



Kaiha 2 Mini Hydropower Project

Environmental and Social Impact Assessment

Final Report

April 18, 2019
Version 1.0

Liberia Rural and Renewable Energy Agency

Kaiha 2 Mini Hydropower Project: *Environmental and Social Impact Assessment*

Final Report

April 18, 2019
Version 1.0

Prepared for RREA by

Earthtime, Monrovia, Liberia
ERM, Cape Town, South Africa

CONTENTS

EXECUTIVE SUMMARY	1
2 INTRODUCTION	1
2.1 PROJECT BACKGROUND	1
2.2 BACKGROUND TO THE ESIA	3
2.3 ESIA OBJECTIVES	5
2.4 ESIA REPORT STRUCTURE	6
3 PROJECT DESCRIPTION	8
3.1 LOCATION	8
3.2 HYDROPOWER PLANT	3
3.3 DIESEL POWER PLANT	13
3.4 TRANSMISSION LINE	15
3.5 PROJECT ACTIVITIES	17
3.6 PROJECT CONTRACTING	25
3.7 PROJECT COST	25
4 ANALYSIS OF ALTERNATIVES	26
4.1 INTRODUCTION	26
4.2 ALTERNATIVE SOURCES FOR ELECTRICITY GENERATION	26
4.3 PROJECT-SPECIFIC ALTERNATIVES	27
4.4 NO PROJECT ALTERNATIVE	31
5 APPROACH AND METHODOLOGY	32
5.1 INTRODUCTION	32
5.2 SCOPING	33
5.3 STAKEHOLDER ENGAGEMENT	34
5.4 DETERMINATION OF BASELINE CONDITIONS	34
5.5 PROJECT DESCRIPTION AND ALTERNATIVES	35
5.6 ASSESSMENT OF IMPACTS	35
5.7 MITIGATION AND MANAGEMENT	40
5.7.1 RESIDUAL IMPACT ASSESSMENT	41
6 LEGAL AND POLICY FRAMEWORK	43
6.1 LIBERIAN ENVIRONMENTAL ADMINISTRATIVE FRAMEWORK	43
6.2 NATIONAL LEGISLATIVE FRAMEWORK	46
6.3 LIBERIA ENVIRONMENTAL QUALITY STANDARDS	59
6.4 LIBERIA ENVIRONMENTAL IMPACT ASSESSMENT REQUIREMENTS	65
6.5 INTERNATIONAL SAFEGUARD POLICIES	68
7 BASELINE CONDITIONS	74

7.1	<i>INTRODUCTION</i>	74
7.2	<i>PHYSICAL ENVIRONMENT</i>	75
7.3	<i>SEISMOLOGY</i>	82
7.4	<i>BIOLOGICAL ENVIRONMENT</i>	93
7.5	<i>HUMAN ENVIRONMENT</i>	119
8	<i>IMPACT ASSESSMENT AND MITIGATION MEASURES</i>	141
8.1	<i>BIOPHYSICAL ENVIRONMENT</i>	143
8.2	<i>SOCIO-ECONOMIC ENVIRONMENT</i>	226
8.3	<i>CUMULATIVE IMPACTS</i>	273
9	<i>ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN</i>	274
9.1	<i>INTRODUCTION</i>	274
9.2	<i>PLANNING</i>	275
9.3	<i>IMPLEMENTATION</i>	277
9.4	<i>MONITORING, CHECKING AND CORRECTIVE ACTION</i>	326
10	<i>STAKEHOLDER ENGAGEMENT</i>	338
10.1	<i>INTRODUCTION</i>	338
10.2	<i>CONSULTATION OBJECTIVES</i>	338
10.3	<i>STAKEHOLDER IDENTIFICATION</i>	339
10.4	<i>STAKEHOLDER ENGAGEMENT CONDUCTED</i>	339
10.5	<i>PLANNED STAKEHOLDER ENGAGEMENT</i>	343
11	<i>REFERENCES</i>	346

ANNEXES

- Annex 1 Documentation of ESIA Registration and Scoping*
- Annex 2 Documentation of Stakeholder Engagement*
- Annex 3 Documentation of Biophysical Field Surveys*
- Annex 4 Operational Management Plans*

