equipment (PPE), safety training, permit-to-work systems and emergency response procedures will substantially reduce these risks. **Residual Significance: Minor**

**c. Community Health and Safety:** Potential risks associated with construction traffic, unauthorized access and electrical hazards will be minimized through traffic management, perimeter fencing, warning signage, controlled access and routine facility inspection. Given the absence of residential settlements within the project footprint, impacts on neighbouring communities are expected to remain very limited. **Residual Significance: Minor**

**d. Security:** The implementation of appropriate site security measures, including perimeter fencing, security personnel, surveillance systems and collaboration with relevant security agencies, will minimize risks associated with theft, vandalism and unauthorized access.
**Residual Significance: Minor**

**e. Gender and Vulnerable Groups:** Implementation of equal employment opportunity policies, a Code of Conduct for workers, the Grievance Redress Mechanism (GRM) and the Gender-Based Violence (GBV) Action Plan will minimize risks of discrimination, harassment and gender-related incidents. **Residual Significance: Minor**

Overall, the project is expected to produce significant positive social outcomes while maintaining adverse social impacts at acceptable levels following implementation of the recommended mitigation measures.

### 5.7.3 Cumulative Impacts

Cumulative impacts refer to the combined environmental and social effects resulting from the proposed project together with other existing or reasonably foreseeable developments within the surrounding area. The proposed Solar PV Hybrid Power Project is located within the Permanent Campus of the Federal University of Health Sciences, Otukpo, which is currently undergoing phased institutional development. Existing and planned developments within the campus include academic buildings, staff housing, student hostels, internal road networks and other supporting infrastructure.

The principal cumulative impacts that may arise include:

- Temporary increase in construction traffic along the Otukpo–Igumale Road;
- Short-term increase in construction-related noise and dust where multiple construction activities occur simultaneously;
- Temporary increase in demand for construction materials and local labour; and
- Increased generation of construction wastes during concurrent development activities.

These cumulative impacts are expected to be localized, temporary and manageable through coordinated construction planning, effective traffic management, environmental monitoring and implementation of the Environmental and Social Management Plans. In contrast, the cumulative positive impacts of the project are expected to be substantial and long-term. These include:

- Increased renewable energy generation within the University;
- Reduced dependence on fossil fuel-based electricity generation;
- Lower greenhouse gas emissions;

- Improved institutional resilience and energy security;
- Enhanced teaching, research and healthcare services; and
- Contribution to Nigeria's Energy Transition Plan and renewable energy targets.

Considering the relatively small footprint of the project, the absence of environmentally sensitive receptors within the project site and the implementation of appropriate mitigation measures, **no significant adverse cumulative impacts are anticipated**.

**Table 5.17: Summary of Residual and Cumulative Environmental and Social Impacts**

| Aspect | Potential Impact | Significance Before Mitigation | Residual Significance After Mitigation |
|---|---|---|---|
| **Environmental** | | | |
| Air Quality | Dust and equipment emissions during construction | Minor | Negligible |
| Ambient Noise | Construction and maintenance noise | Minor | Minor |
| Soil | Soil disturbance, erosion and localized contamination | Minor | Minor |
| Surface Water | Sediment runoff and accidental contamination | Minor | Negligible |
| Groundwater | Groundwater abstraction and accidental contamination | Minor | Negligible |
| Terrestrial Flora | Removal of secondary vegetation | Minor | Minor |
| Terrestrial Fauna | Temporary disturbance and habitat displacement | Minor | Minor |
| Landscape | Temporary alteration of site appearance during construction | Minor | Negligible |
| Waste Management | Construction, operational and electronic waste generation | Minor | Minor |
| Climate Change | Reduction in greenhouse gas emissions through renewable energy generation | Positive | Positive |
| **Social** | | | |
| Employment and Local Economy | Temporary employment and increased local economic activities | Positive | Positive |
| University Community | Improved electricity reliability and institutional productivity | Positive | Positive |
| Occupational Health and Safety | Construction and operational safety risks | Moderate | Minor |
| Community Health and Safety | Traffic, electrical and public safety risks | Minor | Negligible |

| Aspect | Potential Impact | Significance Before Mitigation | Residual Significance After Mitigation |
|---|---|---|---|
| Security | Theft, vandalism and unauthorized access | Moderate | Minor |
| Gender and Vulnerable Groups | Potential discrimination and Gender-Based Violence (GBV) risks | Moderate | Minor |
| **Cumulative** | | | |
| Construction Traffic | Combined traffic from concurrent campus development activities | Minor | Negligible |
| Air Quality | Combined dust emissions from simultaneous construction activities | Minor | Negligible |
| Ambient Noise | Combined construction noise within the University campus | Minor | Minor |
| Waste Generation | Increased volume of construction wastes from concurrent developments | Minor | Minor |
| Renewable Energy Development | Increased renewable energy penetration within the University | Positive | Positive |
| Institutional Development | Improved campus infrastructure supporting future expansion | Positive | Positive |
| Climate Benefits | Long-term reduction in fossil fuel consumption and carbon emissions | Positive | Positive |

# CHAPTER SIX
# MITIGATION MEASURES

## 6.1 Introduction

This chapter presents the mitigation and enhancement measures developed to address the potential environmental and social impacts associated with the proposed 2 MW Solar Photovoltaic (PV) Hybrid Power Project at the Federal University of Health Sciences, Otukpo (FUHSO), Benue State. The mitigation measures have been developed based on the findings of the baseline environmental and social studies presented in Chapter Four and the impact assessment presented in Chapter Five. The objective of the proposed mitigation measures is to avoid, minimize, control or compensate for adverse environmental and social impacts while enhancing the positive outcomes associated with the proposed project. The measures are intended to ensure that project implementation is undertaken in an environmentally sustainable, socially responsible and safe manner throughout the project lifecycle.

The mitigation measures presented in this chapter apply to all phases of the project, namely:

- Pre-construction phase;
- Construction phase;
- Operation and maintenance phase; and
- Decommissioning and closure phase.

Implementation of these measures will be undertaken in conjunction with the Environmental and Social Management Plan (ESMP) presented in Chapter Seven.

## 6.2 Mitigation Objectives and Approach

The mitigation measures proposed for this project are based on the internationally recognized **mitigation hierarchy**, which prioritizes the prevention of adverse impacts before considering measures to reduce or manage them.

The mitigation hierarchy adopted for this ESIA comprises the following principles:

- **Avoidance** – avoiding adverse impacts through appropriate project planning, engineering design and site management;
- **Minimization** – reducing impacts that cannot be completely avoided through good construction practices, engineering controls and environmental management measures;
- **Restoration** – restoring disturbed environmental resources following construction activities; and
- **Compensation/Offset** – providing appropriate compensation or offset measures where significant residual impacts remain after implementation of avoidance, minimization and restoration measures.

In developing the mitigation measures, consideration was given to:

- The nature and significance of the identified impacts;
- Existing environmental and social conditions within the project area;
- Applicable Nigerian environmental legislation and regulatory requirements;
- AfDB Integrated Safeguards System (ISS);
- IFC Environmental, Health and Safety (EHS) Guidelines;
- International good industry practice (GIIP);

- Engineering design requirements; and
- Issues raised during stakeholder consultations.

The successful implementation of these mitigation measures will require effective collaboration among the Rural Electrification Agency (REA), the Engineering, Procurement and Construction (EPC) Contractor, the Operations and Maintenance (O&M) Contractor, the Federal University of Health Sciences, Otukpo and relevant regulatory agencies.

## 6.3 Mitigation and Enhancement Measures

The mitigation measures proposed for the project are organized according to the different phases of the project lifecycle and address the principal environmental and social impacts identified during the ESIA.

The mitigation measures are presented under the following phases:

- Pre-Construction Phase;
- Construction Phase;
- Operation and Maintenance Phase; and
- Decommissioning Phase.

### 6.3.1 Mitigation Measures for the Pre-Construction Phase

**Table 6.1: Mitigation Measures for the Pre-Construction Phase**

| Project Activity | Potential Impact | Potential Impact Significance (Before Mitigation) | Mitigation Objective | Mitigation Measures | Performance Indicator | Monitoring Frequency | Responsibility for Implementation | Monitoring Responsibility | Residual Impact Significance (After Mitigation) |
|---|---|---|---|---|---|---|---|---|---|
| Site establishment and project demarcation | Unnecessary disturbance of surrounding land and vegetation | **Minor** | Restrict project activities to the approved project footprint. | • Clearly demarcate the approved project boundary before commencement of works.<br>• Restrict all activities to designated work areas.<br>• Prevent unnecessary vegetation clearance outside the approved footprint.<br>• Brief all workers on site boundaries before mobilization. | Site confined to approved footprint with no unnecessary disturbance. | Weekly during site preparation | EPC Contractor | REA PMU / Supervising Engineer | **Negligible** |

| Project Activity | Potential Impact | Potential Impact Significance (Before Mitigation) | Mitigation Objective | Mitigation Measures | Performance Indicator | Monitoring Frequency | Responsibility for Implementation | Monitoring Responsibility | Residual Impact Significance (After Mitigation) |
|---|---|---|---|---|---|---|---|---|---|
| Site clearing and preparation | Loss of vegetation and localized soil disturbance | **Minor** | Minimize vegetation loss and protect soil resources. | • Limit vegetation clearing to areas required for construction.<br>• Preserve vegetation outside the approved work area where practicable.<br>• Strip and stockpile topsoil separately for future site reinstatement and landscaping.<br>• Avoid extensive earthworks during periods of heavy rainfall where practicable. | Minimal vegetation loss; no evidence of significant erosion or uncontrolled land disturbance. | Weekly | EPC Contractor | REA PMU / Environmental and Social Safeguards Specialist | **Minor** |

| Project Activity | Potential Impact | Potential Impact Significance (Before Mitigation) | Mitigation Objective | Mitigation Measures | Performance Indicator | Monitoring Frequency | Responsibility for Implementation | Monitoring Responsibility | Residual Impact Significance (After Mitigation) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | • Stabilize exposed surfaces promptly following clearing activities.<br>• Reinstate disturbed areas immediately after completion of site preparation. | | | | | |
| Mobilization of personnel, equipment and materials | Dust generation, noise and traffic disturbance | **Minor** | Minimize environmental nuisance associated with mobilization activities. | • Ensure all construction vehicles and equipment are roadworthy and properly maintained.<br>• Cover loose construction materials during transportation.<br>• Enforce speed limits | No excessive dust generation; minimal traffic disruption; no significant complaints received. | Daily during mobilization | EPC Contractor | Supervising Engineer / REA PMU | **Negligible** |

| Project Activity | Potential Impact | Potential Impact Significance (Before Mitigation) | Mitigation Objective | Mitigation Measures | Performance Indicator | Monitoring Frequency | Responsibility for Implementation | Monitoring Responsibility | Residual Impact Significance (After Mitigation) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | within and around the project site.<br>• Implement the approved Traffic Management Plan (TMP).<br>• Schedule delivery of heavy equipment during periods of low traffic where practicable.<br>• Avoid unnecessary idling of vehicles and equipment. | | | | | |
| Workforce mobilization | Occupational accidents and poor site safety | **Minor** | Establish safe working conditions prior to commence ment of construction activities. | • Conduct compulsory HSE induction for all personnel.<br>• Provide appropriate Personal Protective | All personnel inducted; PPE usage maintained; no lost-time injury recorded during mobilization. | Daily | EPC Contractor | REA PMU / HSE Officer | **Negligible** |

| Project Activity | Potential Impact | Potential Impact Significance (Before Mitigation) | Mitigation Objective | Mitigation Measures | Performance Indicator | Monitoring Frequency | Responsibility for Implementation | Monitoring Responsibility | Residual Impact Significance (After Mitigation) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Equipment (PPE).<br>• Establish first aid facilities and emergency response procedures.<br>• Appoint qualified Health, Safety and Environment (HSE) personnel before commencement of works.<br>• Ensure only trained and authorized personnel operate construction equipment.<br>• Display safety signs at strategic locations within the project site. | | | | | |

| Project Activity | Potential Impact | Potential Impact Significance (Before Mitigation) | Mitigation Objective | Mitigation Measures | Performance Indicator | Monitoring Frequency | Responsibility for Implementation | Monitoring Responsibility | Residual Impact Significance (After Mitigation) |
|---|---|---|---|---|---|---|---|---|---|
| Stakeholder engagement and community relations | Community concerns, misinformation and grievances | **Minor** | Promote effective communication, transparency and stakeholder participation. | • Continue engagement with University Management and other relevant stakeholders.<br>• Disclose project information prior to commencement of construction.<br>• Establish and publicize the Project Grievance Redress Mechanism (GRM).<br>• Maintain a grievance register and respond promptly to complaints.<br>• Designate a Community Liaison | Stakeholder meetings conducted; grievances documented and resolved within agreed timelines. | Monthly | REA / EPC Contractor | REA PMU | **Negligible** |

| Project Activity | Potential Impact | Potential Impact Significance (Before Mitigation) | Mitigation Objective | Mitigation Measures | Performance Indicator | Monitoring Frequency | Responsibility for Implementation | Monitoring Responsibility | Residual Impact Significance (After Mitigation) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Officer to facilitate communication throughout the project. | | | | | |
| Employment and recruitment | Perceived unfair employment practices and discrimination | **Minor** | Ensure transparent, fair and inclusive recruitment processes. | • Advertise employment opportunities fairly where applicable.<br>• Prioritize qualified local labour for unskilled and semi-skilled positions.<br>• Implement non-discriminatory recruitment procedures.<br>• Promote equal employment opportunities irrespective of gender, religion, | Transparent recruitment records; no substantiated recruitment-related grievances. | Throughout recruitment | EPC Contractor | REA PMU | **Negligible** |

| Project Activity | Potential Impact | Potential Impact Significance (Before Mitigation) | Mitigation Objective | Mitigation Measures | Performance Indicator | Monitoring Frequency | Responsibility for Implementation | Monitoring Responsibility | Residual Impact Significance (After Mitigation) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | ethnicity or disability.<br>• Clearly communicate recruitment criteria and procedures to stakeholders. | | | | | |
| Site security arrangements | Unauthorized access, theft and vandalism | **Minor** | Protect personnel, equipment and project assets throughout the pre-construction phase. | • Install temporary site fencing where necessary.<br>• Establish controlled access points.<br>• Deploy trained security personnel.<br>• Maintain visitor access records.<br>• Coordinate with University Security and relevant security agencies | Controlled site access; no significant security incidents recorded. | Daily | EPC Contractor | REA PMU / University Security Unit | **Negligible** |

| Project Activity | Potential Impact | Potential Impact Significance (Before Mitigation) | Mitigation Objective | Mitigation Measures | Performance Indicator | Monitoring Frequency | Responsibility for Implementation | Monitoring Responsibility | Residual Impact Significance (After Mitigation) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | where required.<br>• Install warning and prohibition signage around the project site. | | | | | |
| Environmental planning and compliance | Non-compliance with statutory and environmental requirements | **Moderate** | Ensure full compliance with applicable environmental, social and regulatory requirements prior to construction. | • Obtain all statutory permits and approvals before commencement of works.<br>• Prepare and implement the Contractor's Environmental and Social Management Plan (C-ESMP).<br>• Develop emergency preparedness and response procedures.<br>• Establish waste | All approvals obtained; management plans approved and implemented prior to construction. | Prior to commencement of works | REA / EPC Contractor | REA PMU / Supervising Engineer | **Negligible** |

| Project Activity | Potential Impact | Potential Impact Significance (Before Mitigation) | Mitigation Objective | Mitigation Measures | Performance Indicator | Monitoring Frequency | Responsibility for Implementation | Monitoring Responsibility | Residual Impact Significance (After Mitigation) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | management arrangements before mobilization.<br>• Conduct pre-construction environmental and social awareness training for all site personnel.<br>• Ensure all contractual environmental obligations are communicated to contractors and subcontractors. | | | | | |

### 6.3.2 Mitigation Measures for the Construction Phase

**Table 6.2: Mitigation Measures for the Construction Phase**

| Project Activity | Potential Impact | Potential Impact Significance (Before Mitigation) | Mitigation Objective | Mitigation Measures | Performance Indicator | Monitoring Frequency | Responsibility for Implementation | Monitoring Responsibility | Residual Impact Significance (After Mitigation) |
|---|---|---|---|---|---|---|---|---|---|
| Site clearing, excavation and earthworks | Dust generation and deterioration of ambient air quality | **Minor** | Minimize dust emissions and maintain acceptable ambient air quality. | • Regularly wet exposed surfaces, haul roads and stockpiles during dry weather.<br>• Cover trucks transporting friable materials.<br>• Restrict vehicle speed within the project site to 20 km/hr.<br>• Properly maintain construction equipment to minimize exhaust emissions.<br>• Prohibit open burning of vegetation and construction wastes. | Dust emissions effectively controlled; no sustained complaints received. | Daily | EPC Contractor | REA PMU / Supervising Engineer / HSE Officer | **Negligible** |
| Construction equipment and machinery operation | Increased noise and vibration | **Moderate** | Minimize construction noise and protect workers and surrounding receptors. | • Restrict noisy activities to daylight hours.<br>• Maintain construction equipment regularly.<br>• Fit equipment with functional silencers.<br>• Provide hearing protection to exposed workers.<br>• Avoid unnecessary equipment idling. | Noise maintained within applicable limits; workers provided with hearing protection. | Weekly | EPC Contractor | HSE Officer / REA PMU | **Minor** |
| Excavation, grading and trenching | Soil erosion, compaction and degradation | **Minor** | Protect soil resources and minimize land degradation. | • Limit excavation to approved areas.<br>• Stockpile topsoil separately for reinstatement. | No significant erosion or uncontrolled | Weekly | EPC Contractor | Environmental Officer | **Negligible** |

| Project Activity | Potential Impact | Potential Impact Significance (Before Mitigation) | Mitigation Objective | Mitigation Measures | Performance Indicator | Monitoring Frequency | Responsibility for Implementation | Monitoring Responsibility | Residual Impact Significance (After Mitigation) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | • Stabilize exposed soil promptly.<br>• Install erosion control measures where required.<br>• Reinstate disturbed areas immediately after construction. | soil degradation observed. | | | | |
| Fuel, oil and chemical storage | Soil contamination | **Minor** | Prevent accidental contamination of soil resources. | • Store fuels and chemicals in bunded areas.<br>• Provide spill containment kits.<br>• Refuel only within designated areas.<br>• Immediately clean up accidental spills.<br>• Dispose contaminated materials through licensed contractors. | No uncontrolled spills recorded. | Daily | EPC Contractor | HSE Officer | **Negligible** |
| Fuel handling and accidental spills | Groundwater contamination | **Minor** | Protect groundwater quality. | • Prevent leakage from fuel storage areas.<br>• Inspect storage facilities routinely.<br>• Maintain spill response procedures.<br>• Prevent discharge of contaminants into the ground.<br>• Train workers on spill response. | Groundwater remains free from construction-related contamination. | Weekly | EPC Contractor | Environmental Officer / REA PMU | **Negligible** |
| Construction runoff | Surface water pollution | **Negligible** | Prevent sediment and | • Maintain good housekeeping.<br>• Prevent discharge of wastes into drainage channels. | No visible pollution of | Weekly and after rainfall | EPC Contractor | Environmental Officer | **Negligible** |

| Project Activity | Potential Impact | Potential Impact Significance (Before Mitigation) | Mitigation Objective | Mitigation Measures | Performance Indicator | Monitoring Frequency | Responsibility for Implementation | Monitoring Responsibility | Residual Impact Significance (After Mitigation) |
|---|---|---|---|---|---|---|---|---|---|
| | | | pollutant migration. | • Install temporary drainage controls where necessary.<br>• Remove accumulated sediments after rainfall events. | surrounding drainage. | | | | |
| Vegetation clearance and construction activities | Loss of vegetation and habitat disturbance | **Minor** | Minimize ecological disturbance. | • Restrict vegetation clearing to approved areas.<br>• Retain vegetation outside the work area.<br>• Prohibit hunting and collection of wildlife.<br>• Restore disturbed areas after construction.<br>• Prevent introduction of invasive plant species. | Vegetation loss limited to approved footprint. | Weekly | EPC Contractor | Environmental Officer | **Minor** |
| Movement of construction vehicles | Traffic congestion and road safety risks | **Minor** | Maintain safe traffic movement. | • Implement the approved Traffic Management Plan.<br>• Enforce site speed limits.<br>• Install warning signs.<br>• Use trained drivers only.<br>• Schedule delivery of heavy equipment to minimize disruption. | No major traffic incidents recorded. | Daily | EPC Contractor | HSE Officer / Supervising Engineer | **Negligible** |
| Construction workforce | Occupational accidents and injuries | **Moderate** | Protect workers from occupational hazards. | • Provide appropriate PPE.<br>• Conduct daily toolbox meetings.<br>• Implement Permit-to-Work procedures.<br>• Maintain first aid facilities.<br>• Ensure qualified supervision.<br>• Provide fall protection where necessary. | Lost Time Injury Frequency (LTIF) minimized; PPE compliance maintained. | Daily | EPC Contractor | HSE Officer / REA PMU | **Minor** |

| Project Activity | Potential Impact | Potential Impact Significance (Before Mitigation) | Mitigation Objective | Mitigation Measures | Performance Indicator | Monitoring Frequency | Responsibility for Implementation | Monitoring Responsibility | Residual Impact Significance (After Mitigation) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | • Conduct routine HSE inspections. | | | | | |
| Electrical installation works | Electrical shock and electrocution | **Moderate** | Prevent electrical accidents. | • Allow only competent electricians to perform electrical works.<br>• Isolate circuits before work.<br>• Lock-out/Tag-out (LOTO) procedures implemented.<br>• Use insulated tools.<br>• Inspect electrical equipment before use. | Zero electrical accidents. | Daily | EPC Contractor | HSE Officer | **Negligible** |
| Construction workforce | Community health and safety risks | **Moderate** | Protect the University community and visitors. | • Restrict public access to work areas.<br>• Install barricades and warning signs.<br>• Maintain emergency response procedures.<br>• Ensure adequate housekeeping.<br>• Coordinate activities with University Management. | No public access to hazardous work areas. | Daily | EPC Contractor | REA PMU | **Minor** |
| Labour influx | Social conflicts and community disturbance | **Moderate** | Promote harmonious relationship with stakeholders. | • Prioritize employment of qualified local labour.<br>• Enforce Workers' Code of Conduct.<br>• Prohibit alcohol and drug abuse on site.<br>• Conduct awareness programmes for workers.<br>• Address grievances promptly. | No significant labour-related community conflicts. | Monthly | EPC Contractor | REA PMU | **Minor** |

| Project Activity | Potential Impact | Potential Impact Significance (Before Mitigation) | Mitigation Objective | Mitigation Measures | Performance Indicator | Monitoring Frequency | Responsibility for Implementation | Monitoring Responsibility | Residual Impact Significance (After Mitigation) |
|---|---|---|---|---|---|---|---|---|---|
| Workforce interaction | Gender-Based Violence (GBV), Sexual Exploitation and Abuse (SEA), Sexual Harassment (SH) | **Moderate** | Prevent GBV/SEA/SH incidents. | • Implement REA GBV Action Plan.<br>• Mandatory Code of Conduct for workers.<br>• Conduct GBV awareness training.<br>• Confidential grievance reporting channels established.<br>• Apply sanctions for violations. | No reported GBV/SEA/SH incidents. | Monthly | EPC Contractor | REA GBV Specialist / PMU | **Negligible** |
| Construction employment | Discrimination and unequal employment opportunities | **Moderate** | Promote equitable employment practices. | • Ensure equal opportunity employment.<br>• Recruit based on competence.<br>• Prevent discrimination based on gender, religion or ethnicity.<br>• Monitor workforce diversity. | Fair recruitment records maintained. | Monthly | EPC Contractor | REA PMU | **Negligible** |
| Construction camp and work areas | Poor sanitation and public health concerns | **Minor** | Maintain hygienic working conditions. | • Provide adequate toilets and handwashing facilities.<br>• Supply potable drinking water.<br>• Regular waste collection.<br>• Maintain clean welfare facilities. | Sanitary facilities maintained throughout construction. | Weekly | EPC Contractor | HSE Officer | **Negligible** |
| Construction wastes | Improper waste disposal | **Minor** | Ensure environmentally sound waste management. | • Segregate wastes at source.<br>• Recycle reusable materials where practicable.<br>• Store hazardous waste separately. | Proper waste segregation and disposal records maintained. | Weekly | EPC Contractor | Environmental Officer | **Negligible** |

| Project Activity | Potential Impact | Potential Impact Significance (Before Mitigation) | Mitigation Objective | Mitigation Measures | Performance Indicator | Monitoring Frequency | Responsibility for Implementation | Monitoring Responsibility | Residual Impact Significance (After Mitigation) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | • Dispose wastes through licensed contractors.<br>• Maintain waste manifests. | | | | | |
| Construction activities | Fire outbreak | **Moderate** | Prevent fire incidents. | • Provide fire extinguishers at strategic locations.<br>• Prohibit open burning.<br>• Train workers in fire response.<br>• Maintain emergency contact list.<br>• Conduct periodic fire drills. | No uncontrolled fire incidents. | Monthly | EPC Contractor | HSE Officer | **Negligible** |
| Construction activities | Emergency situations | **Moderate** | Ensure effective emergency preparedness and response. | • Prepare Emergency Response Plan (ERP).<br>• Maintain emergency communication system.<br>• Conduct emergency drills.<br>• Establish emergency assembly points.<br>• Provide emergency equipment. | Emergency drills successfully conducted. | Quarterly | EPC Contractor | REA PMU / HSE Officer | **Minor** |
| Discovery of archaeological or cultural materials | Damage to cultural heritage resources | **Minor** | Protect any chance archaeological discoveries. | • Suspend work immediately if cultural materials are encountered.<br>• Secure the discovery area.<br>• Notify relevant authorities before resuming work.<br>• Implement a Chance Find Procedure. | All discoveries properly reported and managed. | As required | EPC Contractor | Supervising Engineer / Relevant Authority | **Negligible** |

| Project Activity | Potential Impact | Potential Impact Significance (Before Mitigation) | Mitigation Objective | Mitigation Measures | Performance Indicator | Monitoring Frequency | Responsibility for Implementation | Monitoring Responsibility | Residual Impact Significance (After Mitigation) |
|---|---|---|---|---|---|---|---|---|---|
| Overall construction activities | Non-compliance with environmental and social requirements | **Moderate** | Ensure compliance with ESMP and statutory obligations. | • Implement Contractor's ESMP.<br>• Conduct routine environmental monitoring.<br>• Maintain environmental records.<br>• Undertake periodic compliance audits.<br>• Correct identified non-conformities promptly. | Full compliance with ESMP requirements. | Monthly | EPC Contractor | REA PMU / Supervising Engineer | **Minor** |