LIST OF FIGURES

Figure 3.1	Project Location (1)	1
Figure 3.2	Project Location (2)	2
Figure 3.3	Hydropower Plant Layout (schematic)	4
Figure 3.4	Hydropower Plant Layout (with topography)	4
Figure 3.5	Power Plant Layout (overlay on satellite image)	5
Figure 3.6	Approximate Extent of Potential Change in River Water Level	9
Figure 3.7	Hydropower Plant Layout	10
Figure 3.8	Route for Transport of Large Equipment to Project Site	12
Figure 3.9	Phasing of Increase in Diesel Power Plant Capacity	15
Figure 3.10	Transmission Line Design Concepts	16
Figure 3.11	Stages of River Diversion for the Construction of the Hydropower Plant	19
Figure 3.12	Theoretical Generation Capacity vs Generation to Meet Demand	22
Figure 3.13	Projected Hydropower and Diesel Power Generation	22
Figure 3.14	Hydropower Plant Management Organisation	24
Figure 5.1	Overview of the ESIA Process	33
Figure 6.1	Overview of ESIA Process in Liberia	67
Figure 7.1	Rapids and Waterfall at Hydropower Plant Site (viewed looking downstream)	76
Figure 7.2	Rapids and Waterfall at Hydropower Plant Site (viewed looking upstream)	76
Figure 7.3	Typical Landscape along the Road between Kolahun and Foya	77
Figure 7.4	Geology in the Project AoI	78
Figure 7.5	Map of Soil Types in Liberia	80
Figure 7.6	Map of Soil Types in the Project AoI	81
Figure 7.7	GSHAP Seismic Acceleration Map	82
Figure 7.8	Average Monthly Rainfall (mm) at Voinjama (1952 to 1981)	83
Figure 7.9	Average Monthly Minimum and Maximum Temperatures (in Fahrenheit degree) at Kolahun (1953 to 1963)	84
Figure 7.10	Liberia Total National GHG Emissions (Mt CO ₂ e) (projected based on GDP growth, with and without NDC commitments taken into consideration)	87
Figure 7.11	Rehabilitation Works at the Wanwoma Irrigation Scheme	88
Figure 7.12	Catchment in Project AoI	89
Figure 7.13	Calculated Flow at Gauging Station 01MA001 at Kolahun	90
Figure 7.14	Average Monthly Flows at Kaiha 2 Hydropower Plant Site	91
Figure 7.15	Location of Protected Areas Relative to Project Location	94
Figure 7.16	Location of Key Biodiversity Areas relative to the Project Location	96
Figure 7.17	Example of Closed Canopy Gallery Forest at Hydropower Plant Site	98
Figure 7.18	Example of Gallery Forest with Large Mature Trees Downstream of the Hydropower Plant Site	99
Figure 7.19	Sarotherodon Occidentalis (NT) (left) and Doumea Chappuisi (VU) (Loach Catfish Sp.) (Right)	113
Figure 7.20	Slash and Burn Agriculture (left) and Coffee Plantation along the Main Road (right)	124
Figure 7.21	Bolahun Town (left) and Kolahun Town (Kolba City) (right).	125
Figure 7.22	Temporary Farm Shelter along the Planned Access Road	125
Figure 7.23	Fish Traps at the Waterfall at the Hydropower Plant Site (left) and Kru-Canoes used for Fishing at Mbaloma (right)	127
Figure 7.24	Traditional Structures in Northwestern Liberia. Historic Photos (top) and Modern Photos (bottom) of Traditional Western Sudan Style Houses.	135

Figure 7.25	<i>Possible Example of a Western Sudan style structure in Bondowalahun No. 2 Village</i>	136
Figure 7.26	<i>Examples of Late 19th and 20th Century buildings in Liberia: ca. 1920 Holy Cross Episcopal Mission, Bolahun, Lofa County; 20th century Salayea Mosque, Salayea, Lofa County; and Late 19th/early 20th century street in Liberia.</i>	137
Figure 7.27	<i>Poro Enclosure (left) and Sande Ritual Graduation Dance (right)</i>	138
Figure 8.1	<i>Dry Season Flow Regime: All the Inflow is diverted to the Turbines.</i>	159
Figure 8.2	<i>Wet Season Flow Regime: The Turbine Flow Meets the Demand, while the Excess Water is Spilled Over the Dam.</i>	159
Figure 8.3	<i>Transition period flow regime (river flow slightly higher than demand flow): Modest peaking operation with variable downstream flow combined with spilling over the dam for most of the day.</i>	160
Figure 8.4	<i>Transition Period Flow Regime (river flow near the demand flow): Peaking Operation with Variable Downstream Flow Combined with no (Or Minimal) Spilling over the Dam</i>	160
Figure 8.5	<i>Location of Diesel Power Plant</i>	204
Figure 8.6	<i>Summary of estimated GHG emissions arising from the construction (2019-2020) and operations (2021 – 2040) of the Kaiha Hydropower Project</i>	212
Figure 8.7	<i>Seasonal Averages in Temperatures from the Mbaloma area</i>	220
Figure 8.8	<i>Seasonal Averages in Rainfall for Mbaloma area</i>	220
Figure 8.9	<i>Climate Projections for Liberia (precipitation)</i>	222
Figure 8.10	<i>Climate projections for Liberia (temperature)</i>	223
Figure 8.11	<i>Climate projections for Liberia (other)</i>	224
Figure 8.12	<i>Typical Plan Views of a Diesel Generator Inside an Enclosed Room</i>	258