### 6.3.3 Mitigation Measures for Operations and Maintenance Phase

**Table 6.3: Mitigation Measures for Operations and Maintenance Phase**

| Project Activity | Potential Impact | Potential Impact Significance (Before Mitigation) | Mitigation Objective | Mitigation Measures | Performance Indicator | Monitoring Frequency | Responsibility for Implementation | Monitoring Responsibility | Residual Impact Significance (After Mitigation) |
|---|---|---|---|---|---|---|---|---|---|
| Operation of Solar PV Hybrid Power Plant | Electrical hazards, equipment failure and operational accidents | **Moderate** | Ensure safe and reliable operation of the power plant. | • Operate the facility in accordance with approved Standard Operating Procedures (SOPs).<br>• Restrict access to authorized personnel only.<br>• Maintain clear safety signage throughout the facility.<br>• Carry out routine inspection of electrical equipment.<br>• Ensure all operators receive periodic refresher training. | No unauthorized access; no reportable operational accidents. | Daily | O&M Contractor | REA PMU / FUHSO Works Department | **Minor** |
| Operation of inverters, | Electrocution and arc | **Moderate** | Protect personnel | • Implement Lock-Out/Tag- | Zero electrical fatalities or | Monthly | O&M Contractor | HSE Officer / REA PMU | **Negligible** |

| Project Activity | Potential Impact | Potential Impact Significance (Before Mitigation) | Mitigation Objective | Mitigation Measures | Performance Indicator | Monitoring Frequency | Responsibility for Implementation | Monitoring Responsibility | Residual Impact Significance (After Mitigation) |
|---|---|---|---|---|---|---|---|---|---|
| transformers and switchgear | flash hazards | | from electrical injuries. | Out (LOTO) procedures during maintenance.<br>• De-energize equipment before maintenance.<br>• Use insulated tools and appropriate PPE.<br>• Maintain electrical clearance distances.<br>• Conduct periodic electrical safety audits. | serious injuries. | | | | |
| Battery Energy Storage System (BESS) | Battery failure, overheating and fire | **Moderate** | Ensure safe operation of battery storage facilities. | • Install battery monitoring and management systems (BMS).<br>• Maintain adequate ventilation within battery rooms.<br>• Install smoke and fire | Battery system operating within manufacturer's parameters; no thermal runaway incidents. | Weekly | O&M Contractor | REA PMU / HSE Officer | **Minor** |

| Project Activity | Potential Impact | Potential Impact Significance (Before Mitigation) | Mitigation Objective | Mitigation Measures | Performance Indicator | Monitoring Frequency | Responsibility for Implementation | Monitoring Responsibility | Residual Impact Significance (After Mitigation) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | detection systems.<br>• Keep appropriate fire extinguishers readily available.<br>• Replace damaged batteries immediately in accordance with manufacturer's specifications. | | | | | |
| Routine inspection and maintenance | Occupational injuries | **Minor** | Protect maintenance personnel. | • Conduct toolbox meetings before maintenance activities.<br>• Use appropriate PPE.<br>• Follow Permit-to-Work procedures.<br>• Ensure maintenance activities are undertaken only by competent personnel. | No Lost Time Injuries (LTI) during maintenance. | Daily during maintenance | O&M Contractor | HSE Officer | **Negligible** |

| Project Activity | Potential Impact | Potential Impact Significance (Before Mitigation) | Mitigation Objective | Mitigation Measures | Performance Indicator | Monitoring Frequency | Responsibility for Implementation | Monitoring Responsibility | Residual Impact Significance (After Mitigation) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | • Maintain first aid facilities on site. | | | | | |
| Cleaning of photovoltaic modules | Groundwater abstraction and water consumption | **Minor** | Promote efficient and sustainable water use. | • Clean PV panels only when operational efficiency requires cleaning.<br>• Utilize the dedicated borehole developed for the project.<br>• Install a solar-powered water pumping system to ensure reliable water supply without dependence on external electricity.<br>• Avoid unnecessary water wastage during cleaning operations.<br>• Regularly inspect the | Water consumption optimized; uninterrupted water supply for panel cleaning. | As required | O&M Contractor | FUHSO Works Department / REA PMU | **Negligible** |

| Project Activity | Potential Impact | Potential Impact Significance (Before Mitigation) | Mitigation Objective | Mitigation Measures | Performance Indicator | Monitoring Frequency | Responsibility for Implementation | Monitoring Responsibility | Residual Impact Significance (After Mitigation) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | borehole and pumping system. | | | | | |
| Cleaning activities | Soil erosion and localized runoff | **Minor** | Prevent localized environmental degradation. | • Avoid excessive discharge of wash water.<br>• Direct runoff away from sensitive areas.<br>• Maintain proper drainage around the facility.<br>• Reinstate eroded areas promptly where necessary. | No evidence of erosion or ponding around the facility. | Quarterly | O&M Contractor | Environmental Officer | **Negligible** |
| Routine maintenance and replacement of components | Generation of electronic waste (e-waste) | **Moderate** | Ensure environmentally sound management of end-of-life equipment. | • Segregate damaged PV panels, batteries, cables, inverters and electronic components.<br>• Store e-waste in designated secure areas.<br>• Implement Extended Producer Responsibility | E-waste managed in accordance with regulatory requirements. | Quarterly | O&M Contractor | REA PMU / Environmental Officer | **Minor** |

| Project Activity | Potential Impact | Potential Impact Significance (Before Mitigation) | Mitigation Objective | Mitigation Measures | Performance Indicator | Monitoring Frequency | Responsibility for Implementation | Monitoring Responsibility | Residual Impact Significance (After Mitigation) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | (EPR) and manufacturer take-back arrangements where applicable.<br>• Dispose or recycle e-waste through FMEnv/NESREA-approved recycling or disposal facilities.<br>• Maintain inventory and disposal records. | | | | | |
| General operation of the facility | Fire outbreak | **Moderate** | Prevent and control fire incidents. | • Install fire detection and suppression systems.<br>• Maintain functional fire extinguishers at strategic locations.<br>• Conduct periodic fire drills.<br>• Keep emergency | Fire protection systems functional; successful emergency drills conducted. | Quarterly | O&M Contractor | HSE Officer / FUHSO Fire & Safety Unit | **Negligible** |

| Project Activity | Potential Impact | Potential Impact Significance (Before Mitigation) | Mitigation Objective | Mitigation Measures | Performance Indicator | Monitoring Frequency | Responsibility for Implementation | Monitoring Responsibility | Residual Impact Significance (After Mitigation) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | access routes unobstructed.<br>• Prohibit smoking within designated restricted areas. | | | | | |
| Operation of the facility | Security breaches, theft and vandalism | **Minor** | Protect project infrastructure and ensure uninterrupted operation. | • Maintain perimeter fencing and controlled access.<br>• Install security lighting and CCTV surveillance where applicable.<br>• Maintain 24-hour security presence.<br>• Keep visitor access records.<br>• Coordinate with University Security Services. | No significant security incidents recorded. | Daily | FUHSO / O&M Contractor | University Security / REA PMU | **Negligible** |
| Employment during operation | Occupational discrimination and | **Minor** | Promote an inclusive and safe working | • Maintain equal employment opportunities.<br>• Continue implementation | No substantiated GBV or discrimination cases. | Bi-annually | FUHSO / O&M Contractor | REA PMU | **Negligible** |

| Project Activity | Potential Impact | Potential Impact Significance (Before Mitigation) | Mitigation Objective | Mitigation Measures | Performance Indicator | Monitoring Frequency | Responsibility for Implementation | Monitoring Responsibility | Residual Impact Significance (After Mitigation) |
|---|---|---|---|---|---|---|---|---|---|
| | GBV/SEA/ SH | | environment. | of the REA GBV Action Plan.<br>• Enforce the Workers' Code of Conduct.<br>• Maintain confidential grievance reporting channels.<br>• Conduct periodic awareness training. | | | | | |
| Routine operation | Community health and safety | **Negligible** | Protect the university community from operational hazards. | • Maintain adequate warning signs around electrical installations.<br>• Restrict unauthorized access to electrical equipment.<br>• Maintain emergency contact information.<br>• Conduct periodic public | No community safety incidents attributable to project operations. | Quarterly | O&M Contractor | REA PMU / FUHSO | **Negligible** |

| Project Activity | Potential Impact | Potential Impact Significance (Before Mitigation) | Mitigation Objective | Mitigation Measures | Performance Indicator | Monitoring Frequency | Responsibility for Implementation | Monitoring Responsibility | Residual Impact Significance (After Mitigation) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | awareness on electrical safety where necessary. | | | | | |
| Environmental compliance monitoring | Non-compliance with environmental obligations | **Minor** | Ensure continuous compliance with the ESMP and regulatory requirements. | • Conduct routine environmental monitoring.<br>• Maintain operational environmental records.<br>• Undertake periodic compliance audits.<br>• Implement corrective actions for identified non-conformities.<br>• Submit required environmental monitoring reports to REA and relevant regulatory authorities. | Environmental monitoring reports submitted as scheduled; compliance maintained. | Quarterly | O&M Contractor | REA PMU / Environmental Safeguards Specialist | **Negligible** |

### 6.3.4 Mitigation Measures for the Decommissioning Phase

**Table 6.4: Mitigation Measures for the Decommissioning Phase**

| Project Activity | Potential Impact | Potential Impact Significance (Before Mitigation) | Mitigation Objective | Mitigation Measures | Performance Indicator | Monitoring Frequency | Responsibility for Implementation | Monitoring Responsibility | Residual Impact Significance (After Mitigation) |
|---|---|---|---|---|---|---|---|---|---|
| Decommissioning planning | Poor planning leading to environmental and social impacts | **Moderate** | Ensure systematic and environmentally responsible decommissioning. | • Prepare and obtain approval for a detailed Decommissioning and Closure Plan prior to commencement of dismantling activities.<br>• Conduct stakeholder consultation before decommissioning.<br>• Update environmental and social risk assessments.<br>• Obtain all statutory approvals and permits | Approved Decommissioning Plan available before commencement of dismantling. | Prior to decommissioning | FUHSO / REA / O&M Contractor | REA PMU / FMEnv | **Negligible** |

| Project Activity | Potential Impact | Potential Impact Significance (Before Mitigation) | Mitigation Objective | Mitigation Measures | Performance Indicator | Monitoring Frequency | Responsibility for Implementation | Monitoring Responsibility | Residual Impact Significance (After Mitigation) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | required for decommissioning activities. | | | | | |
| Dismantling of PV panels, mounting structures and electrical equipment | Dust, noise and localized environmental disturbance | **Minor** | Minimize environmental disturbance during dismantling activities. | • Restrict dismantling activities to designated work areas.<br>• Suppress dust using water where necessary.<br>• Maintain equipment in good working condition.<br>• Restrict noisy activities to daytime hours.<br>• Remove dismantled materials promptly from work areas. | Dust and noise maintained within acceptable levels. | Daily | Decommissioning Contractor | Environmental Officer / Supervising Engineer | **Negligible** |
| Removal of electrical equipment | Electrical shock and electrocution | **Moderate** | Protect personnel from | • Isolate and de-energize all electrical systems | Zero electrical accidents recorded. | Daily | Decommissioning Contractor | HSE Officer | **Negligible** |

| Project Activity | Potential Impact | Potential Impact Significance (Before Mitigation) | Mitigation Objective | Mitigation Measures | Performance Indicator | Monitoring Frequency | Responsibility for Implementation | Monitoring Responsibility | Residual Impact Significance (After Mitigation) |
|---|---|---|---|---|---|---|---|---|---|
| | | | electrical hazards. | before dismantling.<br>• Implement Lock-Out/Tag-Out (LOTO) procedures.<br>• Allow only competent personnel to undertake electrical works.<br>• Use insulated tools and appropriate PPE.<br>• Display warning signs around active work areas. | | | | | |
| Removal of Battery Energy Storage System (BESS) | Battery damage, fire and hazardous material release | **Major** | Ensure safe handling and transportation of battery systems. | • Disconnect batteries in accordance with manufacturer specifications.<br>• Avoid physical damage | Batteries safely removed without fire or chemical release. | Daily | Decommissioning Contractor | Environmental Officer / REA PMU | **Minor** |

| Project Activity | Potential Impact | Potential Impact Significance (Before Mitigation) | Mitigation Objective | Mitigation Measures | Performance Indicator | Monitoring Frequency | Responsibility for Implementation | Monitoring Responsibility | Residual Impact Significance (After Mitigation) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | during handling.<br>• Store batteries temporarily in secure ventilated areas.<br>• Transport batteries using licensed hazardous waste contractors.<br>• Return batteries under Extended Producer Responsibility (EPR) or manufacturer take-back programmes where applicable. | | | | | |
| Removal of transformers, cables and associated infrastructure | Soil contamination from oils or lubricants | **Minor** | Prevent environmental contamination. | • Drain oils where necessary before | No uncontrolled oil spills or contaminated soil observed. | Daily | Decommissioning Contractor | Environmental Officer | **Negligible** |

| Project Activity | Potential Impact | Potential Impact Significance (Before Mitigation) | Mitigation Objective | Mitigation Measures | Performance Indicator | Monitoring Frequency | Responsibility for Implementation | Monitoring Responsibility | Residual Impact Significance (After Mitigation) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | equipment removal.<br>• Store oils in approved containers.<br>• Maintain spill response equipment on site.<br>• Immediately clean accidental spills.<br>• Dispose contaminated materials through licensed waste contractors. | | | | | |
| Generation of demolition waste | Improper waste disposal | **Moderate** | Promote waste minimization and environmentally sound disposal. | • Segregate wastes into recyclable, reusable and hazardous categories.<br>• Recycle steel, aluminium and other recoverable materials | Waste properly segregated and disposed of in accordance with regulations. | Weekly | Decommissioning Contractor | Environmental Officer / REA PMU | **Negligible** |

| Project Activity | Potential Impact | Potential Impact Significance (Before Mitigation) | Mitigation Objective | Mitigation Measures | Performance Indicator | Monitoring Frequency | Responsibility for Implementation | Monitoring Responsibility | Residual Impact Significance (After Mitigation) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | where practicable.<br>• Dispose non-recyclable wastes through licensed waste contractors.<br>• Maintain waste transfer documentation.<br>• Prohibit open burning and indiscriminate dumping. | | | | | |
| Removal of foundations and reinstatement works | Soil disturbance and erosion | **Minor** | Restore site stability following decommissioning. | • Remove unnecessary concrete foundations where required.<br>• Backfill excavated areas using suitable materials. | Disturbed land restored and stabilized. | Weekly | Decommissioning Contractor | Supervising Engineer | **Negligible** |

| Project Activity | Potential Impact | Potential Impact Significance (Before Mitigation) | Mitigation Objective | Mitigation Measures | Performance Indicator | Monitoring Frequency | Responsibility for Implementation | Monitoring Responsibility | Residual Impact Significance (After Mitigation) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | • Re-grade disturbed surfaces.<br>• Reinstate topsoil and encourage natural vegetation recovery.<br>• Implement erosion control measures until vegetation becomes established. | | | | | |
| Decommissioning workforce | Occupational accidents and injuries | **Moderate** | Protect workers during dismantling activities. | • Conduct task-specific HSE induction.<br>• Provide appropriate PPE.<br>• Maintain first aid and emergency response facilities.<br>• Supervise lifting operations. | No Lost Time Injuries (LTI); PPE compliance maintained. | Daily | Decommissioning Contractor | HSE Officer | **Minor** |

| Project Activity | Potential Impact | Potential Impact Significance (Before Mitigation) | Mitigation Objective | Mitigation Measures | Performance Indicator | Monitoring Frequency | Responsibility for Implementation | Monitoring Responsibility | Residual Impact Significance (After Mitigation) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | • Inspect lifting equipment before use.<br>• Implement Permit-to-Work procedures. | | | | | |
| Movement of dismantled equipment and materials | Traffic and public safety risks | **Minor** | Maintain safe transportation of dismantled materials. | • Prepare a Traffic Management Plan for decommissioning activities.<br>• Secure transported loads.<br>• Use approved haulage routes.<br>• Employ trained drivers only.<br>• Install warning signs where necessary. | No significant traffic incidents associated with decommissioning. | Daily | Decommissioning Contractor | Supervising Engineer | **Negligible** |
| Site restoration and closure | Failure to restore the project site | **Moderate** | Restore the site to a safe and | • Remove temporary facilities and | Site restored and approved for closure by | Upon completion of | REA / FUHSO / Decommissioning Contractor | FMEnv / REA PMU | **Negligible** |

| Project Activity | Potential Impact | Potential Impact Significance (Before Mitigation) | Mitigation Objective | Mitigation Measures | Performance Indicator | Monitoring Frequency | Responsibility for Implementation | Monitoring Responsibility | Residual Impact Significance (After Mitigation) |
|---|---|---|---|---|---|---|---|---|---|
| | | | stable condition. | construction debris.<br>• Reinstate disturbed areas.<br>• Restore natural drainage patterns.<br>• Undertake post-closure environmental inspection.<br>• Obtain site closure approval from relevant regulatory authorities. | relevant authorities. | decommissio ning | | | |

## 6.4 Enhancement Measures for Positive Impacts

### Table 6.5: Enhancement Measures for Positive Impacts

| Positive Impact | Enhancement Objective | Enhancement Measures | Responsibility |
|---|---|---|---|
| Improved electricity supply | Ensure long-term reliability of power supply | Maintain routine preventive maintenance of the Solar PV Hybrid Power Plant and associated infrastructure. | FUHSO / O&M Contractor |
| Improved teaching, research and healthcare services | Maximize institutional benefits | Prioritize uninterrupted power supply to critical academic, research and healthcare facilities. | FUHSO |
| Employment generation | Maximize local economic benefits | Give priority to qualified local personnel during construction and operation where practicable. | EPC Contractor / FUHSO |
| Capacity building | Strengthen renewable energy expertise | Utilize the Renewable Energy Training Centre for continuous staff and student training in solar PV technologies. | FUHSO / REA |
| Reduced greenhouse gas emissions | Promote climate change mitigation | Maintain optimal plant efficiency through regular inspection and maintenance of PV modules and associated equipment. | O&M Contractor |
| Improved campus security | Enhance safety within the University | Maintain and periodically inspect solar-powered street lighting to ensure continuous operation. | FUHSO |
| Technology transfer | Promote sustainable energy development | Encourage collaboration with research institutions and industry partners on renewable energy innovation and applied research. | FUHSO / REA |
| Institutional sustainability | Ensure long-term project viability | Implement preventive maintenance programmes, adequate budgeting and periodic technical audits throughout the project lifecycle. | FUHSO / REA |

# CHAPTER SEVEN
# ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

## 7.1 Introduction

The Environmental and Social Management Plan (ESMP) provides the framework for implementing, monitoring and continuously improving the environmental and social commitments associated with the proposed 2 MW Solar Photovoltaic (PV) Hybrid Power Plant and Associated Infrastructure at the Federal University of Health Sciences, Otukpo (FUHSO), Benue State, under the Rural Electrification Agency (REA) Nigeria Electrification Project (NEP). The ESMP translates the mitigation measures identified in Chapter Six into practical management actions, specifying implementation responsibilities, monitoring requirements, performance indicators, reporting procedures and resource requirements throughout the Project life cycle. This aligns with the purpose of the ESMP as the implementation framework for mitigation, monitoring, responsibilities and costs.

The ESMP applies to all phases of the Project, including pre-construction, construction, operation and maintenance, and eventual decommissioning. It is intended to ensure that Project activities are implemented in compliance with applicable Nigerian environmental legislation, REA environmental and social requirements, the Federal Ministry of Environment (FMEnv) guidelines, the Nigeria Electrification Project Environmental and Social Management Framework (ESMF), the African Development Bank Integrated Safeguards System (AfDB ISS, 2023), the World Bank Environmental and Social Framework (ESF), and relevant international environmental, occupational health and safety standards.

Implementation of this ESMP shall be the collective responsibility of the REA Project Management Unit (PMU), the Engineering, Procurement and Construction (EPC) Contractor, the Operations and Maintenance (O&M) Contractor, FUHSO Management, supervising consultants and relevant regulatory authorities. The ESMP shall remain a living document and may be reviewed and updated during Project implementation to reflect changes in Project activities, regulatory requirements, monitoring results, technological improvements and lessons learned during implementation.

## 7.2 Objectives of the ESMP

The overall objective of the Environmental and Social Management Plan is to ensure that the proposed Project is implemented in an environmentally sustainable, socially responsible and legally compliant manner while maximizing Project benefits and minimizing adverse environmental and social impacts.

The specific objectives of the ESMP are to:

- Provide a practical framework for implementing the environmental and social mitigation measures identified in the ESIA.
- Ensure compliance with applicable Nigerian environmental legislation, REA requirements, World Bank ESF, AfDB ISS (2023), IFC Environmental, Health and Safety (EHS) Guidelines, and other relevant international standards.
- Prevent, minimize, control and monitor adverse environmental and social impacts throughout the Project life cycle.

- Promote the health, safety and welfare of workers, contractors, visitors and neighbouring communities.
- Protect environmental resources including air quality, soil, groundwater, biodiversity and landscape values within the Project Area of Influence.
- Promote efficient utilization of natural resources, including water and energy, and encourage sustainable environmental practices.
- Establish clear institutional roles, responsibilities and reporting arrangements for ESMP implementation.
- Provide environmental and social monitoring programmes for evaluating the effectiveness of mitigation measures and ensuring continual improvement.
- Strengthen stakeholder engagement, information disclosure and grievance management throughout Project implementation.
- Promote gender equality, prevention of Gender-Based Violence (GBV), Sexual Exploitation and Abuse (SEA), Sexual Harassment (SH), and protection of vulnerable groups.
- Establish emergency preparedness and response procedures for potential Project-related incidents and emergencies.
- Ensure proper management of all Project-generated wastes in accordance with the waste management hierarchy and applicable regulations.
- Facilitate environmental compliance auditing, reporting, corrective actions and continual performance improvement throughout the Project life cycle.
- Provide a basis for environmental and social training, awareness creation and capacity building for Project personnel and relevant stakeholders.

These objectives shall guide the implementation of all environmental and social management measures presented in this chapter and provide the basis for effective environmental monitoring, performance evaluation and adaptive management throughout the life of the Project.

## 7.3 Environmental and Social Management Measures

The environmental and social management measures presented in this ESMP have been developed based on the findings of the Environmental and Social Impact Assessment (ESIA), baseline environmental studies, stakeholder consultations, applicable legal and regulatory requirements, and international good practice. The measures are intended to prevent, avoid, minimize, mitigate or compensate for adverse environmental and social impacts while enhancing the positive benefits associated with the proposed Project. The ESMP adopts the mitigation hierarchy, which prioritizes:

- Avoidance of adverse environmental and social impacts where practicable;
- Minimization of impacts that cannot be avoided;
- Restoration or rehabilitation of affected environmental and social resources; and
- Compensation or offset measures where residual impacts remain unavoidable.

The management measures developed for the Project cover all phases of the Project lifecycle, namely:

- Pre-construction Phase;
- Construction Phase;
- Operation and Maintenance Phase; and
- Decommissioning and Closure Phase.

The mitigation measures identify the specific Project activities, associated environmental and social impacts, mitigation objectives, recommended management actions, performance indicators, monitoring requirements, implementation responsibilities, monitoring responsibilities and anticipated residual impacts following implementation.

**Table 7.1a: Environmental Management Measures for the Pre-Construction Phase of the Proposed Project**

| Summary of Potential Impact | Mitigation Measures | Monitoring Requirements / Parameters | Frequency | Performance Indicator | Responsibility for Implementation | Responsibility for Monitoring | Estimated Cost (USD) |
|---|---|---|---|---|---|---|---|
| **Vegetation clearance, localized habitat disturbance and loss of ground cover during site preparation** | Vegetation clearance shall be restricted strictly to the approved Project footprint. | Site inspection | Daily during site clearing | Clearing confined to approved Project boundary | EPC Contractor | REA PMU / FUHSO Site Engineer | **1500** |
| | Mechanical clearing methods shall be adopted. Open burning and indiscriminate vegetation removal shall be prohibited. | Inspection records | Daily | Compliance with approved clearing method | EPC Contractor | REA PMU | |
| | Mature trees outside the approved Project footprint shall be retained wherever practicable. | Inspection | Weekly | No unnecessary tree removal | EPC Contractor | REA PMU | |
| | Cleared topsoil shall be stripped separately, stockpiled appropriately and preserved for site restoration. | Topsoil stockpile inspection | Weekly | Topsoil stockpiled and protected | EPC Contractor | Supervising Engineer | |
| | Disturbed areas not required for permanent infrastructure shall | Revegetation records | Monthly | Successful vegetation establishment | EPC Contractor | Benue State Ministry of Environment and Climate Change | |

| Summary of Potential Impact | Mitigation Measures | Monitoring Requirements / Parameters | Frequency | Performance Indicator | Responsibility for Implementation | Responsibility for Monitoring | Estimated Cost (USD) |
|---|---|---|---|---|---|---|---|
| | be progressively stabilized and revegetated with indigenous species. | | | | | | |
| | Hunting, trapping, harassment or deliberate killing of wildlife by Project personnel shall be strictly prohibited. | HSE inspection | Daily | Zero wildlife incidents | EPC Contractor | REA PMU | |
| **Soil disturbance, compaction and localized erosion** | Restrict earthworks to approved work areas only. | Site inspection | Daily | No unnecessary land disturbance | EPC Contractor | REA PMU | **2000** |
| | Minimize exposed soil surfaces and stabilize disturbed areas as soon as practicable. | Inspection | Weekly | No active erosion observed | EPC Contractor | Supervising Engineer | |
| | Install temporary erosion and sediment control measures where necessary. | Inspection | Weekly | Effective erosion control | EPC Contractor | REA PMU | |
| | Earthworks shall, where practicable, be scheduled outside periods of intense rainfall. | Construction programme | Throughout earthworks | Compliance with construction schedule | EPC Contractor | Supervising Engineer | |

| Summary of Potential Impact | Mitigation Measures | Monitoring Requirements / Parameters | Frequency | Performance Indicator | Responsibility for Implementation | Responsibility for Monitoring | Estimated Cost (USD) |
|---|---|---|---|---|---|---|---|
| **Dust generation and deterioration of ambient air quality** | Construction equipment shall be maintained in good operating condition to minimize exhaust emissions. | Equipment maintenance records | Weekly | Maintenance records available | EPC Contractor | REA PMU | **1200** |
| | Water shall be applied to exposed surfaces and access roads where excessive dust generation is observed. | Inspection | Daily (as required) | Dust effectively controlled | EPC Contractor | FUHSO Site Engineer | |
| | Vehicles transporting friable materials shall be adequately covered. | Vehicle inspection | Daily | No uncovered dusty materials transported | EPC Contractor | Supervising Engineer | |
| | Speed limits of not more than **20 km/h** shall be enforced within the Project site. | Speed monitoring | Daily | Compliance with site speed limit | EPC Contractor | HSE Officer | |
| **Noise generation from site preparation activities** | Site preparation activities shall be limited to normal daytime working hours. | Site inspection | Daily | No unauthorized night work | EPC Contractor | REA PMU | **800** |

| Summary of Potential Impact | Mitigation Measures | Monitoring Requirements / Parameters | Frequency | Performance Indicator | Responsibility for Implementation | Responsibility for Monitoring | Estimated Cost (USD) |
|---|---|---|---|---|---|---|---|
| | Equipment shall be fitted with functional silencers and maintained regularly. | Maintenance records | Weekly | Noise control equipment functional | EPC Contractor | Supervising Engineer | |
| **Pollution from accidental fuel or lubricant spills** | Refuelling and equipment servicing shall be undertaken only at designated areas with spill containment facilities. | Inspection | Daily | No uncontrolled spills | EPC Contractor | REA PMU | **1500** |
| | Spill kits shall be available at all equipment operating areas and personnel trained in spill response procedures. | Availability of spill kits | Weekly | Spill response equipment available | EPC Contractor | HSE Officer | |
| **Poor environmental compliance during mobilization** | Contractor's Environmental and Social Management Plan (C-ESMP) shall be prepared and approved before mobilization. | Approved C-ESMP | Once before mobilization | Approved management plan available | EPC Contractor | REA PMU | **2000** |
| | All statutory environmental approvals and | Approval documents | Prior to mobilization | All approvals obtained | REA / EPC Contractor | FMEnv / Benue State Ministry of | |

| Summary of Potential Impact | Mitigation Measures | Monitoring Requirements / Parameters | Frequency | Performance Indicator | Responsibility for Implementation | Responsibility for Monitoring | Estimated Cost (USD) |
|---|---|---|---|---|---|---|---|
| | permits shall be obtained prior to commencement of site activities. | | | | | Environment and Climate Change | |

**Table 7.1b: Social Management Measures for the Pre-Construction Phase of the Proposed Project**

| Summary of Potential Impact | Mitigation Measures | Monitoring Requirements / Parameters | Frequency | Performance Indicator | Responsibility for Implementation | Responsibility for Monitoring | Estimated Cost (USD) |
|---|---|---|---|---|---|---|---|
| **Community concerns, misinformation and inadequate stakeholder awareness** | Continue stakeholder engagement with FUHSO Management, relevant government agencies and other identified stakeholders prior to commencement of construction activities. | Stakeholder engagement records | Monthly and prior to construction | Stakeholder meetings conducted and documented | REA PMU / EPC Contractor | REA PMU | **3000** |
| | Disclose relevant Project information through meetings, notices and other appropriate communication channels. | Disclosure records | Throughout pre-construction | Evidence of information disclosure | REA PMU | FMEnv / Benue State Ministry of Environment and Climate Change | |
| | Maintain regular communication with FUHSO Management throughout the pre-construction phase. | Meeting minutes | Monthly | Coordination meetings held | REA PMU | FUHSO Management | |
| **Stakeholder grievances and complaints** | Establish and operationalize the Project Grievance Redress | Approved GRM and | Prior to mobilization | Functional GRM established | EPC Contractor | REA PMU | **2000** |

| Summary of Potential Impact | Mitigation Measures | Monitoring Requirements / Parameters | Frequency | Performance Indicator | Responsibility for Implementation | Responsibility for Monitoring | Estimated Cost (USD) |
|---|---|---|---|---|---|---|---|
| | Mechanism (GRM) before commencement of construction. | grievance register | | | | | |
| | Publicize grievance reporting channels to all stakeholders. | Awareness records | Prior to construction | Stakeholders aware of GRM | EPC Contractor | REA PMU | |
| | Maintain a grievance register and investigate all complaints promptly. | Grievance register | Continuous | Percentage of grievances resolved within agreed timelines | EPC Contractor | REA PMU | |
| **Unfair recruitment and employment practices** | Employment opportunities shall be openly advertised where applicable and recruitment shall be based on competence, transparency and equal opportunity. | Recruitment records | Throughout recruitment | Transparent recruitment process | EPC Contractor | REA PMU | **1500** |
| | Priority shall be given to qualified local labour for unskilled and semi-skilled positions where available. | Employment records | During recruitment | Percentage of local employment | EPC Contractor | FUHSO Management | |
| | No child labour or forced labour shall be permitted. All employment shall comply with applicable Nigerian labour legislation. | Employment records | Continuous | Full compliance with labour requirements | EPC Contractor | REA PMU | |
| | Recruitment shall be free from discrimination based on gender, ethnicity, religion or disability. | Employment records | Continuous | No discrimination complaints recorded | EPC Contractor | REA PMU | |

| Summary of Potential Impact | Mitigation Measures | Monitoring Requirements / Parameters | Frequency | Performance Indicator | Responsibility for Implementation | Responsibility for Monitoring | Estimated Cost (USD) |
|---|---|---|---|---|---|---|---|
| **Occupational health and safety during mobilization** | Conduct mandatory HSE induction for all Project personnel before site mobilization. | Training records | Once before mobilization | 100% workforce inducted | EPC Contractor | REA PMU | **2500** |
| | Provide appropriate Personal Protective Equipment (PPE) to all personnel before commencement of work. | PPE issuance records | Prior to mobilization | Full PPE compliance | EPC Contractor | HSE Officer | |
| | Ensure only trained and authorized personnel operate vehicles, equipment and machinery. | Competency certificates | Prior to mobilization | Qualified operators engaged | EPC Contractor | Supervising Engineer | |
| | Establish first aid facilities and emergency response arrangements before site activities commence. | First aid and emergency equipment inspection | Prior to mobilization | Emergency facilities available | EPC Contractor | REA PMU | |
| **Traffic safety risks during mobilization** | Develop and implement a Traffic Management Plan (TMP) prior to mobilization. | Approved TMP | Before mobilization | TMP fully implemented | EPC Contractor | REA PMU | **1500** |
| | Restrict vehicle speed within the University campus to approved limits. | Speed monitoring records | Daily | Compliance with speed limits | EPC Contractor | HSE Officer | |
| | Install temporary traffic signs, warning signs and barriers along haulage routes where required. | Site inspection | Before and during mobilization | Appropriate traffic control measures in place | EPC Contractor | Supervising Engineer | |
| | Ensure all Project drivers possess valid driver's licences | Driver records and training certificates | Prior to mobilization | Competent drivers deployed | EPC Contractor | REA PMU | |

| Summary of Potential Impact | Mitigation Measures | Monitoring Requirements / Parameters | Frequency | Performance Indicator | Responsibility for Implementation | Responsibility for Monitoring | Estimated Cost (USD) |
|---|---|---|---|---|---|---|---|
| | and receive defensive driving training where necessary. | | | | | | |
| | Maintain records of all traffic incidents and implement corrective actions where necessary. | Incident register | Continuous | Declining trend in traffic incidents | EPC Contractor | REA PMU | |
| **Unauthorized site access and security risks** | Secure the Project site using controlled access points, temporary fencing where necessary and appropriate security arrangements. | Security inspection | Daily | Unauthorized access prevented | EPC Contractor | FUHSO Security Unit | **2500** |
| | Maintain visitor access records and restrict entry to authorized personnel only. | Visitor register | Daily | Controlled site access maintained | EPC Contractor | FUHSO Security Unit | |
| | Coordinate site security arrangements with FUHSO Security Unit and relevant security agencies throughout the pre-construction phase. | Security meeting records | Monthly | Effective security coordination | EPC Contractor | FUHSO Management | |

**Table 7.2a: Environmental Management Measures for the Construction Phase of the Proposed Project**

| Summary of Potential Impact | Mitigation Measures | Monitoring Requirements / Parameters | Frequency | Performance Indicator | Responsibility for Implementation | Responsibility for Monitoring | Estimated Cost (USD) |
|---|---|---|---|---|---|---|---|
| **Air pollution from earthworks, excavation, transportation of materials and construction equipment** | Sprinkle water on exposed surfaces and access roads whenever excessive dust generation is observed. | Visual inspection; particulate dust level | Daily | Minimal visible dust beyond work areas | EPC Contractor | REA PMU / Supervising Engineer | **45000** |
| | Cover trucks transporting friable materials. | Vehicle inspection | Daily | All haulage trucks covered | EPC Contractor | Supervising Engineer | |
| | Maintain construction equipment in good operating condition to minimize exhaust emissions. | Equipment maintenance records | Weekly | Equipment maintenance records available | EPC Contractor | REA PMU | |
| | Switch off construction equipment when not in use. | Site inspection | Daily | Reduced unnecessary engine idling | EPC Contractor | HSE Officer | |
| **Increase in ambient noise and vibration** | Restrict noisy construction activities to normal daytime working hours. | Working hour inspection | Daily | No unauthorized night-time construction | EPC Contractor | REA PMU | **25000** |
| | Ensure equipment is fitted with functional silencers | Maintenance records | Weekly | Functional silencers installed | EPC Contractor | Supervising Engineer | |

| Summary of Potential Impact | Mitigation Measures | Monitoring Requirements / Parameters | Frequency | Performance Indicator | Responsibility for Implementation | Responsibility for Monitoring | Estimated Cost (USD) |
|---|---|---|---|---|---|---|---|
| | and maintained regularly. | | | | | | |
| | Provide hearing protection to workers exposed to excessive noise. | PPE inspection | Daily | Full compliance with hearing protection | EPC Contractor | HSE Officer | |
| | Monitor occupational noise exposure where required. | Noise measurements | Monthly | Compliance with FMEnv occupational noise limits | EPC Contractor | REA PMU | |
| **Soil compaction, erosion and degradation** | Restrict movement of heavy equipment to designated access routes. | Site inspection | Daily | No unnecessary soil disturbance | EPC Contractor | Supervising Engineer | **4000** |
| | Preserve stockpiled topsoil for site restoration. | Stockpile inspection | Weekly | Topsoil properly protected | EPC Contractor | REA PMU | |
| | Stabilize exposed surfaces immediately after excavation. | Site inspection | Weekly | No active erosion | EPC Contractor | REA PMU | |
| | Install temporary erosion and sediment control measures where required. | Inspection | Weekly | Effective erosion control measures | EPC Contractor | Supervising Engineer | |
| **Groundwater and soil contamination** | Store fuels, lubricants and chemicals in | Storage area inspection | Weekly | Bund integrity maintained | EPC Contractor | REA PMU | **3500** |

| Summary of Potential Impact | Mitigation Measures | Monitoring Requirements / Parameters | Frequency | Performance Indicator | Responsibility for Implementation | Responsibility for Monitoring | Estimated Cost (USD) |
|---|---|---|---|---|---|---|---|
| **from fuel, lubricants and chemicals** | designated bunded storage areas. | | | | | | |
| | Refuel equipment only at designated refuelling locations. | Site inspection | Daily | Controlled refuelling practices | EPC Contractor | HSE Officer | |
| | Maintain spill kits at all fuel handling areas and train personnel on spill response procedures. | Spill kit inspection | Weekly | Spill kits available and functional | EPC Contractor | REA PMU | |
| | Immediately contain and remediate any accidental spill. | Incident reports | As required | Zero uncontrolled spills | EPC Contractor | REA PMU | |
| **Surface water contamination from sediment runoff and construction waste** | Prevent discharge of construction wastes into drainage channels. | Site inspection | Daily | No waste observed in drainage paths | EPC Contractor | REA PMU | **2500** |
| | Install temporary drainage and sediment traps where necessary. | Inspection | Weekly | Effective sediment control | EPC Contractor | Supervising Engineer | |
| | Maintain good housekeeping throughout the Project site. | Site inspection | Daily | Clean work environment | EPC Contractor | REA PMU | |
| **Generation of construction wastes** | Segregate wastes according to type and provide labelled | Waste segregation records | Daily | Proper waste segregation | EPC Contractor | REA PMU | **4500** |

| Summary of Potential Impact | Mitigation Measures | Monitoring Requirements / Parameters | Frequency | Performance Indicator | Responsibility for Implementation | Responsibility for Monitoring | Estimated Cost (USD) |
|---|---|---|---|---|---|---|---|
| | waste collection containers. | | | | | | |
| | Reuse or recycle suitable construction materials where practicable. | Waste records | Weekly | Increased material recovery | EPC Contractor | Supervising Engineer | |
| | Dispose of non-recyclable wastes through FMEnv/NESREA-approved waste contractors. | Waste manifests | Monthly | Proper waste disposal records | EPC Contractor | REA PMU | |
| | Store hazardous wastes separately pending off-site disposal. | Hazardous waste inspection | Weekly | No hazardous waste mixing | EPC Contractor | REA PMU | |
| **Loss of vegetation and disturbance to wildlife** | Restrict vegetation clearance to approved work areas only. | Site inspection | Daily | No unnecessary vegetation removal | EPC Contractor | REA PMU | **3000** |
| | Prohibit hunting, trapping or harassment of wildlife by Project personnel. | HSE inspection | Daily | Zero wildlife incidents | EPC Contractor | Supervising Engineer | |
| | Restore disturbed areas following completion of | Restoration inspection | Monthly | Disturbed areas rehabilitated | EPC Contractor | REA PMU | |

| Summary of Potential Impact | Mitigation Measures | Monitoring Requirements / Parameters | Frequency | Performance Indicator | Responsibility for Implementation | Responsibility for Monitoring | Estimated Cost (USD) |
|---|---|---|---|---|---|---|---|
| | construction activities. | | | | | | |
| **Poor housekeeping and environmental sanitation** | Maintain clean work areas at all times. | Site inspection | Daily | Good housekeeping maintained | EPC Contractor | Supervising Engineer | **2000** |
| | Remove waste from work areas regularly. | Waste inspection | Daily | No accumulation of wastes | EPC Contractor | REA PMU | |
| | Provide adequate sanitation facilities for construction personnel. | Facility inspection | Weekly | Functional sanitation facilities available | EPC Contractor | REA PMU | |
| **Fire and accidental environmental pollution** | Maintain fire extinguishers at fuel storage areas, workshops and electrical installation locations. | Equipment inspection | Weekly | Fire extinguishers available and serviceable | EPC Contractor | HSE Officer | **2500** |
| | Train workers on emergency response procedures. | Training records | Quarterly | Emergency response training completed | EPC Contractor | REA PMU | |
| | Prohibit open burning throughout the Project site. | Site inspection | Daily | Zero open burning incidents | EPC Contractor | Supervising Engineer | |

**Table 7.2b: Social Management Measures for the Construction Phase of the Proposed Project**

| Summary of Potential Impact | Mitigation Measures | Monitoring Requirements / Parameters | Frequency | Performance Indicator | Responsibility for Implementation | Responsibility for Monitoring | Estimated Cost (USD) |
|---|---|---|---|---|---|---|---|
| **Employment opportunities and local participation** | Give priority to qualified local labour for unskilled and semi-skilled positions where available. | Employment records | Monthly | Percentage of local workforce employed | EPC Contractor | REA PMU / FUHSO Management | **3000** |
| | Ensure recruitment is transparent, fair and based on competence. | Recruitment records | Throughout recruitment | No recruitment-related grievances | EPC Contractor | REA PMU | |
| | Maintain equal employment opportunities irrespective of gender, religion or ethnicity. | Employment records | Quarterly | No discrimination cases reported | EPC Contractor | REA PMU | |
| **Occupational Health and Safety (OHS)** | Implement the approved Occupational Health and Safety Plan throughout construction. | HSE inspection reports | Daily | Full implementation of OHS Plan | EPC Contractor | REA PMU / Supervising Engineer | **8000** |
| | Provide appropriate Personal Protective | PPE compliance inspection | Daily | 100% PPE compliance | EPC Contractor | HSE Officer | |

| Summary of Potential Impact | Mitigation Measures | Monitoring Requirements / Parameters | Frequency | Performance Indicator | Responsibility for Implementation | Responsibility for Monitoring | Estimated Cost (USD) |
|---|---|---|---|---|---|---|---|
| | Equipment (PPE) and enforce its use. | | | | | | |
| | Conduct daily toolbox meetings before commencement of work. | Toolbox meeting records | Daily | Toolbox meetings conducted | EPC Contractor | REA PMU | |
| | Ensure first aid facilities, trained first aiders and emergency response equipment are available on site. | Inspection records | Weekly | Emergency facilities available | EPC Contractor | REA PMU | |
| | Report, investigate and document all incidents, accidents and near misses. | Incident register | Continuous | Incident investigations completed | EPC Contractor | REA PMU | |
| **Community health and safety** | Restrict public access to active construction areas using barriers, warning signs and controlled entry points. | Site inspection | Daily | No unauthorized access | EPC Contractor | FUHSO Security / REA PMU | **3000** |

| Summary of Potential Impact | Mitigation Measures | Monitoring Requirements / Parameters | Frequency | Performance Indicator | Responsibility for Implementation | Responsibility for Monitoring | Estimated Cost (USD) |
|---|---|---|---|---|---|---|---|
| | Install adequate safety signs around hazardous work areas. | Inspection | Weekly | Safety signage installed | EPC Contractor | Supervising Engineer | |
| | Ensure construction materials are stored safely to prevent accidents. | Site inspection | Weekly | Safe storage maintained | EPC Contractor | REA PMU | |
| **Traffic disruption and road safety** | Implement the approved Traffic Management Plan (TMP). | Traffic inspection | Daily | TMP effectively implemented | EPC Contractor | REA PMU | **2500** |
| | Schedule delivery of heavy equipment during periods of low traffic where practicable. | Delivery schedule | Weekly | Minimal traffic disruption | EPC Contractor | Supervising Engineer | |
| | Install traffic warning signs and deploy trained flagmen where necessary. | Site inspection | Daily | Traffic control measures functional | EPC Contractor | REA PMU | |
| | Ensure all construction vehicles comply with approved speed limits | Vehicle inspection | Daily | Compliance with speed limits | EPC Contractor | HSE Officer | |

| Summary of Potential Impact | Mitigation Measures | Monitoring Requirements / Parameters | Frequency | Performance Indicator | Responsibility for Implementation | Responsibility for Monitoring | Estimated Cost (USD) |
|---|---|---|---|---|---|---|---|
| | within the University. | | | | | | |
| **Labour and working conditions** | Ensure all workers receive written employment conditions in accordance with Nigerian Labour legislation. | Employment contracts | Prior to engagement | Employment documentation completed | EPC Contractor | REA PMU | **2000** |
| | Prohibit child labour, forced labour and all forms of workplace discrimination. | Labour inspection | Monthly | Zero labour violations | EPC Contractor | REA PMU | |
| | Establish workers' grievance procedures separate from the community GRM. | Workers' grievance register | Continuous | Grievances resolved promptly | EPC Contractor | REA PMU | |
| **Gender-Based Violence (GBV), Sexual Exploitation and Abuse (SEA) and Sexual** | Implement the REA GBV Action Plan throughout construction. | GBV monitoring reports | Monthly | GBV Action Plan implemented | EPC Contractor | REA PMU | **4000** |
| | All workers shall sign and comply with the Project Code of Conduct. | Signed Code of Conduct | Prior to mobilization | 100% workforce compliance | EPC Contractor | REA PMU | |

| Summary of Potential Impact | Mitigation Measures | Monitoring Requirements / Parameters | Frequency | Performance Indicator | Responsibility for Implementation | Responsibility for Monitoring | Estimated Cost (USD) |
|---|---|---|---|---|---|---|---|
| **Harassment (SH)** | Conduct regular GBV/SEA/SH awareness training for all workers. | Training records | Quarterly | Training completed | EPC Contractor | REA PMU / Social Safeguards Specialist | |
| | Maintain confidential grievance channels for GBV-related complaints. | GRM records | Continuous | Functional confidential reporting mechanism | EPC Contractor | REA PMU | |
| **Stakeholder engagement and community relations** | Continue stakeholder engagement throughout construction in accordance with the Stakeholder Engagement Plan (SEP). | Consultation records | Monthly | Stakeholder meetings conducted | REA PMU / EPC Contractor | REA PMU | **3000** |
| | Provide regular updates on construction progress and planned activities. | Meeting minutes and notices | Monthly | Timely information disclosure | EPC Contractor | FUHSO Management | |
| | Respond promptly to stakeholder concerns through | Grievance register | Continuous | Percentage of grievances resolved within agreed timelines | EPC Contractor | REA PMU | |

| Summary of Potential Impact | Mitigation Measures | Monitoring Requirements / Parameters | Frequency | Performance Indicator | Responsibility for Implementation | Responsibility for Monitoring | Estimated Cost (USD) |
|---|---|---|---|---|---|---|---|
| | the established GRM. | | | | | | |
| **Site security and protection of Project assets** | Maintain controlled access to the Project site through designated entry points. | Security inspection | Daily | Site access effectively controlled | EPC Contractor | FUHSO Security Unit | **3500** |
| | Deploy trained security personnel and maintain visitor records. | Visitor register | Daily | Security procedures implemented | EPC Contractor | FUHSO Security Unit | |
| | Coordinate security arrangements with the University Security Unit and relevant government security agencies where required. | Security meeting records | Monthly | Effective security coordination | EPC Contractor | REA PMU | |

**Table 7.3a: Environmental Management Measures for the Operational Phase of the Proposed Project**

| Summary of Potential Impact | Mitigation Measures | Monitoring Requirements / Parameters | Frequency | Performance Indicator | Responsibility for Implementation | Responsibility for Monitoring | Estimated Cost (USD/Year) |
|---|---|---|---|---|---|---|---|
| **Waste generation from routine maintenance (damaged PV modules, batteries, electrical components and packaging materials)** | Implement the approved Waste Management Plan throughout operation. Segregate wastes at source and store hazardous wastes separately. Engage only FMEnv/NESREA-approved waste handlers. Implement the Extended Producer Responsibility (EPR) programme and manufacturer's take-back scheme for spent PV panels, batteries and electrical components. | Waste inventory, storage condition, disposal manifests | Monthly | Proper waste segregation and disposal records maintained | O&M Contractor / FUHSO | REA PMU / FMEnv | **3,500** |
| **Soil contamination from accidental oil, lubricant or battery** | Carry out routine inspection of transformers, batteries and electrical | Spill records, inspection reports | Monthly | No significant soil contamination incidents | O&M Contractor | REA PMU | **1,500** |

| Summary of Potential Impact | Mitigation Measures | Monitoring Requirements / Parameters | Frequency | Performance Indicator | Responsibility for Implementation | Responsibility for Monitoring | Estimated Cost (USD/Year) |
|---|---|---|---|---|---|---|---|
| **electrolyte leakage** | equipment. Maintain spill kits at strategic locations. Immediately contain and remediate accidental spills. Store oils and chemicals within bunded areas. | | | | | | |
| **Groundwater abstraction for PV panel cleaning** | Clean PV panels only when necessary based on dust accumulation and performance monitoring. Utilize the dedicated borehole equipped with a solar-powered pumping system to eliminate dependence on external electricity supply. Regularly inspect the borehole and pumping system to prevent water wastage. | Water consumption records; borehole inspection | Monthly | Efficient water use with no operational interruption | O&M Contractor | FUHSO / REA PMU | **1,200** |

| Summary of Potential Impact | Mitigation Measures | Monitoring Requirements / Parameters | Frequency | Performance Indicator | Responsibility for Implementation | Responsibility for Monitoring | Estimated Cost (USD/Year) |
|---|---|---|---|---|---|---|---|
| **Groundwater quality deterioration** | Prohibit disposal of chemicals, oils and hazardous wastes on bare ground. Inspect battery storage and transformer areas regularly for leakage. Promptly address any identified contamination. | Groundwater inspection records | Quarterly | No evidence of groundwater contamination | O&M Contractor | REA PMU / Benue State Ministry of Environment and Climate Change | **1,000** |
| **Reduced energy efficiency due to dust accumulation on PV modules** | Implement condition-based cleaning of PV modules in accordance with manufacturer's recommendations. Monitor energy generation efficiency and schedule cleaning accordingly. | Energy production records; maintenance logs | Monthly | PV system operating at optimum efficiency | O&M Contractor | FUHSO | **2,000** |
| **Fire hazard associated with battery energy storage system (BESS), inverters and** | Maintain automatic isolation systems, fire extinguishers and emergency shutdown facilities. Inspect battery | Fire protection inspection reports | Quarterly | Fire protection systems functional | O&M Contractor | REA PMU / FUHSO Safety Unit | **2,500** |

| Summary of Potential Impact | Mitigation Measures | Monitoring Requirements / Parameters | Frequency | Performance Indicator | Responsibility for Implementation | Responsibility for Monitoring | Estimated Cost (USD/Year) |
|---|---|---|---|---|---|---|---|
| **electrical installations** | banks and electrical equipment regularly. Conduct periodic fire drills and emergency response exercises. | | | | | | |
| **Vegetation encroachment beneath and around PV arrays** | Control vegetation through periodic mechanical clearing. Avoid indiscriminate herbicide application except where specifically approved. Maintain adequate vegetation clearance around electrical installations. | Site inspection | Quarterly | Vegetation maintained within acceptable limits | O&M Contractor | FUHSO | **1,000** |
| **Visual deterioration and poor housekeeping** | Maintain good housekeeping practices throughout the facility. Remove wastes promptly. Maintain drainage channels, access roads and landscaped areas in good condition. | Site inspection | Monthly | Clean and orderly facility | O&M Contractor | FUHSO | **800** |

| Summary of Potential Impact | Mitigation Measures | Monitoring Requirements / Parameters | Frequency | Performance Indicator | Responsibility for Implementation | Responsibility for Monitoring | Estimated Cost (USD/Year) |
|---|---|---|---|---|---|---|---|
| **Air emissions associated with maintenance vehicles** | Ensure all maintenance vehicles are regularly serviced and maintained. Minimize unnecessary engine idling during maintenance activities. | Vehicle inspection records | Quarterly | Properly maintained vehicles | O&M Contractor | REA PMU | **500** |
| **Environmental non-compliance** | Conduct periodic environmental monitoring and internal environmental audits. Implement corrective actions where non-conformities are identified. Maintain environmental records and submit monitoring reports to REA and relevant regulatory agencies. | Monitoring reports; audit reports | Quarterly | Full environmental compliance achieved | O&M Contractor / FUHSO | REA PMU / FMEnv | **2,500** |

**Table 7.3b: Social Management Measures for the Operational Phase of the Proposed Project**

| Summary of Potential Impact | Mitigation Measures | Monitoring Requirements / Parameters | Frequency | Performance Indicator | Responsibility for Implementation | Responsibility for Monitoring | Estimated Cost (USD/Year) |
|---|---|---|---|---|---|---|---|
| **Occupational health and safety risks during operation and maintenance** | Implement the approved Occupational Health and Safety (OHS) Plan. Ensure all operational personnel receive regular HSE training and refresher courses. Provide and enforce the use of appropriate Personal Protective Equipment (PPE). | HSE inspection reports; PPE compliance records | Monthly | Zero fatalities and reduced Lost Time Injury Frequency Rate (LTIFR) | O&M Contractor / FUHSO | REA PMU | **3,000** |
| | Maintain first aid facilities, emergency response equipment and trained first aid personnel at the facility. | Inspection records | Monthly | Emergency facilities functional | O&M Contractor | FUHSO | |
| | Conduct routine safety inspections and investigate all incidents, accidents and near misses. | Incident register | Monthly | Corrective actions implemented | O&M Contractor | REA PMU | |
| **Electrical hazards, electrocution** | Restrict access to electrical installations to authorized and | Maintenance records; inspection reports | Monthly | Zero unauthorized access to | O&M Contractor | REA PMU | **2,000** |

| Summary of Potential Impact | Mitigation Measures | Monitoring Requirements / Parameters | Frequency | Performance Indicator | Responsibility for Implementation | Responsibility for Monitoring | Estimated Cost (USD/Year) |
|---|---|---|---|---|---|---|---|
| **and arc flash risks** | competent personnel only. Implement Lock-Out/Tag-Out (LOTO) procedures before maintenance activities. Clearly label all electrical equipment and maintain appropriate warning signage. | | | electrical installations | | | |
| **Gender-Based Violence (GBV), Sexual Exploitation and Abuse (SEA) and Sexual Harassment (SH)** | Continue implementation of the REA GBV Action Plan. Maintain awareness programmes and enforce the Workers' Code of Conduct. Maintain confidential reporting channels and ensure prompt investigation of all complaints. | Training records; grievance records | Quarterly | Zero unresolved GBV/SEA/SH complaints | FUHSO / O&M Contractor | REA PMU | **1,500** |
| **Labour welfare and employment conditions** | Maintain fair employment practices in accordance with Nigerian labour legislation and International Labour | Employment records | Annual | Full compliance with labour requirements | FUHSO / O&M Contractor | REA PMU | **800** |

| Summary of Potential Impact | Mitigation Measures | Monitoring Requirements / Parameters | Frequency | Performance Indicator | Responsibility for Implementation | Responsibility for Monitoring | Estimated Cost (USD/Year) |
|---|---|---|---|---|---|---|---|
| | Organization (ILO) principles. Provide equal employment opportunities and prohibit discrimination, child labour and forced labour. | | | | | | |
| **Community health and safety** | Maintain perimeter fencing, warning signs and controlled access to the solar facility. Prevent unauthorized public access to operational equipment. Ensure emergency contacts remain publicly available. | Site inspection | Monthly | Zero public safety incidents | FUHSO | REA PMU | **1,000** |
| **Stakeholder engagement and public communication** | Continue implementation of the Stakeholder Engagement Plan (SEP). Periodically engage University Management and other relevant stakeholders on Project performance | Stakeholder meeting records | Quarterly | Stakeholder consultations conducted | FUHSO | REA PMU | **1,500** |

| Summary of Potential Impact | Mitigation Measures | Monitoring Requirements / Parameters | Frequency | Performance Indicator | Responsibility for Implementation | Responsibility for Monitoring | Estimated Cost (USD/Year) |
|---|---|---|---|---|---|---|---|
| | and operational issues. | | | | | | |
| **Grievance management** | Maintain and operate the Grievance Redress Mechanism (GRM). Record, investigate and resolve all complaints within the prescribed timeframe. Maintain grievance records for audit purposes. | Grievance register | Continuous | ≥95% grievances resolved within specified timelines | FUHSO | REA PMU | **700** |
| **Security of Project facilities** | Maintain adequate security personnel and surveillance systems. Control visitor access and coordinate security arrangements with the University's Security Unit and relevant government security agencies where necessary. | Security inspection reports | Monthly | No major security breaches | FUHSO | REA PMU | **2,000** |
| **Capacity building and technical competence** | Conduct periodic technical training on PV system operation, battery management, emergency response, | Training records | Bi-annually | Staff competency maintained | FUHSO / O&M Contractor | REA PMU | **2,500** |

| Summary of Potential Impact | Mitigation Measures | Monitoring Requirements / Parameters | Frequency | Performance Indicator | Responsibility for Implementation | Responsibility for Monitoring | Estimated Cost (USD/Year) |
|---|---|---|---|---|---|---|---|
| | electrical safety, environmental management and fire prevention for operational personnel. | | | | | | |
| **Emergency preparedness and business continuity** | Conduct periodic emergency drills covering fire, electrocution, battery failure and extreme weather events. Review and update the Emergency Preparedness and Response Plan annually. | Drill reports | Bi-annually | Emergency response readiness maintained | FUHSO / O&M Contractor | REA PMU | **2,000** |

## 7.4 Roles, Responsibilities and Accountabilities

Successful implementation of the ESMP will require clearly defined institutional responsibilities and effective coordination among all organizations involved in the Project. Each party shall be responsible for implementing environmental and social management measures within its respective scope of work while ensuring compliance with applicable environmental legislation, regulatory requirements, REA environmental and social policies, and international good practice.

The principal organizations responsible for ESMP implementation include:

- Rural Electrification Agency (REA);
- REA Project Management Unit (PMU);
- Federal University of Health Sciences, Otukpo (FUHSO);
- Engineering, Procurement and Construction (EPC) Contractor;
- Operations and Maintenance (O&M) Contractor;
- Supervising Engineer/Owner's Engineer;
- Federal Ministry of Environment (FMEnv);
- Benue State Ministry of Environment and Climate Change;
- Otukpo Local Government Authority;
- Relevant environmental, health and safety regulatory agencies; and
- Host stakeholders and other interested parties.

The roles and responsibilities of these organizations during the various phases of the Project are presented in the following sections.

### 7.4.1 Roles, Responsibilities and Accountabilities During the Pre-Construction Phase

**Table 7.4: Roles and Responsibilities during the Pre-Construction Phase**

| Organization | Roles and Responsibilities |
|---|---|
| **Rural Electrification Agency (REA)** | • Provide overall Project oversight and coordination.<br>• Ensure compliance with the approved ESIA and ESMP.<br>• Secure statutory approvals prior to Project commencement.<br>• Ensure adequate environmental and social safeguards are integrated into Project implementation. |
| **REA Project Management Unit (PMU)** | • Supervise implementation of the ESMP.<br>• Review and approve the Contractor's Environmental and Social Management Plan (C-ESMP).<br>• Monitor compliance with environmental and social requirements.<br>• Coordinate environmental reporting and stakeholder engagement activities. |
| **Federal University of Health Sciences, Otukpo (FUHSO)** | • Provide access to the approved Project site.<br>• Liaise with REA and the EPC Contractor throughout Project implementation.<br>• Facilitate communication with University stakeholders.<br>• Support stakeholder consultations and grievance resolution where required. |

| Organization | Roles and Responsibilities |
|---|---|
| **Engineering, Procurement and Construction (EPC) Contractor** | • Prepare and implement the Contractor's ESMP.<br>• Develop project-specific management plans before mobilization.<br>• Conduct environmental and HSE induction for all personnel.<br>• Provide competent environmental, social and HSE personnel.<br>• Ensure compliance with all environmental and social obligations contained in the contract documents. |
| **Supervising Engineer / Owner's Engineer** | • Supervise construction readiness activities.<br>• Verify Contractor compliance before commencement of works.<br>• Review environmental documentation submitted by the Contractor.<br>• Report non-conformities to REA PMU. |
| **Federal Ministry of Environment (FMEnv)** | • Provide regulatory oversight.<br>• Review ESIA compliance where applicable.<br>• Conduct environmental compliance inspections as required. |
| **Benue State Ministry of Environment and Climate Change** | • Monitor compliance with applicable State environmental requirements.<br>• Participate in environmental inspections where necessary.<br>• Liaise with REA on environmental compliance matters within the State. |
| **Otukpo Local Government Authority** | • Support coordination of local administrative issues where applicable.<br>• Facilitate communication with relevant local stakeholders when required. |
| **University Security Unit** | • Support site security during mobilization.<br>• Control access to the Project site before construction commences.<br>• Coordinate security arrangements with the EPC Contractor. |
| **Environmental and Social Safeguards Specialist (REA PMU)** | • Monitor implementation of environmental and social safeguard requirements.<br>• Conduct compliance inspections.<br>• Verify implementation of mitigation measures.<br>• Review environmental monitoring reports submitted by the Contractor. |
| **Health, Safety and Environment (HSE) Officer (Contractor)** | • Develop Project HSE procedures.<br>• Conduct safety induction.<br>• Ensure availability of PPE and emergency facilities.<br>• Maintain HSE records and incident reporting system. |

### 7.4.2 Roles, Responsibilities and Accountabilities During the Construction Phase

**Table 7.5: Roles and Responsibilities during the Construction Phase**

| Organization | Roles and Responsibilities |
|---|---|
| **REA PMU** | • Overall supervision of ESMP implementation.<br>• Conduct periodic environmental and social compliance monitoring.<br>• Review Contractor's monthly environmental reports.<br>• Ensure implementation of corrective actions where necessary. |
| **EPC Contractor** | • Implement all mitigation measures contained in the ESMP.<br>• Ensure compliance with statutory environmental requirements.<br>• Implement approved management plans.<br>• Maintain environmental monitoring records.<br>• Report environmental incidents promptly. |
| **Contractor's Environmental Officer** | • Conduct routine environmental inspections.<br>• Monitor waste management, erosion control, pollution prevention and housekeeping.<br>• Prepare environmental monitoring reports.<br>• Coordinate environmental awareness programmes. |
| **Contractor's HSE Officer** | • Enforce HSE procedures.<br>• Conduct toolbox meetings.<br>• Investigate accidents and incidents.<br>• Monitor PPE compliance.<br>• Coordinate emergency preparedness activities. |
| **Supervising Engineer** | • Verify Contractor compliance with contract specifications and ESMP requirements.<br>• Conduct routine site inspections.<br>• Recommend corrective actions where required. |
| **FUHSO Management** | • Coordinate Project activities within the University.<br>• Facilitate access to Project facilities.<br>• Participate in stakeholder engagement activities.<br>• Support grievance resolution where necessary. |
| **FMEnv / Benue State Ministry of Environment** | • Conduct regulatory inspections where applicable.<br>• Verify environmental compliance.<br>• Enforce applicable environmental legislation where necessary. |
| **University Security Unit** | • Maintain security of Project facilities.<br>• Control site access.<br>• Support emergency response where necessary. |
| **Community Liaison Officer** | • Maintain communication with stakeholders.<br>• Manage stakeholder enquiries.<br>• Maintain grievance register.<br>• Coordinate community consultations. |

### 7.4.3 Roles, Responsibilities and Accountabilities During the Operation Phase

**Table 7.6: Roles and Responsibilities during Operation Phase**

| Organization | Roles and Responsibilities |
|---|---|
| **Federal University of Health Sciences, Otukpo (FUHSO)** | • Assume overall ownership and day-to-day management of the facility.<br>• Ensure adequate budgetary provision for operation and maintenance.<br>• Implement the ESMP throughout facility operation. |
| **Operations and Maintenance (O&M) Contractor** | • Operate and maintain the Solar PV Hybrid Power Plant.<br>• Implement preventive maintenance programmes.<br>• Conduct routine inspections.<br>• Maintain operational records.<br>• Implement environmental monitoring programmes. |
| **REA PMU** | • Undertake periodic post-construction environmental audits.<br>• Monitor long-term ESMP implementation.<br>• Review operational environmental reports submitted by FUHSO and the O&M Contractor. |
| **FUHSO Works and Physical Planning Department** | • Coordinate routine operation of the facility.<br>• Monitor equipment performance.<br>• Coordinate maintenance scheduling.<br>• Maintain asset management records. |
| **Environmental Officer** | • Monitor environmental performance.<br>• Supervise waste management activities.<br>• Coordinate environmental reporting.<br>• Verify implementation of corrective actions. |
| **HSE Officer** | • Monitor occupational health and safety performance.<br>• Conduct periodic safety inspections.<br>• Coordinate emergency drills.<br>• Maintain incident reporting system. |
| **FMEnv / Benue State Ministry of Environment and Climate Change** | • Conduct periodic compliance inspections.<br>• Review environmental monitoring reports where required.<br>• Verify continued regulatory compliance. |
| **University Security Unit** | • Maintain security of Project assets.<br>• Control access to electrical installations.<br>• Support emergency response activities. |
| **Battery and Equipment Suppliers** | • Provide technical support under warranty agreements where applicable.<br>• Participate in Extended Producer Responsibility (EPR) and equipment take-back programmes for end-of-life batteries, PV modules and other electrical equipment. |

## 7.5 Additional Management Plans

This section provides a framework for the preparation and implementation of additional environmental and social management plans required to support the effective implementation of the Environmental and Social Management Plan (ESMP) for the proposed 2 MW Solar Photovoltaic (PV) Hybrid Power Project and Associated Infrastructure at the Federal University of Health Sciences, Otukpo (FUHSO), Benue State.

These management plans provide detailed procedures for managing specific environmental and social aspects identified during the ESIA and shall be prepared and implemented by the EPC Contractor prior to commencement of construction, and subsequently maintained by the Operations and Maintenance (O&M) Contractor throughout the operational phase of the Project.
The plans shall be developed in accordance with the requirements of the Environmental and Social Management Framework (ESMF) for the Nigeria Electrification Project (NEP), the African Development Bank Integrated Safeguards System (ISS, 2023), applicable Federal and Benue State environmental regulations, and recognized international good industry practice.

### 7.5.1 Stakeholder Engagement Plan (SEP)

A comprehensive Stakeholder Engagement Plan (SEP) shall be prepared and implemented throughout the Project lifecycle to ensure continuous engagement with all stakeholders who may influence, or be affected by, the proposed Project.
The objectives of the SEP shall include:

- Ensuring early and continuous stakeholder participation throughout the Project lifecycle;
- Promoting open, transparent and culturally appropriate communication with stakeholders;
- Providing accurate and timely information regarding Project activities and implementation schedules;
- Establishing and maintaining productive relationships between the Rural Electrification Agency (REA), FUHSO and other stakeholders;
- Ensuring vulnerable and potentially disadvantaged groups are adequately consulted and able to participate effectively;
- Managing stakeholder expectations regarding Project benefits and potential impacts;
- Providing opportunities for stakeholders to express concerns, suggestions and recommendations;
- Ensuring stakeholder consultations are conducted free from intimidation, manipulation or coercion; and
- Ensuring compliance with applicable national legislation, AfDB safeguard requirements and international good practice.

REA shall ensure that adequate institutional arrangements, personnel and financial resources are made available for effective implementation of the SEP throughout the Project lifecycle.
In accordance with the NEP Environmental and Social Management Framework (ESMF), the SEP shall include, among others:

- Applicable legal and institutional requirements for stakeholder engagement and information disclosure;
- Identification and analysis of Project stakeholders;
- Stakeholder engagement strategy and implementation schedule;

- Roles and responsibilities for implementation;
- Communication methods and information disclosure procedures;
- Documentation and reporting procedures; and
- Integration of stakeholder engagement into the overall Project management system.

#### 7.5.1.1 Grievance Redress Mechanism (GRM)

A Project-specific Grievance Redress Mechanism (GRM) shall be established before commencement of construction and maintained throughout the Project lifecycle. The GRM shall provide an accessible, transparent and timely process for receiving, documenting, investigating and resolving complaints arising from Project activities. The mechanism shall be readily accessible to all stakeholders, including University staff, contractors, visitors and other interested parties.
The GRM shall include:

- Multiple grievance reporting channels;
- Registration and acknowledgement of grievances;
- Investigation and assessment procedures;
- Resolution and feedback mechanisms;
- Documentation and tracking of grievances;
- Appeal procedures where necessary; and
- Periodic reporting on grievance management performance.

Appropriate procedures shall also be established for confidential reporting and management of Gender-Based Violence (GBV), Sexual Exploitation and Abuse (SEA), and Sexual Harassment (SH) complaints.

### 7.5.2 Traffic Management Plan (TMP)

A Traffic Management Plan shall be developed prior to commencement of construction to minimize traffic disruption and ensure the safety of Project personnel, University users and other road users. The TMP shall include traffic routing, speed limits, vehicle scheduling, warning signage, designated parking areas, driver requirements, emergency access arrangements and incident reporting procedures.

### 7.5.3 Waste Management Plan (WMP)

A Waste Management Plan shall be prepared and implemented to ensure that all wastes generated during construction and operation are managed in accordance with the waste management hierarchy of avoidance, reduction, reuse, recycling and environmentally sound disposal.
The Plan shall include procedures for managing:

- Domestic wastes;
- Construction wastes;
- Hazardous wastes;
- Electronic wastes (e-waste);
- Waste batteries;
- Used oils and lubricants; and
- Spill response and contaminated materials.

### 7.5.4 Occupational Health and Safety (OHS) Plan

A comprehensive Occupational Health and Safety Plan shall be implemented throughout the Project lifecycle. The Plan shall include:

- Hazard identification and risk assessment;
- Safe work procedures;
- Personal Protective Equipment (PPE);
- Occupational health surveillance;
- Emergency response procedures;
- Incident reporting and investigation;
- Safety inspections and audits;
- Toolbox meetings;
- Worker training and competency development; and
- Continuous monitoring of occupational health and safety performance.

### 7.5.5 Local Employment Management Plan (LEMP)

The Local Employment Management Plan shall promote fair, transparent and non-discriminatory employment practices while maximizing employment opportunities for qualified local personnel, particularly for unskilled and semi-skilled positions. The Plan shall include employment targets, recruitment procedures, skills development, training programmes and monitoring of workforce composition.

### 7.5.6 Erosion Control Management Plan

The Erosion Control Management Plan shall minimize soil erosion and sediment transport during Project implementation. The Plan shall include:

- Limiting vegetation clearance to approved work areas;
- Temporary stabilization of exposed soils;
- Stockpiling and protection of topsoil;
- Installation of erosion and sediment control measures;
- Progressive site restoration; and
- Inspection following significant rainfall events.

### 7.5.7 Water Conservation Plan

The Water Conservation Plan shall promote efficient use of groundwater resources during construction and operation. The Plan shall include:

- Efficient water use during construction;
- Condition-based cleaning of photovoltaic modules;
- Use of the dedicated Project borehole equipped with a solar-powered pumping system;
- Routine inspection of the borehole and pumping facilities;
- Leak detection and repair; and
- Monitoring of water consumption.

### 7.5.8 Emergency Preparedness and Response Plan (EPRP)

The Emergency Preparedness and Response Plan shall provide procedures for responding to foreseeable emergency situations associated with the Project. The Plan shall address:

- Fire outbreaks;
- Battery thermal runaway incidents;
- Electrical faults and electrocution;
- Fuel and chemical spills;
- Medical emergencies;
- Severe weather events;
- Emergency communication procedures;
- Emergency response training and drills; and
- Periodic review and testing of emergency response arrangements.

### 7.5.9 REA Gender-Based Violence (GBV) Action Plan

The REA GBV Action Plan shall be implemented throughout the Project lifecycle to prevent and respond effectively to Gender-Based Violence (GBV), Sexual Exploitation and Abuse (SEA), and Sexual Harassment (SH). The Plan shall include:

- GBV risk management;
- Contractor Code of Conduct;
- GBV awareness training;
- Confidential reporting mechanisms;
- Survivor-centred response procedures;
- Appointment of designated focal persons where required; and
- Integration of GBV monitoring into the Project GRM.

### 7.5.10 Livelihood Restoration Plan (LRP)

Based on the findings of this ESIA, the proposed Project will be developed entirely within University-owned land at the FUHSO Permanent Campus and is not expected to result in physical displacement or significant economic displacement requiring a standalone Livelihood Restoration Plan. Nevertheless, should unforeseen livelihood impacts arise during Project implementation, appropriate livelihood restoration measures consistent with the REA Environmental and Social Management Framework (ESMF) and applicable national regulations shall be implemented to restore affected persons to at least their pre-impact livelihood conditions.

### 7.5.11 Summary of Additional Management Plans

Table 7.7 summarizes the additional environmental and social management plans to be prepared and implemented for the proposed 2 MW Solar Photovoltaic (PV) Hybrid Power Project and Associated Infrastructure at the Federal University of Health Sciences, Otukpo (FUHSO), Benue State. These plans shall complement the ESMP and provide detailed procedures for managing specific environmental and social risks throughout the Project lifecycle.

### Table 7.7: Summary of Additional Management Plans

| S/N | Management Plan | Primary Objective | Timing for Development | Estimated Cost (USD) |
|---|---|---|---|---|
| **1** | Stakeholder Engagement Plan (SEP) | Promote continuous stakeholder engagement, communication and information disclosure throughout the Project lifecycle. | Pre-Construction | **2,500** |
| **2** | Grievance Redress Mechanism (GRM) | Provide an effective mechanism for receiving, documenting and resolving Project-related grievances. | Pre-Construction | **2,000** |
| **3** | Traffic Management Plan (TMP) | Minimize traffic disruption and ensure road safety during construction and operation. | Pre-Construction | **2,000** |
| **4** | Waste Management Plan (WMP) | Ensure environmentally sound management of hazardous and non-hazardous wastes generated by the Project. | Pre-Construction | **3,500** |
| **5** | Occupational Health and Safety (OHS) Plan | Protect workers and visitors through effective occupational health and safety management. | Pre-Construction | **3,000** |
| **6** | Local Employment Management Plan (LEMP) | Promote transparent recruitment, local employment and workforce development. | Pre-Construction | **2,000** |
| **7** | Erosion Control Management Plan | Prevent soil erosion and sediment transport during Project implementation. | Pre-Construction | **2,000** |
| **8** | Water Conservation Plan | Promote efficient groundwater use and sustainable water management for construction and operation. | Pre-Construction | **1,500** |
| **9** | Emergency Preparedness and Response Plan (EPRP) | Establish effective emergency response procedures for foreseeable emergencies. | Pre-Construction | **3,000** |
| **10** | REA Gender-Based Violence (GBV) Action Plan | Prevent and manage GBV, SEA and SH risks throughout the Project lifecycle. | Pre-Construction | **2,500** |
| **11** | Livelihood Restoration Framework (if required) | Provide a framework for addressing any unforeseen livelihood impacts that may arise during Project implementation. | As Required | **1,500** |
| **Total Estimated Cost** | | | | **25,500** |

## 7.6 Environmental Monitoring Programme

Environmental and social monitoring forms an integral component of the Environmental and Social Management Plan (ESMP). The monitoring programme is intended to verify compliance with applicable environmental legislation, regulatory requirements and international good industry practice, while evaluating the effectiveness of the mitigation measures proposed in this ESIA. The monitoring programme will be implemented throughout the construction and operational phases of the Project and will enable the timely identification of any unforeseen environmental or social issues requiring corrective action. Monitoring results shall be documented, reviewed periodically and submitted to the Rural Electrification Agency (REA) and relevant regulatory authorities in accordance with applicable reporting requirements. Table 7.8 presents the proposed environmental and social monitoring programme for the Project.

### Table 7.8: Environmental and Social Monitoring Programme

| Environmental/ Social Component | Monitoring Location | Monitoring Method | Parameters | Compliance Requirement | Frequency | Responsibility for Implementation | Monitoring Responsibility | Project Phase | Estimated Cost (USD) |
|---|---|---|---|---|---|---|---|---|---|
| Air Quality | Project site and surrounding work areas | Portable air quality monitor | $PM_{2.5}$, $PM_{10}$, TSP, CO, $NO_2$, $SO_2$ | FMEnv, WHO, AfDB ISS | Monthly | EPC Contractor | REA PMU / Benue State Ministry of Environment and Climate Change | Construction | 2,500 |
| Ambient Noise | Project site boundary | Sound level meter | Daytime and Night-time Noise Levels (dBA) | FMEnv, WHO | Monthly | EPC Contractor | REA PMU | Construction | 1,500 |
| Soil Quality | Project site | Soil sampling and laboratory analysis | pH, EC, TOC, TPH, Heavy Metals, Nutrients | FMEnv / NESREA | Quarterly | EPC Contractor / O&M Contractor | REA PMU | Construction & Operation | 3,500 |
| Groundwater Quality | Project borehole | Water sampling and laboratory analysis | pH, EC, TDS, Turbidity, Major Ions, Heavy Metals, Microbiology | FMEnv / WHO | Quarterly | O&M Contractor | REA PMU | Operation | 3,500 |
| Surface Water Quality | Aloma River (Representative Monitoring Location) | Water sampling and laboratory analysis | Temperature, pH, EC, TDS, DO, BOD, COD, Nutrients, | FMEnv / WHO | Annually | O&M Contractor | REA PMU | Operation | 2,500 |

| Environmental/ Social Component | Monitoring Location | Monitoring Method | Parameters | Compliance Requirement | Frequency | Responsibility for Implementation | Monitoring Responsibility | Project Phase | Estimated Cost (USD) |
|---|---|---|---|---|---|---|---|---|---|
| | | | Heavy Metals | | | | | | |
| Waste Management | Project site | Inspection and records review | Waste segregation, storage, transportation and disposal records | FMEnv / NESREA | Monthly | EPC Contractor / O&M Contractor | REA PMU | Construction & Operation | 2,000 |
| Occupational Health and Safety | Entire Project site | Site inspection | PPE compliance, incident records, unsafe acts/conditions | Factories Act, ILO, FMEnv | Daily / Monthly Reporting | EPC Contractor / O&M Contractor | REA PMU | Construction & Operation | 2,500 |
| Vegetation and Site Restoration | Project site | Visual inspection | Vegetation recovery, erosion, invasive species | ESMP Requirements | Quarterly | EPC Contractor / O&M Contractor | REA PMU | Construction & Operation | 1,500 |
| Water Consumption | Project borehole and solar-powered pumping system | Meter readings and inspection | Water abstraction, borehole performance, leaks | Water Conservation Plan | Monthly | O&M Contractor | FUHSO / REA PMU | Operation | 1,200 |
| Stakeholder Engagement | FUHSO and relevant stakeholders | Review of consultation records | Stakeholder meetings, grievances, information disclosure | Stakeholder Engagement Plan | Quarterly | REA / FUHSO | REA PMU | Construction & Operation | 2,000 |

| Environmental/ Social Component | Monitoring Location | Monitoring Method | Parameters | Compliance Requirement | Frequency | Responsibility for Implementation | Monitoring Responsibility | Project Phase | Estimated Cost (USD) |
|---|---|---|---|---|---|---|---|---|---|
| Grievance Redress Mechanism | Project Area of Influence | GRM register review | Number of grievances received, resolved and pending | GRM Procedures | Quarterly | REA / FUHSO | REA PMU | Construction & Operation | 1,000 |
| GBV/SEA/SH Monitoring | Project workforce | Records review and awareness monitoring | GBV complaints, awareness activities, Code of Conduct compliance | REA GBV Action Plan | Quarterly | EPC Contractor / O&M Contractor | REA PMU | Construction & Operation | 1,500 |
| **Total Estimated Monitoring Cost** | | | | | | | | | **USD 25,200** |

## 7.7 Training, Awareness and Capacity Building

Effective implementation of the ESMP requires that all personnel involved in the Project possess adequate knowledge of their environmental and social responsibilities. Accordingly, REA shall ensure that appropriate training, awareness and capacity-building programmes are implemented for Project personnel throughout the Project lifecycle. Training programmes shall focus on improving technical competence, environmental awareness, occupational health and safety, emergency preparedness, waste management, stakeholder engagement, and implementation of the ESMP. Where necessary, specialized training shall also be provided on battery energy storage systems, electrical safety, fire prevention, and emergency response procedures. Awareness programmes shall equally be extended to relevant University personnel and other stakeholders to promote environmental stewardship and safe operation of the facility.

**Table 7.9: Institutional Capacity Strengthening Plan**

| Target Group | Training Programme | Frequency | Estimated Cost (USD) |
|---|---|---|---|
| REA PMU, Supervising Engineer, EPC Contractor and O&M Contractor | ESMP implementation, environmental compliance, monitoring and reporting | Before commencement of works and annually | 3,000 |
| Site Engineers and Technical Personnel | Solar PV operation, battery management, electrical safety, emergency shutdown procedures | Annually | 2,500 |
| Health, Safety and Environment Personnel | Occupational health and safety, incident investigation, emergency response and first aid | Annually | 2,000 |
| FUHSO Facility Management Personnel | Operation and maintenance of the solar hybrid system and environmental management | Annually | 2,000 |
| Security Personnel | Emergency response, fire prevention and access control | Annually | 1,000 |
| Project Workforce | Environmental awareness, PPE, waste management, Code of Conduct and GBV awareness | Quarterly | 2,000 |
| Relevant Stakeholders | Environmental awareness, community health and safety, stakeholder engagement and grievance procedures | Annually | 1,500 |
| **Total Capacity Building Cost:** | | | **USD 14,000** |

## 7.8 Implementation Schedule and Reporting

Implementation of the ESMP shall commence prior to mobilization and continue throughout the construction, operational and decommissioning phases of the Project. The EPC Contractor shall be responsible for implementing the ESMP during construction, while the Operations and Maintenance (O&M) Contractor, in collaboration with FUHSO, shall implement the ESMP during operation. Environmental and social monitoring reports shall be prepared and submitted periodically to the REA Project Management Unit (PMU), while statutory compliance reports shall be submitted to the Federal Ministry of Environment, Benue State Ministry of Environment and Climate Change, and other relevant regulatory authorities as required. Any environmental incidents, accidents or non-compliance identified during implementation shall be investigated promptly, and corrective actions implemented without undue delay.

## 7.9 ESMP Costing

The estimated cost for implementing the Environmental and Social Management Plan (ESMP) is presented in Table 7.10. The cost covers environmental and social mitigation measures, monitoring activities, preparation and implementation of additional management plans, institutional capacity strengthening, stakeholder engagement and environmental reporting.

**Table 7.10: Summary of ESMP Cost Estimate**

| S/N | ESMP Activity | Estimated Cost (USD) |
|---|---|---|
| **1** | Pre-Construction Environmental Management Measures | 9,000 |
| **2** | Pre-Construction Social Management Measures | 13,000 |
| **3** | Construction Environmental Management Measures | 29,000 |
| **4** | Construction Social Management Measures | 29,000 |
| **5** | Operational Environmental Management Measures (Annual) | 16,500 |
| **6** | Operational Social Management Measures (Annual) | 17,000 |
| **7** | Additional Management Plans | 25,500 |
| **8** | Environmental and Social Monitoring Programme | 25,200 |
| **9** | Training, Awareness and Capacity Building | 14,000 |
| **Total Initial ESMP Implementation Cost** *(excluding annual operational costs)* | | **144,700** |
| **Annual Operational ESMP Cost** | | **33,500 per annum** |

## 7.10 Stakeholder Engagement

Stakeholder engagement is a continuous and systematic process of identifying stakeholders, disclosing relevant Project information, obtaining feedback, addressing concerns, and fostering constructive relationships throughout the Project lifecycle. Effective stakeholder engagement promotes transparency, accountability and informed decision-making, while strengthening public confidence in Project implementation. For the proposed 2 MW Solar Photovoltaic (PV) Hybrid Power Project and Associated Infrastructure at the Federal University of Health Sciences, Otukpo (FUHSO), Benue State, stakeholder engagement commenced during the ESIA process through consultations with the University Management, relevant government institutions and other identified stakeholders. The process provided an opportunity to obtain baseline information, understand stakeholder expectations, identify potential environmental and social concerns, and

incorporate stakeholder inputs into Project planning and impact mitigation. REA shall continue stakeholder engagement throughout the construction, operational and decommissioning phases of the Project in accordance with the Nigeria Electrification Project (NEP) Environmental and Social Management Framework (ESMF), the African Development Bank Integrated Safeguards System (ISS, 2023), the Environmental Impact Assessment Act Cap E12 LFN 2004, and other applicable national legislation and international good practice.

### 7.10.1 Legal and Administrative Framework Guiding Stakeholder Engagement

Stakeholder engagement for the proposed Project shall be undertaken in accordance with applicable national legislation and international environmental and social safeguard requirements.

**a. Nigerian Legislative Requirements**

The principal legislation guiding stakeholder engagement includes:

- Environmental Impact Assessment (EIA) Act Cap E12, Laws of the Federation of Nigeria (LFN), 2004;
- Federal Ministry of Environment (FMEnv) EIA Procedural Guidelines;
- National Environmental Standards and Regulations Enforcement Agency (NESREA) Act and relevant regulations;
- Other applicable Federal and Benue State environmental legislation.

These instruments require public participation, information disclosure and stakeholder consultation during environmental assessment and Project implementation.

**b. International Requirements**

The Project shall also comply with relevant international requirements, including:

- African Development Bank Integrated Safeguards System (ISS, 2023);
- African Development Bank Operational Safeguards;
- Nigeria Electrification Project (NEP) Environmental and Social Management Framework (ESMF);
- International Finance Corporation (IFC) Good Practice Handbook on Stakeholder Engagement; and
- Other applicable international good industry practice.

### 7.10.2 Objectives of Stakeholder Engagement

The objectives of stakeholder engagement are to:

- provide timely, accurate and accessible information on the proposed Project;
- promote transparency and accountability throughout Project implementation;
- obtain stakeholder views and incorporate relevant concerns into Project planning;
- identify and manage environmental and social risks at an early stage;
- strengthen collaboration between REA, FUHSO, regulatory agencies and other stakeholders;
- establish effective communication channels throughout the Project lifecycle;
- promote inclusive participation, particularly for vulnerable and disadvantaged groups; and
- provide an effective mechanism for resolving Project-related grievances.

### 7.10.3 Stakeholder Identification and Analysis

Stakeholders include individuals, groups and institutions that may influence, be affected by, or have an interest in the Project.

Based on the ESIA consultations, the principal stakeholders include:

- Rural Electrification Agency (REA);
- African Development Bank (AfDB);
- Federal Ministry of Environment (FMEnv);
- National Environmental Standards and Regulations Enforcement Agency (NESREA);
- Federal Ministry of Power;
- Benue State Ministry of Environment and Climate Change;
- Benue State Environmental Sanitation Authority (where applicable);
- Benue State Ministry of Women Affairs and Social Development;
- Benue State Ministry of Health;
- Otukpo Local Government Authority;
- Federal University of Health Sciences, Otukpo (University Management);
- Physical Planning Unit;
- Works and Maintenance Department;
- University Security Unit;
- Staff and students of FUHSO;
- Contractors and suppliers; and
- Other relevant government agencies and interested stakeholders.

Unlike many infrastructure projects, the proposed Project is located entirely within the University's Permanent Campus on University-owned land. The immediate Project area is largely undeveloped and there are no neighbouring residential communities within the Project footprint that would be directly affected by Project implementation.

### 7.10.4 Stakeholder Register

REA shall maintain and periodically update a Stakeholder Register containing:

- stakeholder name and organization;
- category of stakeholder;
- contact information;
- stakeholder interests and concerns;
- consultation records;
- commitments made;
- follow-up actions; and
- status of implementation.

The register shall be reviewed and updated throughout the Project lifecycle.

### 7.10.5 Stakeholder Engagement Process

Stakeholder engagement shall remain an ongoing process throughout Project implementation.

The engagement programme shall include:

- periodic stakeholder identification and review;
- continuous information disclosure;
- regular consultations and meetings;
- documentation of stakeholder concerns and responses;

- operation of the Project Grievance Redress Mechanism (GRM);
- monitoring of stakeholder satisfaction; and
- periodic reporting of stakeholder engagement activities.

The engagement process shall be conducted in a transparent, inclusive, culturally appropriate and non-discriminatory manner, free from coercion, intimidation or manipulation.

### 7.10.6 Stakeholder Engagement Tools and Communication

Depending on the stakeholder group and Project phase, communication may include:

- formal stakeholder meetings;
- one-on-one consultations;
- focus group discussions;
- technical workshops;
- official correspondence;
- telephone and electronic communication;
- emails;
- Project notices and information boards;
- Project reports and information materials;
- grievance reporting channels; and
- periodic monitoring visits.

The communication method adopted shall be appropriate to the nature of the stakeholder and the information being communicated.

### 7.10.7 Principles for Effective Stakeholder Engagement

Stakeholder engagement throughout the Project shall be guided by the following principles:

- transparency in information disclosure and decision-making;
- inclusiveness and equal opportunity for participation;
- accountability for commitments made during consultations;
- respect for stakeholder rights, values and cultural diversity;
- timely response to stakeholder concerns and grievances;
- mutual trust and collaboration; and
- continuous improvement through monitoring and feedback.

### 7.10.8 Stakeholder Consultation Methods

The principal consultation methods to be adopted include:

- formal meetings with regulatory agencies;
- meetings with University Management;
- technical consultations with relevant departments;
- stakeholder workshops where necessary;
- focus group discussions;
- one-on-one consultations;
- written correspondence;
- electronic communication; and
- periodic Project progress meetings.

The frequency of engagement shall depend on the Project phase, stakeholder needs and the significance of issues requiring consultation.

### 7.10.9 Summary of Previous Stakeholder Engagement Activities

Stakeholder engagement was undertaken during the ESIA process to facilitate early participation of stakeholders in the planning of the proposed 2 MW Solar Photovoltaic (PV) Hybrid Power Project and Associated Infrastructure at the Federal University of Health Sciences, Otukpo (FUHSO), Benue State. The consultations were designed to introduce the Project, explain the objectives and scope of the ESIA, obtain baseline environmental and socio-economic information, identify potential concerns and expectations, and provide stakeholders with the opportunity to contribute to Project planning. The consultations also served as a platform for verifying field observations and obtaining institutional and community-level information required for the environmental assessment. Two principal stakeholder consultation meetings were conducted during the ESIA. The first involved a reconnaissance visit and institutional consultation with the Management of the Federal University of Health Sciences, Otukpo (FUHSO), representatives of the Federal Ministry of Environment (FMEnv), Benue State Ministry of Environment, Benue State Ministry of Water Resources, Environment and Climate Change, and the ESIA Consultant Team. The second consultation was held with the host Akwete-Akpa Community and involved traditional leadership, community executives, youth and women representatives, community members, representatives of the Federal Ministry of Environment and the ESIA Consultant Team.

*See Appendix V for the On-Site Meeting with Representatives of the FUHSO Management, Federal Ministry of Environment, Benue State environmental agencies, and Akwete-Akpa Community*

The consultations confirmed that the proposed Project site is located entirely within approximately 10 hectares of University-owned land inside the FUHSO Permanent Campus and does not require additional land acquisition or physical displacement. University Management further confirmed that the permanent campus currently has no electricity supply or connection to the national grid, reinforcing the need for the proposed solar hybrid power project to support future academic, research, administrative and healthcare activities. Site verification also confirmed that the Project site is largely undeveloped, covered predominantly by natural vegetation and void of key farming activities, surface water bodies or groundwater sources within the proposed development footprint. During the community consultation, community members welcomed the proposed Project and expressed appreciation for being informed at the planning stage. Discussions focused on the objectives of the Project, anticipated benefits, the ESIA process, baseline socio-economic data collection and environmental sampling activities. In order to ensure effective participation, the presentations were delivered in English and interpreted into the local language. Community members participated actively in the discussions and socio-economic questionnaire survey, while no significant environmental concerns, objections or conflicts relating to the proposed Project were identified during the consultation.

The consultation process also resulted in several important resolutions that informed the ESIA. Because academic activities had not yet commenced at the permanent campus during the survey period, it was agreed that socio-economic surveys and stakeholder consultations should be extended to the host community to ensure adequate baseline information. In addition, following confirmation that there were no surface water bodies within the Project site, Aloma River, located within Akwete-Akpa Community, was selected as the representative surface-water sampling location for the baseline environmental assessment. University Management also committed to providing continued access to the Project site and relevant institutional information required

throughout the ESIA process. The principal outcomes of the stakeholder engagement are summarized in Table 7.11.

**Table 7.11: Summary of Previous Stakeholder Engagement Activities**

| Stakeholder | Key Issues Discussed | Outcome / Response | How Incorporated into the ESIA |
|---|---|---|---|
| FUHSO Management | Project introduction, site suitability, campus electricity demand, institutional development plans | Confirmed allocation of approximately 10 ha of University-owned land and absence of grid electricity at the permanent campus | Used in Project description, site selection assessment and project justification |
| Federal Ministry of Environment | ESIA requirements, environmental compliance and baseline studies | Confirmed regulatory expectations and supervised commencement of baseline investigations | Reflected in the ESIA methodology and environmental management framework |
| Benue State environmental agencies | Environmental baseline requirements and regulatory coordination | Supported site verification and environmental sampling activities | Incorporated into baseline studies and environmental monitoring programme |
| Akwete-Akpa Community | Project benefits, ESIA process, community expectations and socio-economic survey | Community welcomed the Project, participated in surveys and raised no significant objections | Community views incorporated into the socio-economic baseline, impact assessment and stakeholder engagement plan |
| All stakeholders | Absence of water sources within the Project site | Agreed that Aloma River would serve as the representative surface-water sampling location | Incorporated into the baseline water quality assessment |
| All stakeholders | Continued stakeholder engagement during Project implementation | Agreement to maintain communication throughout the Project lifecycle | Reflected in the Stakeholder Engagement Plan (SEP) and Grievance Redress Mechanism (GRM) |

# CHAPTER EIGHT
# REMEDIATION PLAN AFTER DECOMMISSIONING/CLOSURE

## 8.1 Introduction

This chapter discusses the activities associated with the decommissioning of the proposed 2 MW Solar Photovoltaic (PV) Hybrid Power Project and Associated Infrastructure at the Federal University of Health Sciences, Otukpo (FUHSO), Benue State, including the potential environmental and social impacts associated with the decommissioning activities as well as the measures required to address such impacts. In addition, an overview of the remediation plan to be implemented following the decommissioning and closure of the Project is presented. The objective is to ensure that the Project site is restored to a safe, stable and environmentally acceptable condition in accordance with applicable national regulations and international good industry practice.

## 8.2 Consultation

Prior to commencement of decommissioning activities, consultation shall be undertaken with all relevant stakeholders to communicate the proposed decommissioning programme, obtain stakeholder inputs and ensure compliance with applicable statutory requirements. The consultation process shall involve the Rural Electrification Agency (REA), the Federal University of Health Sciences, Otukpo (FUHSO), the Federal Ministry of Environment (FMEnv), National Environmental Standards and Regulations Enforcement Agency (NESREA), Benue State Ministry of Environment and Climate Change, Otukpo Local Government Authority, relevant emergency response agencies, licensed waste management contractors and other stakeholders considered relevant at the time of Project closure. The consultation shall provide stakeholders with information on the proposed decommissioning activities, implementation schedule, environmental and social management measures, waste management procedures and site restoration programme. The existing Stakeholder Engagement Plan (SEP) and Grievance Redress Mechanism (GRM) developed for the Project shall remain operational throughout the decommissioning period to ensure that stakeholder concerns are promptly addressed. Records of all consultations shall be maintained and incorporated into the final Project Close-out Report.

## 8.3 Decommissioning Activities

Decommissioning refers to the process of removing all the operating assets of a project after completion of its life cycle. The average operational life span of the proposed 2 MW Solar Photovoltaic (PV) Hybrid Power Project is approximately 25–30 years, which can be extended through regular maintenance and periodic replacement of selected components. Although the photovoltaic (PV) modules may continue to generate electricity beyond their design life with reduced efficiency, eventual decommissioning of the facility will be required at the end of its operational or economic life.

The decommissioning activities will typically include the following:

- Dismantling and removal of PV panels and associated infrastructure (mounting structures, underground armoured cables, inverters, transformers, battery energy storage systems, switchgear and associated electrical equipment);

- Removal of sub-surface installations, including underground electrical cables and foundations where practicable;
- Waste generation, segregation, recycling and environmentally sound disposal of dismantled materials;
- Rehabilitation and restoration of disturbed areas, including reinstatement of soil and vegetation where necessary.

### 8.3.1 Management of Decommissioning Activities

In the event of decommissioning, REA, in conjunction with the Management of the Federal University of Health Sciences, Otukpo (FUHSO), shall ensure that the Project site is left in a safe and environmentally acceptable condition. A standard decommissioning, abandonment and closure programme shall be implemented. The activities shall include, amongst others:

- Evacuation of dismantled PV panels, inverters, transformers, switchgear and other reusable electrical equipment to approved manufacturers or recycling facilities;
- Transportation of spent lithium-ion batteries to approved battery recycling or recovery facilities in accordance with applicable regulations;
- Restoration of the Project site to conditions as close as reasonably practicable to the pre-development state;
- Assessment of any residual environmental impacts associated with the Project; and
- Monitoring of the restored Project site where necessary to confirm the effectiveness of the remediation programme.

Decommissioning activities shall only commence following consultation with relevant stakeholders and approval by the appropriate regulatory authorities. The decommissioning programme shall be implemented in accordance with the provisions of the National Guidelines for Decommissioning of Facilities in Nigeria (FMEnv, 2017) and other applicable environmental, occupational health and safety regulations.

### 8.3.2 Decommissioning Planning Requirements

Typically, the following actions shall be undertaken during decommissioning:

- An updated Decommissioning Plan, taking into account the most cost-effective methods, applicable legal requirements and current industry best practices, shall be prepared and submitted to the Federal Ministry of Environment (FMEnv) and other relevant regulatory authorities for approval. The Plan shall include, but not be limited to:
    - Description of the Project site and facilities to be decommissioned;
    - Description of the decommissioning scope, objectives, end-state and strategy;
    - Activities to be carried out during decommissioning;
    - Schedule of decommissioning activities;
    - Estimated decommissioning costs;
    - Inventory of wastes expected to be generated and proposed management procedures;
    - Composition of the decommissioning team, including qualifications, roles and responsibilities.

### 8.3.3 Evaluation of Decommissioning Options

To ensure that due consideration is given to all available options, a detailed evaluation of decommissioning alternatives shall be undertaken. The options shall include:

- Facility mothballing;
- Partial decommissioning; and
- Complete decommissioning and site restoration.

The evaluation shall consider environmental, technical, health and safety, economic and future land-use requirements in determining the most appropriate option. Based on the intended future use of the University land and the nature of the proposed Project, complete decommissioning and restoration of the Project site shall be the preferred option unless future repowering or redevelopment of the facility is considered.

### 8.3.4 Risk Assessment and Safety

A comprehensive risk assessment shall be conducted prior to commencement of decommissioning to ensure that no condition capable of posing risks to workers, future land users or the surrounding environment remains after Project closure.

The assessment shall include:

- Identification of hazards associated with electrical installations, battery systems and dismantling activities;
- Hazard identification and analysis to determine specific safety concerns;
- Development and implementation of an appropriate Health, Safety and Environment (HSE) Plan;
- Notification of relevant third parties before commencement of demolition activities; and
- Phased implementation of decommissioning activities to minimize environmental and safety risks.

### 8.3.5 Socio-Economic Considerations

Socio-economic considerations associated with Project decommissioning shall include assessment of potential impacts arising from termination of employment and cessation of Project activities. Measures to minimise these impacts shall include:

- Ensuring that employees are adequately informed of the decommissioning programme and its implications before Project closure;
- Building local capacity to manage opportunities associated with post-decommissioning activities;
- Providing training in equipment dismantling, environmental restoration and post-closure monitoring where appropriate; and
- Facilitating the transfer of acquired skills to alternative employment opportunities and related industries.

### 8.3.6 Waste Management

An effective Waste Management Plan shall be implemented throughout the decommissioning programme. The principal waste streams are expected to include photovoltaic modules, battery systems, transformers, electrical cables, steel mounting structures, concrete debris, packaging materials and general domestic wastes. Where practicable, dismantled equipment and recyclable materials shall be returned to manufacturers or licensed recycling facilities under approved recycling or take-back schemes. Hazardous wastes shall be managed in accordance with applicable

FMEnv and NESREA regulations, while detailed records of waste generation, transportation, recycling and disposal shall be maintained throughout the decommissioning programme.

### 8.3.7 Used Battery Management

Lithium-ion batteries that have reached the end of their operational life shall be regarded as hazardous waste and managed accordingly. Used batteries shall be segregated from other waste streams and packaged in accordance with the manufacturer's recommendations prior to transportation. The Extended Producer Responsibility (EPR) principle shall be adopted for the Project. Battery manufacturers or suppliers shall be responsible for the collection, recovery, recycling or environmentally sound disposal of spent batteries through approved take-back arrangements. Where local recycling facilities are unavailable or technically unsuitable, the batteries shall be transferred to approved facilities in accordance with applicable national regulations and international requirements. The University shall also develop procedures for the safe handling, temporary storage, transportation and documentation of used batteries generated during Project operation and decommissioning. Relevant personnel shall receive appropriate training on battery handling, emergency response and spill management to minimize environmental and occupational health risks.

## 8.4 Abandonment Plan

Following completion of the decommissioning activities, the Project site shall be rehabilitated to ensure that it no longer poses any environmental, health or safety risks to future users or the surrounding environment. The abandonment programme shall focus on restoring the site to a stable condition that is suitable for future development or other beneficial land uses as determined by the Federal University of Health Sciences, Otukpo (FUHSO).

The abandonment programme shall include, but not be limited to, the following activities:

- Complete removal of all Project equipment, foundations and associated infrastructure that are no longer required;
- Removal of all construction debris, hazardous materials and other wastes from the Project site;
- Removal of temporary storage facilities and ancillary structures;
- Backfilling and grading of excavated or disturbed areas where necessary;
- Replacement of stockpiled topsoil where applicable;
- Restoration and stabilization of disturbed land to prevent erosion;
- Re-vegetation of disturbed areas using suitable indigenous plant species where necessary;
- Verification that no contaminated soil or hazardous materials remain on site;
- Final environmental inspection and certification by the relevant regulatory authorities; and
- Handover of the restored site to the Federal University of Health Sciences, Otukpo (FUHSO).

Following completion of the abandonment activities, a Final Site Closure Report shall be prepared and submitted to the Federal Ministry of Environment (FMEnv), the National Environmental Standards and Regulations Enforcement Agency (NESREA) and other relevant regulatory authorities for review and approval. The report shall document the decommissioning activities undertaken, wastes generated and managed, environmental restoration measures implemented, results of post-restoration inspections, and confirmation that the Project site has been restored to an environmentally acceptable condition.

## 8.5 Roles, Responsibilities and Accountabilities for Decommissioning Phase

Successful implementation of the decommissioning and site restoration programme will require clearly defined roles and responsibilities among the various organizations involved. REA shall retain overall responsibility for ensuring that decommissioning activities are undertaken in accordance with the approved Decommissioning Plan, applicable environmental regulations and international good industry practice. The principal responsibilities of the various stakeholders are summarized in **Table 8.1**.

**Table 8.1: Roles, Responsibilities and Accountabilities for Decommissioning Phase**

| Organization | Roles and Responsibilities |
|---|---|
| **Rural Electrification Agency (REA)** | Overall coordination and supervision of decommissioning activities; provision of financial resources; engagement of qualified decommissioning contractors; implementation of approved Decommissioning Plan; ensuring compliance with statutory requirements; submission of decommissioning and closure reports to regulatory authorities. |
| **Federal University of Health Sciences, Otukpo (FUHSO)** | Provide access to the Project site; participate in decommissioning planning; monitor restoration activities; verify satisfactory restoration of University land prior to final handover; participate in final site acceptance. |
| **Decommissioning Contractor** | Execute all dismantling, demolition, waste management, site restoration and rehabilitation activities in accordance with approved procedures; provide qualified personnel, equipment and HSE resources; ensure compliance with environmental and safety requirements throughout the decommissioning programme. |
| **Federal Ministry of Environment (FMEnv)** | Review and approve the Decommissioning Plan; monitor compliance with applicable environmental regulations; conduct regulatory inspections; verify satisfactory implementation of environmental restoration measures prior to Project closure. |
| **National Environmental Standards and Regulations Enforcement Agency (NESREA)** | Monitor compliance with applicable environmental standards and waste management regulations; oversee environmentally sound handling, transportation and disposal of hazardous and non-hazardous wastes; undertake regulatory inspections where necessary. |
| **Benue State Ministry of Environment and Climate Change** | Participate in environmental monitoring and inspection activities; provide regulatory guidance where applicable; monitor compliance with State environmental requirements during decommissioning and restoration activities. |
| **Licensed Waste Management Contractors** | Collect, transport, recycle and dispose of hazardous and non-hazardous wastes generated during decommissioning in accordance with approved waste management procedures and applicable regulations. |
| **Battery Manufacturer/Supplier** | Implement the Extended Producer Responsibility (EPR) programme through collection, recovery, recycling or |

| Organization | Roles and Responsibilities |
|---|---|
| | environmentally sound disposal of spent lithium-ion batteries and other applicable electrical components under approved take-back arrangements. |
| **Supervising Engineer/Environmental Consultant** | Monitor implementation of the Decommissioning Plan; undertake environmental inspections; verify compliance with mitigation measures; prepare monitoring reports and provide technical advice throughout the decommissioning process. |
| **Emergency Response Agencies** | Provide emergency response support where required during decommissioning activities involving fire, hazardous materials, accidents or other emergency situations. |

**Table 8.2: Environmental and Social Management Measures for Decommissioning Phase**

| Summary of Potential Impact | Mitigation Measures | Monitoring Requirements / Parameters | Frequency | Performance Indicator | Responsible Party (Implementation) | Responsible Party (Monitoring) | Estimated Cost (US Dollars) |
|---|---|---|---|---|---|---|---|
| **Removal of PV panels, battery energy storage systems (BESS), inverters, transformers, mounting structures and associated facilities. Potential impacts: Soil contamination due to waste generation; soil compaction; localized erosion.** | Excavation and dismantling activities shall not be undertaken during periods of heavy rainfall or adverse weather conditions. | Inspection | Daily | Compliance with approved decommissioning procedures | Contractor(s) engaged for facility decommissioning | REA-PMU | **5,000** |
| | Stockpiles shall be properly covered to minimize soil loss due to wind and water erosion. | Inspection | Daily | Compliance with mitigation measures | | FUHSO (Site Manager/Director of Physical Planning) | |
| | Hazardous substances (fuel, lubricants, oils, etc.) shall be stored on impervious surfaces with adequate secondary containment. Portable spill kits shall be maintained on site. | Inspection | Daily | Compliance with mitigation measures | | FMEnv | |

| Summary of Potential Impact | Mitigation Measures | Monitoring Requirements / Parameters | Frequency | Performance Indicator | Responsible Party (Implementation) | Responsible Party (Monitoring) | Estimated Cost (US Dollars) |
|---|---|---|---|---|---|---|---|
| | PV panels, lithium-ion batteries, inverters and other electronic components shall be returned to manufacturers or approved recycling facilities under the Extended Producer Responsibility (EPR) programme. | Waste transfer records / Consignment notes | Daily | Evidence of approved recycling | | NESREA | |
| | Disturbed areas shall be reinstated and revegetated with suitable indigenous plant species where necessary. | Inspection | Daily | Successful site restoration | | Benue State Ministry of Environment and Climate Change | |
| | An approved Decommissioning Plan shall be implemented throughout the decommissioning programme. | Decommissioning implementation records | Daily | Compliance with approved plan | | | |

| Summary of Potential Impact | Mitigation Measures | Monitoring Requirements / Parameters | Frequency | Performance Indicator | Responsible Party (Implementation) | Responsible Party (Monitoring) | Estimated Cost (US Dollars) |
|---|---|---|---|---|---|---|---|
| **Air quality deterioration due to dust generated during dismantling activities.** | Dust suppression measures (water spraying where necessary) shall be implemented during dismantling activities. | Inspection | Daily | Compliance with mitigation measures | Contractor(s) engaged for facility decommissioning | REA-PMU | **1,000** |
| | All decommissioning equipment and vehicles shall be properly serviced and maintained to minimise exhaust emissions. | Inspection / Maintenance records | Before commencement of decommissioning | Equipment maintenance records available | | FUHSO | |
| | Vehicles transporting dismantled materials shall be properly covered to minimise dust emissions. | Inspection | Daily | Compliance with mitigation measures | | FMEnv | |
| | Air quality complaints shall be investigated and appropriate corrective actions implemented. | Complaint records | Weekly | Complaints addressed | | Benue State Ministry of Environment and Climate Change | |

| Summary of Potential Impact | Mitigation Measures | Monitoring Requirements / Parameters | Frequency | Performance Indicator | Responsible Party (Implementation) | Responsible Party (Monitoring) | Estimated Cost (US Dollars) |
|---|---|---|---|---|---|---|---|
| **Increase in ambient noise during dismantling activities.** | Noise suppression devices (e.g. silencers and mufflers) shall be fitted on equipment where applicable. | Inspection | Daily | Compliance with mitigation measures | Contractor(s) engaged for facility decommissioning | REA-PMU | **2,000** |
| | Decommissioning activities shall be restricted to normal daytime working hours. | Inspection | Daily | Working hour compliance | | FUHSO | |
| | Equipment shall be switched off when not in use. | Inspection | Daily | Reduced unnecessary noise | | FMEnv | |
| | Equipment shall be properly serviced and maintained. | Inspection / Maintenance records | Prior to commencement | Maintenance records | | Benue State Ministry of Environment and Climate Change | |
| | Noise complaints shall be documented and promptly addressed through the Project GRM. | Complaint register | Weekly | Complaints resolved | | | |

| Summary of Potential Impact | Mitigation Measures | Monitoring Requirements / Parameters | Frequency | Performance Indicator | Responsible Party (Implementation) | Responsible Party (Monitoring) | Estimated Cost (US Dollars) |
|---|---|---|---|---|---|---|---|
| | Noise monitoring shall be undertaken where persistent complaints occur. | Noise monitoring records | Monthly | Compliance with FMEnv/World Bank limits | | | |
| **Groundwater and surface water contamination due to accidental spills and waste generation.** | Workers shall receive training on safe handling, storage and transportation of hazardous materials. | Training records | Prior to commencement | Training certificates | Contractor(s) engaged for facility decommissioning | REA-PMU | **1,500** |
| | Hazardous substances shall be stored on impervious surfaces with secondary containment. Spill response kits shall be maintained on site. | Inspection | Daily | Compliance with mitigation measures | | FUHSO | |
| | The approved Waste Management Plan shall be fully implemented. | Waste Management Plan implementation records | Daily | Compliance with WMP | | FMEnv | |

| Summary of Potential Impact | Mitigation Measures | Monitoring Requirements / Parameters | Frequency | Performance Indicator | Responsible Party (Implementation) | Responsible Party (Monitoring) | Estimated Cost (US Dollars) |
|---|---|---|---|---|---|---|---|
| | Spill incidents shall be immediately contained, cleaned up and reported. | Spill records | As required | Zero uncontrolled spills | | NESREA | |
| **Traffic impacts associated with transportation of dismantled equipment, batteries and other wastes.** | Traffic Management Plan (TMP) shall be implemented throughout the decommissioning period. | TMP implementation records | Daily | Compliance with TMP | Contractor(s) engaged for facility decommissioning | REA-PMU | **2,500** |
| | Appropriate warning signs, traffic marshals and barriers shall be provided where necessary. | Inspection | Before commencement | Adequate traffic control | | FUHSO | |
| | Drivers shall possess valid licences and receive defensive driving training where required. | Driver competency records | Before commencement | Qualified drivers | | FMEnv | |
| | All traffic incidents shall be recorded, investigated and | Incident records | Daily | Completed incident reports | | Benue State Ministry of Environment and Climate Change | |

| Summary of Potential Impact | Mitigation Measures | Monitoring Requirements / Parameters | Frequency | Performance Indicator | Responsible Party (Implementation) | Responsible Party (Monitoring) | Estimated Cost (US Dollars) |
|---|---|---|---|---|---|---|---|
| | corrective measures implemented. | | | | | | |
| **Occupational health and safety risks (electrical shock, slips, trips, falls, cuts and manual handling injuries).** | Daily toolbox meetings shall be conducted before commencement of work activities. | Toolbox meeting records | Daily | Compliance with HSE Plan | Contractor(s) engaged for facility decommissioning | REA-PMU | **2,500** |
| | Appropriate PPE shall be provided and worn by all personnel. | PPE inspection records | Daily | PPE compliance | | FUHSO | |
| | A qualified HSE Officer shall supervise all decommissioning activities. | Appointment records | Prior to commencement | Dedicated HSE Officer on site | | FMEnv | |
| | Lock-Out/Tag-Out (LOTO) procedures shall be implemented before dismantling electrical equipment. | LOTO records | Daily | Zero accidental energization | | NESREA | |
| | The approved Occupational Health and Safety Plan and | HSE implementation records | Daily | Compliance with approved HSE Plan | | Benue State Ministry of Environment and Climate Change | |

| Summary of Potential Impact | Mitigation Measures | Monitoring Requirements / Parameters | Frequency | Performance Indicator | Responsible Party (Implementation) | Responsible Party (Monitoring) | Estimated Cost (US Dollars) |
|---|---|---|---|---|---|---|---|
| | Emergency Response Plan shall be implemented throughout the decommissioning period. | | | | | | |
| **Total Estimated Cost** | | | | | | **USD 12,000** | |

# CHAPTER NINE
# SUMMARY AND CONCLUSION

## 9.1 Summary

The proposed 2 MW Solar Photovoltaic (PV) Hybrid Power Project and Associated Infrastructure at the Federal University of Health Sciences, Otukpo (FUHSO), Benue State forms part of the Nigeria Electrification Project (NEP) being implemented by the Rural Electrification Agency (REA) to improve access to reliable, sustainable and affordable electricity in Federal tertiary institutions across Nigeria. The Project is designed to provide an independent and dedicated solar-hybrid electricity supply to the University's Permanent Campus, thereby supporting teaching, research, healthcare delivery, administrative activities and future institutional expansion while reducing dependence on fossil fuel-based electricity generation.

In compliance with the requirements of the Environmental Impact Assessment (EIA) Act Cap E12, Laws of the Federation of Nigeria (LFN), 2004, the relevant guidelines of the Federal Ministry of Environment (FMEnv), the African Development Bank (AfDB) Integrated Safeguards System (ISS, 2023) and other applicable national environmental legislation, an Environmental and Social Impact Assessment (ESIA) has been undertaken for the proposed Project. The ESIA covered the entire Project life cycle, including the pre-construction, construction, operational, decommissioning and closure phases. The study comprised desktop review, stakeholder consultation, baseline environmental and socio-economic studies, laboratory analyses of environmental samples, identification and evaluation of potential impacts, development of mitigation measures, preparation of an Environmental and Social Management Plan (ESMP), environmental monitoring programme and decommissioning framework.

Baseline investigations confirmed that the proposed Project site is located within approximately 10 hectares of University-owned land inside the FUHSO Permanent Campus. The site is largely undeveloped, free from existing buildings and public infrastructure, and does not require land acquisition, physical displacement or economic resettlement. Environmental baseline studies further indicated that the site contains no environmentally sensitive habitats, protected areas or cultural heritage resources that would preclude the proposed development. The proposed Project will provide a reliable and sustainable electricity supply to support academic activities, scientific research, medical laboratories, healthcare services, administrative functions and future infrastructural development within the University. In addition, the Project will contribute to improved energy security, reduced dependence on diesel-powered generators, lower greenhouse gas emissions and increased utilization of renewable energy technologies in line with Nigeria's energy transition objectives and commitments under the Paris Agreement on Climate Change.

## 9.2 Conclusion

The Environmental and Social Impact Assessment (ESIA) for the proposed 2 MW Solar Photovoltaic (PV) Hybrid Power Project and Associated Infrastructure at the Federal University of Health Sciences, Otukpo (FUHSO), Benue State has been conducted in accordance with the applicable requirements of the Federal Ministry of Environment (FMEnv), the Environmental Impact Assessment Act, the African Development Bank Integrated Safeguards System (ISS, 2023), and other relevant national environmental legislation and international good industry practice. The

ESIA process involved desktop studies, stakeholder consultations, baseline environmental and socio-economic investigations, field measurements, laboratory analyses, impact identification and evaluation, development of mitigation measures, preparation of an Environmental and Social Management Plan (ESMP), environmental monitoring programme, and preparation of a decommissioning and site restoration framework.

The assessment established that the proposed Project will generate significant long-term environmental, social and economic benefits through the provision of reliable and sustainable electricity to the University's Permanent Campus. The principal positive impacts associated with the Project include:

- Provision of reliable, clean and sustainable electricity to support teaching, research, healthcare delivery and administrative activities within the University;
- Reduction in dependence on diesel-powered electricity generation, resulting in lower operating costs and reduced greenhouse gas emissions;
- Improvement in energy security and operational efficiency within the University;
- Creation of direct and indirect employment opportunities during the construction and operational phases;
- Capacity development through technology transfer and increased utilization of renewable energy systems;
- Stimulation of local economic activities through procurement of goods, services and labour;
- Improvement in safety and security through the provision of reliable electricity and associated infrastructure;
- Contribution to Nigeria's renewable energy development objectives and Nationally Determined Contributions (NDCs) under the Paris Agreement; and
- Strengthening of collaboration among REA, FUHSO, the Federal Government of Nigeria, development partners and relevant regulatory institutions.

The assessment also identified a number of potential adverse environmental and social impacts associated with the Project. However, these impacts are predominantly temporary, localized and of **minor to moderate significance**, and are typical of utility-scale solar photovoltaic developments. The principal potential adverse impacts include:

- Temporary deterioration of ambient air quality arising from dust emissions during construction and decommissioning activities;
- Temporary increase in ambient noise levels associated with construction equipment and vehicular movement;
- Localized soil disturbance, compaction and erosion during site preparation and civil works;
- Generation of construction, operational and decommissioning wastes, including electronic wastes associated with photovoltaic equipment and battery systems;
- Potential risks of soil and groundwater contamination resulting from improper handling of hazardous materials and wastes;
- Occupational health and safety risks to workers during construction, operation and decommissioning;
- Community health and safety risks associated with increased construction traffic and movement of heavy equipment; and

- Potential environmental risks associated with the handling, storage, transportation and disposal of spent lithium-ion batteries at the end of their operational life.

The assessment further confirmed that the proposed Project will **not require land acquisition, physical displacement or involuntary resettlement**, and no cultural heritage resources or environmentally sensitive ecological features were identified within the Project footprint that would significantly constrain Project implementation.

Based on the findings of this ESIA, it is concluded that the proposed Project is **environmentally and socially acceptable**. The identified adverse impacts can be effectively avoided, minimized or mitigated to As Low As Reasonably Practicable (ALARP) through the implementation of the mitigation measures presented in Chapter Six, the Environmental and Social Management Plan (ESMP) presented in Chapter Seven, and the Decommissioning and Site Restoration Plan presented in Chapter Eight. Accordingly, it is recommended that the proposed 2 MW Solar Photovoltaic (PV) Hybrid Power Project and Associated Infrastructure at the Federal University of Health Sciences, Otukpo (FUHSO), Benue State should proceed to implementation, subject to compliance with the recommended environmental and social management measures, applicable statutory requirements and continuous environmental monitoring throughout the Project life cycle.

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# APPENDIX I

## SOCIO-ECONOMICS QUESTIONAIRE SAMPLE

**SOCIO-ECONOMIC IMPACT ASSESSMENT QUESTIONNAIRE OF THE PROPOSED PREPARATION OF ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT (ESIA) FOR THE 2MW SOLAR POWER PROJECT AT THE FEDERAL UNIVERSITY OF HEALTH SCIENCES, OTUKPO (FUHSO), BENUE STATE.**

The Federal Government of Nigeria (FGN), through the Rural Electrification Agency (REA), is implementing the Energizing Education Program (EEP) Nigeria Electrification Project Phase II (Desert-to-Power) with financial support from the African Development Bank (AfDB). As part of the exercise, BOLBEN Energy and Environmental Services Limited is saddled with the responsibility of identifying the potential socio-economic impacts of the project on the local communities. Therefore, your assistance is required in filling out this brief survey. The questionnaire can be completed by ticking in the preferred boxes like this √ and providing appropriate answers in the available spaces.

**Section A: Background Information**

1. Name of Project Host Community/AoI .....

2. Gender (a) Male ☐ (b) Female ☐

3. Age (a) 18 – 30 yrs. ☐ (b) 31 – 45 Yrs. ☐ (c) 46 – 54 Yrs. ☐ (d) 55 Yrs. and above ☐

4. Religion: (a) Christianity ☐ (b) Islam ☐ (c) Traditional ☐ (d) Other (specify).....

5. Education: (a) Informal Education ☐ (d) NCE/ND ☐
(b) Primary School ☐ (e) HND/B.Sc. ☐
(c) Secondary School ☐ (f) Others (Specify) .....

6. Occupation: (a) Student ☐ (b) Academic Staff ☐ (c) Non-academic Staff ☐ (d) Trader ☐
(d) Others (Specify) .....

7. Monthly Income: (a) #0 - #30, 000 ☐ (b) #31, 000- #60,000 ☐ (c) # 61, 000-#90, 000 ☐
(d) #120,000 and above ☐

8. Duration of stay in the institution/community (a) 1-5 Yrs. ☐ (b) 6–10 Yrs. ☐ (c) 11–19 ☐
(d) 20 and above ☐

9. Types of language spoken in the communities; English ☐ Idoma ☐ Akweya (Akpa) ☐
Agatu ☐ Igede ☐ Ufia ☐ Hausa ☐ Yoruba ☐ Igbo ☐
Others.....

**Section B: Health Status**

10. What is the health facility available in your institution/community (a) Primary Health Centre ☐
(b) General Hospital ☐ (c) Private Hospitals ☐ (d) Sick bay ☐
(e) Others(Specify).....

11. Condition of the health facility within the Institution/community; Very Good ☐ Good ☐
Fair ☐ Poor ☐

12. Please tick the health conditions you experience most frequently.

| Health Conditions | Tick | Health Conditions | Tick | Others (specify) |
|---|---|---|---|---|
| Malaria | | Tuberculosis | | |
| Typhoid fever | | Hypertension | | |
| Cholera | | Asthma | | |
| Rheumatism | | Diabetics | | |
| Pneumonia | | Rashes | | |

13. Do you think the proposed project will have a negative impact on your health/environment?
(a) YES ☐ (b) NO ☐
If yes, how? (a) Air Pollution ☐ (b) Noise Pollution ☐ (c) Ground water contamination
(d) Surface water contamination ☐ (e) others (specify) .....

14. How do you think these impacts can be averted .....

1

**Section C: Gender Based Violence**

**15.** Have you or anyone in your household had experienced gender-based violence?
(a) YES ☐ (b) NO ☐

**16.** Do you think men and women have equal access to economic opportunities in your institution/community? (a) YES ☐ (b) NO ☐

**17.** Do you believe that cultural norms in your institution/community influence the prevalence of GBV?(a) YES ☐ (b) NO ☐

**18.** Are there adequate support services available for survivors of GBV in your institution/community? (a) YES ☐ (b) NO ☐

**Section D: Public Services**

**19.** What is the source of water supply in your institution/community? (a) Well ☐ (b) Borehole ☐
(c) River/Stream ☐ (d) Govt Water Board ☐ (e) Others (specify) .....

**20.**Condition of portable water within the institution/community: Very Good ☐ Good ☐ Fair ☐
Poor ☐

**21.**What is the available source of power in the institution/community? (a) National Grid ☐
(b) Generator ☐ (c) Lantern ☐ (d) Touch light ☐ (e) Solar power ☐
(f) Others (specify) .....

**22.**Condition of public electricity within the institution/community: Very Good ☐ Good ☐ Fair ☐
Poor ☐

**23.**Sanitation facility in the institution/community; Water closet ☐ Pit Latrine ☐
Open Defecation ☐ Others ☐

**24.**What is the most available/affordable source of cooking? (a) Gas cooker ☐ (b) Stove ☐
(c) Firewood ☐ (d) Charcoal ☐ (e) Others (specify) .....

**25.**What are the educational institutions available in your institution/community? (a) Primary school ☐
(b) Secondary school ☐ (c) Tertiary Institution ☐ (d) Others (specify).....

**26.**Waste disposal method:- Bush Burning ☐ Public open dump ☐ Private Open dump ☐
Organized collection ☐ Burying ☐ Others_____

**Section E: Existing Socio-Economic Condition of the Study Area**

**27.** Indicate the traditional economic activity practiced by member of the institution/community:
(a) Trading ☐ (b) Cybercafe ☐ (c) POS Services ☐ (d) Printing Press ☐
(e) Others (specify) .....

**28.** Do you think the proposed project will affect any valued resources/ cultural assets / archeological sites within the institution/community? (a) YES ☐ (b) NO ☐

If yes, mention the name(s) of the resources.....

**Section F: Potential Socio-Economic Impact of the Proposed Project**

**29.** Do you think the institution management members are fully aware of the proposed project?
(a)YES ☐ (b) NO ☐

**30.** What do you think is the socio-economic benefit of the project?

_____

_____

**31.**Indicate the social associations existing in your institution/community: (a) Student Union ☐
(b) Teaching Staff Association ☐ (c) Non-Teaching Staff Association ☐
(d) Traders Association ☐ (e) Others Specify .....

**32.** Which neighboring institution/communities do you think will benefit from the new developmental project?

.....

2

# APPENDIX II

## CHAIN OF CUSTODY FORM

**P**ollution Control Laboratory, Farm Centre
Ministry of Environment, Kano
Block No. 5 AuduBako Secretariat

No. 125 T/ShanuTarauni, Kano State.
Hon. Commissioner: 064-668371
Perm. Secretary Fax: 669413

Page: 1 of 3

**CUSTODY TRANSFER FORM**

| | | | | |
|---|---|---|---|---|
| Client Name: | Bolben Energy Limited | Relinquished by(Sinature): | Date: 25/7/26 | Time: 11:30 am |
| Project Name: | 2MW Solar powered project | Received by (Signature): | Date: | Time: |
| Address: | Fed. Uni. of Health Science OTUKPO | FMEVT Representative: | Date: | Time: |
| Consultant | | Address: | | |

POLLUTION CONTROL LABORATORY MINISTRY OF ENVIRONMENT AND CLIMATE CHANGE Sign:..... Date:.....

| Type of Simple | | | | Number of Samples: |
|---|---|---|---|---|
| Water Sample ☐ | Soil Sample ☑ | Others (Specify): | ☐ | 14 Samples |
| | | | | Date Sampled: 25/7/25 |

| S/No. | Sample ID | Sample Location | Laboratory Description of Sample |
|---|---|---|---|
| 1 | S4 | Fed. Uni. of Health Science OTUKPO | S4 Top |
| 2 | S4 | ✓ | S4 Bottom |
| 3 | S5 | ✓ | S5 Top |
| 4 | S5 | ✓ | S5 Bottom |
| 5 | S6 | ✓ | S6 Top |
| 6 | S6 | ✓ | S6 Bottom |
| 7 | S7 | ✓ | S7 Top |
| 8 | S7 | ✓ | S7 Bottom |
| 9 | S8 | ✓ | S8 Top |
| 10 | S8 | ✓ | S8 Bottom |
| 11 | S9 | ✓ | S9 Top |
| 12 | S9 | ✓ | S9 Bottom |
| 13 | S cont | ✓ | S cont Top |
| 14 | S cont | ✓ | S cont Bottom |

# APPENDIX III

## LABORATORY ANALYSIS RESULT (SURFACE WATER SAMPLES)

**MINISTRY OF ENVIRONMENT AND CLIMATE CHANGE**

**POLLUTION CONTROL LABORATORY**

Address: Farm Centre, Near Cool FM, Kano State.
Tel: +2347030166686

| | |
|---|---|
| **CLIENT:** | BOLBEN ENERGY LIMITED |
| **PROJECT NAME:** | ESIA NIGERIA ELECTRIFICATION PROJECT (NEP) UNDER RURAL ELECTRIFICATION AGENCY TO 2MM SOLAR POWERED PLANTS |
| **PROJECT ADDRESS:** | FEDERAL UNIVERSITY OF HEALTH SCIENCE OTUKPO (FUHSO) PERMANENT, BENUE STATE |
| **QUANTITY:** | 1 LITRE |
| **PRESERVATION METHOD:** | ICEING |

**WATER QUALITY ASSESSMENT RESULT**

Please find below the result of water quality carried out at University of Health Science Otukpo (FUSO) Permanent Site, Benue State.

| S/N | PARAMETERS | UNIT | SURFACE WATER (SW1) | SURFACE WATER (SW2) | SURFACE WATER (SW3) | FMENT LIMIT |
|---|---|---|---|---|---|---|
| (A) | PHYSIOCHEMICAL TEST | | | | | |
| 1. | Colour | Tcu | Pale brown | Pale grayish | Pale grayish | Clear |
| 2. | Odour | - | Odourless | Odourless | Odourless | Unobjectionable |
| 3. | Taste | - | Tasteless | Tasteless | Tasteless | Unobjectionable |
| 4. | PH | - | 7.20 | 7.30 | 7.17 | 65.85 |
| 5. | Temperature | °c | 31.0 | 29.7 | 29.2 | Ambient |
| 6. | Electrical conductivity | us/cm | 60 | 50 | 58 | 1000 |
| 7. | Turbidity | NTU | 18 | 15 | 15 | 50 |
| 8. | Total dissolve solid | mg/l | 30 | 30 | 29 | 500 |
| 9. | Total suspended solid | mg/l | 4 | 6 | 8 | 20 |
| 10. | Dissolve oxygen | mg/l | 3.9 | 4.1 | 4.0 | 2-8 |
| 11. | B.O.D | mg/l | 2.2 | 2.5 | 2.5 | NS |
| 12. | C.O.D | mg/l | 3 | 6 | 6 | 30 |
| 13. | Salinity | % | 0.00 | 0.00 | 0.00 | <1000 |
| 14. | ORP | mV | 118 | 104 | 116 | 200-600 |

**LABORATORY ANALYSIS RESULT (SURFACE WATER SAMPLES) CONTINUATION…**

| | | | | | | |
|---|---|---|---|---|---|---|
| **(B)** | **CHEMICAL TEST** | | | | | |
| 15. | Aluminium ($Al^{3+}$) | mg/l | 0.76 | 0.62 | 0.57 | NS |
| 16. | Calcium ($Ca^{2+}$) | mg/l | 5.77 | 6.21 | 5.63 | 200 |
| 17. | Magnesium ($Mg^{2+}$) | mg/l | 2.74 | 2.86 | 2.28 | 20 |
| 18. | Total hardness | mg/l | 94 | 81 | 87 | 150 |
| 19. | Potassium ($K^{+}$) | mg/l | 4.3 | 5.2 | 4.7 | 20 |
| 20. | Nitrate ($NO^{2-}_{3}$) | mg/l | 104.1 | 86.1 | 92.3 | 50 |
| 21. | Nitrite ($No^{-}_{2}$) | mg/l | 0.175 | 0.201 | 0.186 | 0.02 |
| 22. | Chloride ($Cl^{-}$) | mg/l | 45.2 | 47.2 | 41.3 | 150 |
| 23. | Phosphate ($PO^{2-}_{4}$) | mg/l | 8.55 | 8.63 | 7.92 | NS |
| 24. | Sulphate ($SO^{2-}_{4}$) | mg/l | 48 | 37 | 42 | 100 |
| 25. | Fuoride ($Fl^{-}$) | mg/l | 3.50 | 3.62 | 2.96 | NS |
| **(C)** | **HEAVY METALS** | | | | | |
| 26. | Cupper ($Cu^{2+}$) | mg/l | 2.90 | 2.84 | 2.62 | 1.5 |
| 27. | Chromium | mg/l | 0.55 | 0.47 | 0.43 | 0.05 |
| 28. | Cadmium | ug/l | 0.246 | 0.384 | 0.394 | 0.000 |
| 29. | Lead ($Pb^{2+}$) | ug/l | 0.382 | 0.438 | 0.286 | 0.01 |
| 30. | Zinc ($Zn^{2+}$) | mg/l | 1.38 | 1.98 | 1.36 | 3.0 |
| 31. | Nickel ($Ni^{2+}$) | mg/l | 0.086 | 0.128 | 0.186 | 0.07 |
| 32. | Cobalt ($Co^{2+}$) | mg/l | 0.124 | 0.238 | 0.211 | 0.2 |
| 33. | Mercury ($Hg^{+}$) | ug/l | 0.143 | 0.298 | 0.199 | 0.001 |
| 34. | Iron ($Fe^{2+}$) | mg/l | 0.96 | 0.82 | 0.744 | 0.3 |
| (D) | ORGANICS | | | | | |
| 35. | Benzenze | mg/l | 0.00 | 0.0 | 0.00 | 0.01 |
| 36. | Toluene | mg/l | 0 | 0 | 0 | 0.7 |
| 37. | Ethybenzenze | mg/l | 0.000 | 0.000 | 0.000 | 0.30 |
| 38. | Xylene | mg/l | 0.0 | 0.0 | 0.0 | 0.5 |
| 39. | Phenols | mg/l | 0.278 | 0.198 | 0.286 | 0.05 |
| 40. | Oil and grease | mg/l | 0 | 0 | 0 | 10 |
| **(E)** | **MICROBIOLOGICAL TEST** | | | | | |
| 41. | E. coli | cfu/ml | 32 | 47 | 40 | Nil |
| 42. | Total coliform | cfu/ml | 256 | 301 | 275 | 10 |

## LABORATORY ANALYSIS RESULT (SOIL SAMPLES)

### SOIL SAMPLES ANALYSIS RESULT

**QUANTITY: 2.1 Kg**

| S/N | PARAMETERS | UNIT | S1 TOP | S2 BASE | S3 TOP | S4 BASE | S5 TOP | S6 BASE | S7 TOP | S8 Base | S9 TOP | S10 BASE | S11 TOP | S12 BASE | Control Top | Control Base |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (A) | **PHYSICAL TEST** | | | | | | | | | | | | | | | |
| 1. | PH | - | 7.3 | 6.6 | 6.75 | 6.34 | 6.68 | 6.94 | 6.64 | 6.76 | 6.64 | 5.88 | 7.05 | 6.61 | 6.61 | 6.70 |
| 2. | Electrical conductivity | us/cm | 51768 | 1768 | 866 | 1660 | 1714 | 1758 | 1778 | 1491 | 1272 | 1485 | 1543 | 1467 | 1756 | 1663 |
| 3. | Temperature | °c | 30.9 | 30.1 | 31.8 | 32.0 | 31.4 | 32.3 | 31.4 | 32.0 | 31.4 | 32.8 | 31.6 | 32.1 | 32.8 | 33.0 |
| 4. | Salinity | % | 0.08 | 0.08 | 0.04 | 0.08 | 0.08 | 0.08 | 0.08 | 0.07 | 0.07 | 0.07 | 0.07 | 0.06 | 0.08 | 0.08 |
| 5. | ORP | mV | 114 | 134 | 124 | 163 | 110 | 114 | 199 | 166 | 80 | 121 | 207 | 131 | 145 | 158 |
| 6. | Colour | Tcu | Dark yellow brown | Dark brown | Dark brown | Dark Yellowish brown | Dark Yellowish brown | Dark Yellowish brown | Very Dark brown | Black | Dark brown | Yellowish brown | Dark brown | Dark yellowish brown | Dark yellowish brown | Dark yellow brown |
| (B) | **EXCHANGEABLE CATION** | | | | | | | | | | | | | | | |
| 7. | Calcium ($Ca^{2+}$) | mg/kg | 0.41 | 3.46 | 0.39 | 3.27 | 1.52 | 1.78 | 2.23 | 2.96 | 1.43 | 0.86 | 2.44 | 2.44 | 0.56 | 0.74 |
| 8. | Megnasium ($Mg^{2+}$) | mg/kg | 1.88 | 2.99 | 1.45 | 1.92 | 0.86 | 0.92 | 1.14 | 1.17 | 2.22 | 2.01 | 1.06 | 1.07 | 0.05 | 0.32 |
| 9. | Aluminum ($A1^{3+}$) | mg/kg | 1.066 | 1.234 | 0.862 | 0.966 | 0.112 | 0.173 | 0.863 | 0.934 | 1.005 | 0.396 | 0.000 | 0.042 | 0.00 | 0.000 |
| 10. | Potassium ($K^{+}$) | mg/kg | 2.7 | 3.8 | 2.3 | 2.5 | 2.5 | 2.3 | 0.9 | 1.7 | 3.7 | 6.9 | 2.3 | 2.1 | 0.7 | 1.0 |
| 11. | Ammonium ($NH_4^{+}$) | mg/kg | 0.11 | 0.47 | 0.93 | 1.86 | 0.77 | 1.02 | 0.56 | 0.34 | 0.19 | 0.29 | 0.34 | 1.55 | 0.06 | 0.12 |
| (C) | **EXCHANGEABLE ANION** | | | | | | | | | | | | | | | |
| 12. | Chloride ($Cl^{-}$) | mg/kg | 2.7 | 0.7 | 1.4 | 0.0 | 0.3 | 0.6 | 1.8 | 2.7 | 1.9 | 1.9 | 2.6 | 1.5 | 0.0 | 0.0 |
| 13. | Fluoride ($F^{-}$) | mg/kg | 0.00 | 0.13 | 0.32 | 0.41 | 0.72 | 0.11 | 0.05 | 0.04 | 0.51 | 0.36 | 0.51 | 0.86 | 0.10 | 0.0 |
| 14. | Nitrate ($No^{2-}_3$) | mg/kg | 21.4 | 20.6 | 15.4 | 23.5 | 16.8 | 35.1 | 29.7 | 30.3 | 27.7 | 18.5 | 24.6 | 24.9 | 11.6 | 8.9 |
| 15. | Nitrite ($NO_2^{-}$) | mg/kg | 0.047 | 0.011 | 0.026 | 0.037 | 0.032 | 0.006 | 0.001 | 0.030 | 0.026 | 0.110 | 0.306 | 0.002 | 0.00 | 0.000 |
| 16. | Sulphate ($so^{2-}_4$) | mg/kg | 53 | 59 | 63 | 74 | 44 | 39 | 68 | 90 | 28 | 19 | 42 | 33 | 20 | 14 |
| 17. | Phosphate ($PO_4^{3-}$) | mg/kg | 6.47 | 4.33 | 2.86 | 2.81 | 3.34 | 2.94 | 2.86 | 3.00 | 2.55 | 1.89 | 2.04 | 2.77 | 1.36 | 0.04 |
| (D) | **HEAVY METALS** | | | | | | | | | | | | | | | |
| 18. | Chromium ($Cr^{2+}$) | mg/kg | 0.02 | 0.09 | 0.00 | 0.01 | 0.04 | 0.03 | 0.15 | 0.02 | 0.22 | 0.05 | 0.11 | 0.36 | 0.01 | 0.08 |

## LABORATORY ANALYSIS RESULT (SOIL SAMPLES) CONTINUATION….

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 19. | Copper ($Cu^{2+}$) | mg/kg | 1.05 | 0.24 | 1.00 | 1.03 | 2.04 | 2.02 | 0.47 | 0.86 | 0.51 | 0.36 | 0.17 | 0.17 | 0.02 | 0.03 |
| 20. | Iron ($Fe^{2+}$) | mg/kg | 0.86 | 1.19 | 0.46 | 0.41 | 1.88 | 1.24 | 0.36 | 0.39 | 0.52 | 0.09 | 1.26 | 0.86 | 0.11 | 0.10 |
| 21. | Lead ($Pb^{2+}$) | mg/kg | 0.000 | 0.000 | 0.025 | 0.044 | 0.000 | 0.000 | 0.000 | 0.000 | 0.004 | 0.000 | 0.001 | 0.001 | 0.000 | 0.000 |
| 22. | Manganese (Mn) | mg/kg | 0.2 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.0 | 0.0 |
| 23. | Mercury (Hg+) | ug/kg | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 24. | Cobalt ($Co^{2+}$) | mg/kg | 0.2 | 0.1 | 0.2 | 0.3 | 0.2 | 0.4 | 0.7 | 0.7 | 0.1 | 0.2 | 0.1 | 0.0 | 0.0 | 0.1 |
| 25. | Nickel ($Ni^{2+}$) | mg/kg | 0.002 | 0.001 | 0.003 | 0.000 | 0.014 | 0.003 | 0.136 | 0.148 | 0.056 | 0.037 | 0.004 | 0.004 | 0.006 | 0.006 |
| **(E)** | **ORGANICS** | | | | | | | | | | | | | | | |
| 26. | Oil and grease | mg/kg | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 27. | Phenol | mg/kg | 0.034 | 0.031 | 0.118 | 0.033 | 0.116 | 0.026 | 0.034 | 0.011 | 0.056 | 0.118 | 0.021 | 0.341 | 0.962 | 0.565 |
| 28. | BTEX | mg/kg | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **(F)** | **SOIL CHARACTERISTICS** | | | | | | | | | | | | | | | |
| 29. | Sandy | % | 55 | 48 | 58 | 60 | 58 | 63 | 64 | 69 | 67 | 54 | 72 | 56 | 59 | 41 |
| 30. | Loam | % | 31 | 25 | 37 | 28 | 33 | 31 | 25 | 34 | 28 | 38 | 21 | 40 | 36 | 50 |
| 31. | Clay | % | 9 | 13 | 0 | 9 | 6 | 1 | 18 | 2 | 2 | 7 | 2 | 0 | 4 | 6 |
| 32. | Silt | % | 5 | 10 | 5 | 3 | 3 | 5 | 21 | 14 | 3 | 1 | 5 | 4 | 1 | 3 |
| **(G)** | **MICROBIOLOGICAL TEST** | | | | | | | | | | | | | | | |
| 33. | E. coli | cfu/100kg | 34 | 19 | 14 | 35 | 32 | 21 | 6 | 17 | 43 | 29 | 15 | 27 | 18 | 18 |
| 34. | Fungal | cfu/100kg | 219 | 56 | 62 | 294 | 301 | 87 | | 69 | 396 | 94 | 65 | 99 | 54 | 54 |

Best Wishes,

POLLUTION CONTROL LABORATORY MAKURDI SIGN DATE

San. Abdulkadir H. Umar (ACSO)
**ASSISTANT CHIEF SCIENTIFIC OFFICER**

# APPENDIX IV

## ATTENDANCE SHEETS

BOLBEN ENERGY
AND ENVIRONMENTAL SERVICES LTD

**ENVIRONEMENTAL AND SOCIAL IMPACT ASSESSMENT (ESIA) SITE VERIFICATION AND BASELINE DATA GATHERING EXERCISES FOR THE PROPOSED REA-NEP (DtP PHASE II) POWER PROJECT, FUHSO, BENUE STATE.**

**PROJECT TITLE:** 2 MW SOLAR PHOTOVOLTAIC POWER PROJECT AND ASSOCIATED INFRASTRUCTURE UNDER THE NIGERIA ELECTRIFICATION PROGRAM (NEP) DESERT TO POWER PHASE II (DTP II) BY RURAL ELECTRIFICATION AGENCY.

**LOCATION:** Federal University of Health Sciences, Otukpo LGA

**STATE:** BENUE STATE

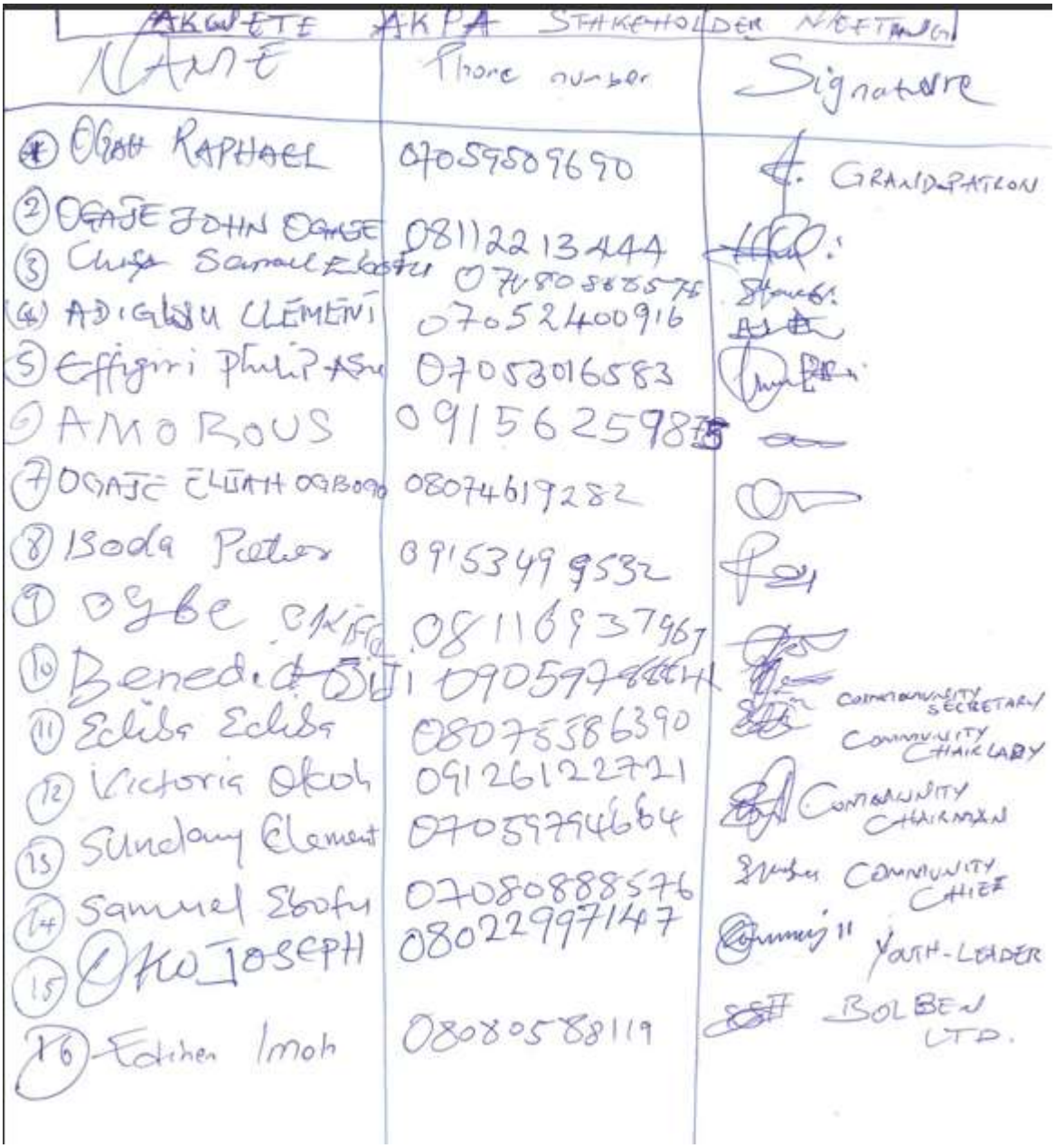
**DATE:** 18-07-2026

| S/N | NAME | DESIGNATION/POSITION | PHONE NO. | SIGN |
|---|---|---|---|---|
| 1 | Prof. Friday C. Okibe | DVC (Acad.) | 07039502969 | |
| 2 | Michael Okoko Ogiji | Registrar | 08035885261 | |
| 3 | Arc Jonah J Akujuru | DPP | 07036151938 | |
| 4 | Mr Michael S Amebi | CSO | 08067094510 | |
| 5 | Engr Abdulsalam B Muhammad | Senior Engr/ DPP | 08131272314 | |
| 6 | Arc. Victor A. AKIGNU | DPP (P.Sec) | 07085069924 | |
| 7 | Edeh christian Ugochukwu | Senior Engr / DPP | 07034945897 | |
| 8 | Emmanuel Agbo | Information unit | 08025444887 | |
| 9 | Emmanuel Onoja Ameh | " | 08035371873 | |

FUHSO SITE VERIFICATION EXERCISE
Continuation

| S/N | NAME | DESIGNATION/POSITION | PHONE NO. | SIGN |
|---|---|---|---|---|
| 10 | MBAKIGHIR HEMBADOON DEBORAH | STATE MANAGER BCC | 07033447824 | |
| 11 | Ngbede Bayo Anthony | Engineering Assistant | 07038790687 | |
| 12 | Ogbidi Matthew Tabi | Engr. Abuja | 08164014778 | |
| 13 | Edeh Ikoh | Bolben Ltd | 09080528119 | |
| 14 | Engr. D. Nwadeaa Emmanuel Ahmed | Bolben Engr (Ltd) | 07063641815 | |
| 15 | Mayosore Abdulmajeed | " | 07034403660 | |
| 16 | Offem Ephraim | " | 08137694342 | |
| | | | | |
| | | | | |

## *ATTENDANCE SHEET CONTINUATION….*



| S/N | NAME | Phone number | Signature |
|---|---|---|---|
| 1 | Ogah RAPHAEL | 07059509690 | GRANDPATRON |
| 2 | OGAJE JOHN OGWE | 08112213444 | |
| 3 | Chief Samuel Ebofu | 07080888576 | |
| 4 | ADIGWU CLEMENT | 07052400916 | |
| 5 | Effigiri Philip Asu | 07053016583 | |
| 6 | AMOROUS | 09156259875 | |
| 7 | OGAJE ELIJAH OGBOGO | 08074619282 | |
| 8 | Isoda Peter | 09153499532 | |
| 9 | Ogbe Chief | 08116937967 | |
| 10 | Benedict Oji | 09059784644 | COMMUNITY SECRETARY |
| 11 | Eclis Eclis | 08075586390 | COMMUNITY CHAIRLADY |
| 12 | Victoria Okoh | 09126122721 | |
| 13 | Sunday Clement | 07059794664 | COMMUNITY CHAIRMAN |
| 14 | Samuel Ebofu | 07080888576 | COMMUNITY CHIEF |
| 15 | Oko JOSEPH | 08022997147 | YOUTH-LEADER |
| 16 | Edibon Imoh | 08080588119 | BOLBEN LTD. |

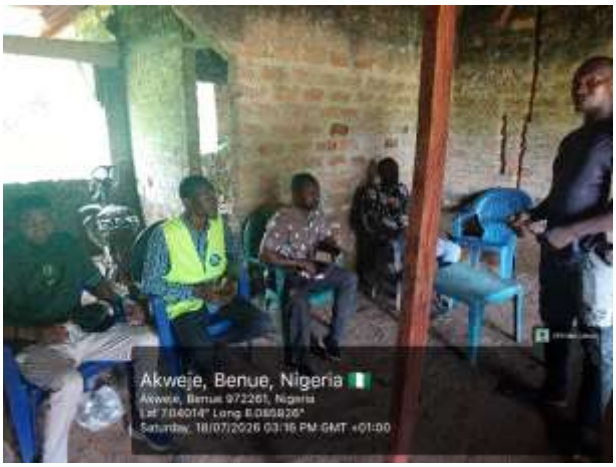
# APPENDIX V

## PICTORIAL EVIDENCE OF STAKEHOLDER ENGAGEMENT












# APPENDIX VI

## PICTORIAL EVIDENCE OF SOIL SAMPLING











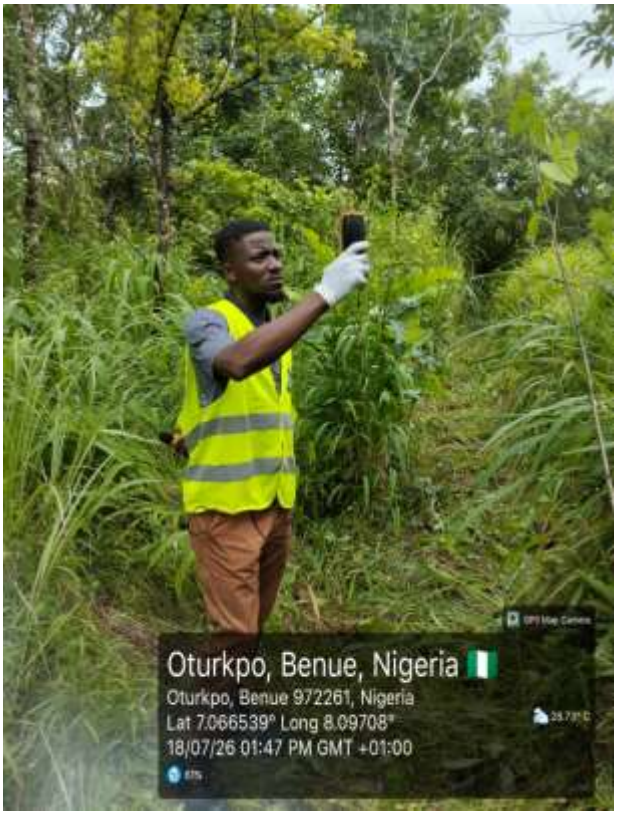

# APPENDIX VII

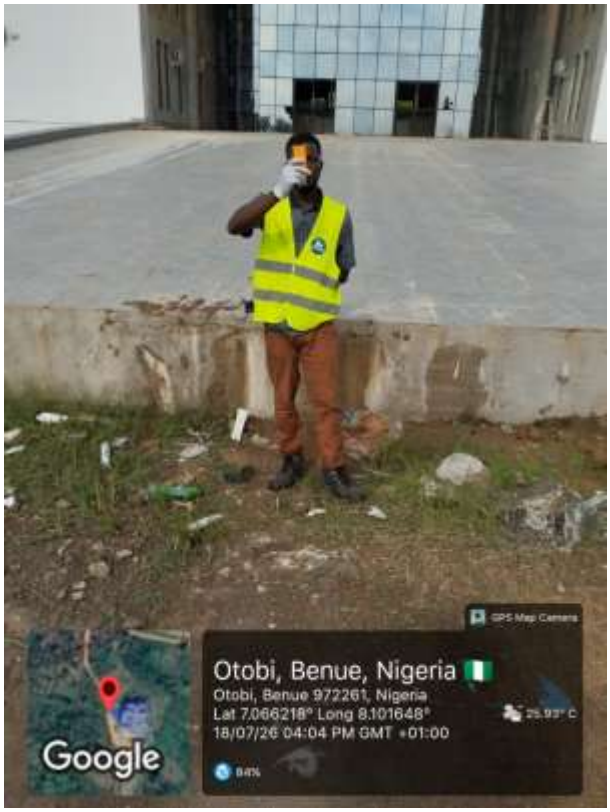
## PICTORIAL EVIDENCE OF AMBIENT AIR AND NOISE LEVEL SAMPLING





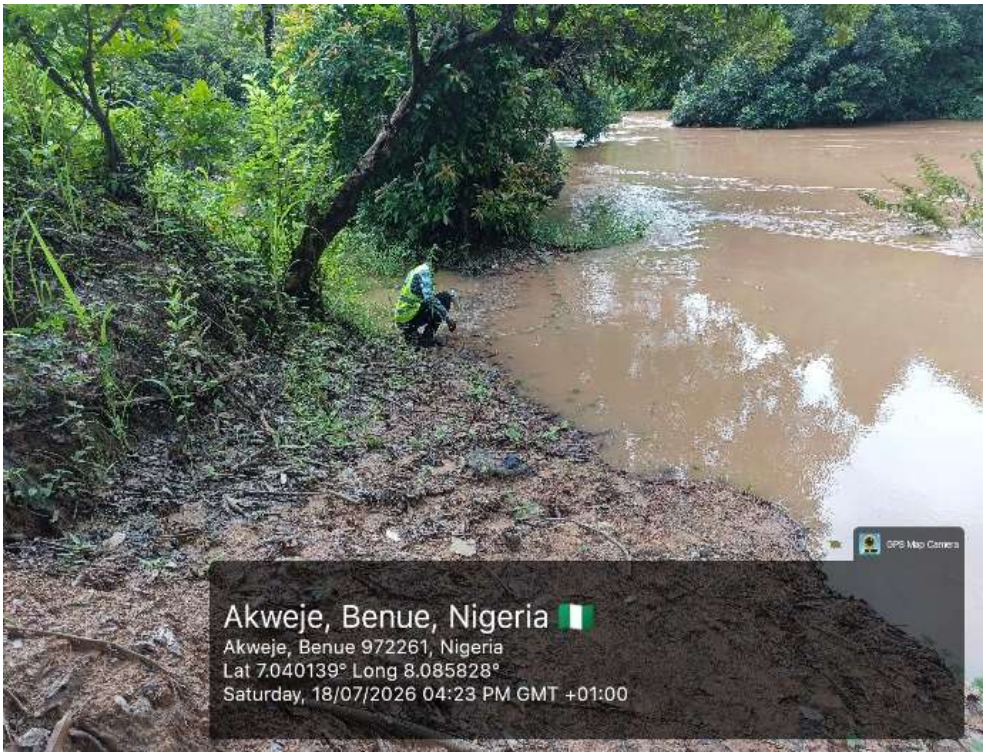




# APPENDIX VIII

## PICTORIAL EVIDENCE OF WATER SAMPLING






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# APPENDIX IX

## LIST OF SAMPLING EQUIPEMENTS

| *Category* | *Equipment* | *Purpose* |
|---|---|---|
| ***Navigation & Survey*** | Handheld GPS | Record sampling locations and project coordinates |
| | Measuring Tape (30–100 m) | Distance measurements |
| ***Documentation*** | Digital Camera | Photographic documentation |
| | Smartphone | Data collection, GPS, communication |
| | Field Notebook | Recording observations |
| | Clipboard | Support for field forms |
| | Pens/Markers | Writing |
| | Paper Tape | Sample identification |
| | Chain of custody forms | Samples logging and tracking |
| ***Water Quality Sampling*** | Water Sampling Bottles | Water sample collection |
| | Cooler Box with Ice Packs | Preserve samples during transport |
| | Multiparameter Water Quality Meter | Measure pH, EC, TDS, DO, Temperature |
| ***Soil Sampling*** | Soil Auger | Collect soil samples |
| | Hand Trowel | Surface soil sampling |
| | Ziploc Bags | Store soil samples |
| ***Social Survey*** | Questionnaires | Stakeholder surveys |
| | Attendance Sheets | Stakeholder engagement records |
| ***Health & Safety*** | High-Visibility Vest | Personnel safety |
| | Safety Boots | Foot protection |

***Detection limits for air quality instruments***

| Parameter Measured | Equipment | Detection Limit |
|---|---|---|
| PM2.5 | Elitech Temtop LKC-1000S+ 2nd Generation | 0 to 999 µg/m³ |
| PM10 | Elitech Temtop LKC-1000S+ 2nd Generation | 0 to 999 µg/m³ |
| Formaldehyde (HCHO) | Elitech Temtop LKC-1000S+ 2nd Generation | 0 to 5 mg/m³ (Resolution: 0.001 mg/m³) |
| Total VOC (TVOC) | Elitech Temtop LKC-1000S+ 2nd Generation | 0 to 5 mg/m³ (Resolution: 0.001 mg/m³) |
| Temperature | VT-9IN1 Air Quality Monitor Tester | 32°F to 158°F (0°C to 70°C) |
| Relative humidity | VT-9IN1 Air Quality Monitor Tester | 0% to 99% RH |
| AQI | Elitech Temtop LKC-1000S+ 2nd Generation | 0 to 999 |
| Particle number | Elitech Temtop LKC-1000S+ 2nd Generation | 0 to 9,999 particles per liter (particles/L) [1, 2] |
| $CO_2$ / Oxygen ($O_2$) | VT-9IN1 Air Quality Monitor Tester | $CO_2$ ranges from 400 to 5000 ppm; and 0–30% vol for $O_2$ |
| Ambient noise level | V-Resourcing Hand-Held Sound Level Meter | 30 dBA to 130 dBA (Accuracy: ±1.5 dB) |