LIST OF TABLES

Table 0.1	<i>Summary of Project Impacts and Risks</i>	3
Table 0.2	<i>Summary of Estimated Costs to Implement ESMP</i>	10
Table 2.1	<i>World Bank Safeguard Policies Triggered</i>	5
Table 2.2	<i>ESIA Report Structure</i>	7
Table 3.1	<i>Summary of Hydropower Plant Design Specifications</i>	3
Table 3.2	<i>Summary of Transmission Line Specifications</i>	16
Table 3.3	<i>Preliminary Implementation Schedule</i>	21
Table 3.4	<i>Estimate of Land Required for Project Components</i>	24
Table 5.1	<i>Impact Characteristics</i>	35
Table 5.2	<i>Impact Types</i>	36
Table 5.3	<i>Likelihood Definitions</i>	37
Table 5.4	<i>Impact Significances</i>	39
Table 6.1	<i>Categories of Legislations in Liberia</i>	47
Table 6.2	<i>Summary of Applicable Environmental Laws</i>	48
Table 6.3	<i>Relevant National Policies, Strategies and Plans</i>	51
Table 6.4	<i>Relevant International Environmental Conventions Signed/Ratified by Liberia</i>	52
Table 6.5	<i>Liberia Ambient Air Quality Standards</i>	61
Table 6.6	<i>Liberian Drinking Water Quality Standards</i>	63
Table 6.7	<i>Maximum Permissible Noise Levels for General Environment</i>	64
Table 6.8	<i>Maximum Permissible Noise Levels (Continuous or intermittent noise) from a Factory or Workshop</i>	64
Table 6.9	<i>Maximum Permissible Noise Levels for Residential & Commercial Areas</i>	64
Table 6.10	<i>Applicability of World Bank Safeguard Policies</i>	69
Table 7.1	<i>Hydrological Data for Kaiha 2 Hydropower Plant</i>	90
Table 7.2	<i>Water Quality Data at the Hydropower Plant Site</i>	92
Table 7.3	<i>Water Quality Data Upstream (U/S) and Downstream (D/S) of the 2 Hydropower Plant Site</i>	92
Table 7.4	<i>Canadian Water Quality Guidelines for Dissolved Oxygen for the Protection of Aquatic Life</i>	92
Table 7.5	<i>Landcover in the Project Area (within 1km of Hydropower Plant, Reservoir, Transmission Line and Diesel Power Plant)</i>	97
Table 7.6	<i>Distribution of Vulnerable (VU) and Near Threatened (NT) Plant Species</i>	101
Table 7.7	<i>Mammal Species in the Project Area</i>	102
Table 7.8	<i>Threatened and Near Threatened Bird Species Recorded in the Project Area</i>	105
Table 7.9	<i>Amphibian Species in the Project Area</i>	108
Table 7.10	<i>Reptile Species in the Project Area</i>	111
Table 7.11	<i>Reptile Species Identified through Interviews</i>	111
Table 7.12	<i>Fish Species in the Kaiha River in the Project Area</i>	113
Table 7.13	<i>Fish Species of Conservation Concern Identified Through Interviews</i>	116
Table 7.14	<i>Endangered and Critically Endangered Species in the Project Area and Status</i>	118
Table 7.15	<i>Population in the Project Area by County and District (2008)</i>	119
Table 7.16	<i>Household Head Population in the Project Area by Town, Clan, Chiefdom and District (2008)</i>	120
Table 7.17	<i>Estimated Population in the Project Area (2018)</i>	121
Table 7.18	<i>Comparison of Social Indicators for Females and Males in Liberia</i>	122
Table 7.19	<i>Current Land Cover that will be Permanently Altered by Flooding</i>	125
Table 7.20	<i>Three Categories of Households Based on Declared Income</i>	128

Table 7.21	<i>Distance from Clinics to Kolahun Hospital</i>	129
Table 7.22	<i>Number of Schools per Districts</i>	130
Table 7.23	<i>Percentage of Population with Access to Safe Water in Lofa County</i>	131
Table 7.24	<i>Main Energy Sources for Households in Each Income Category (excluding cooking)</i>	132
Table 7.25	<i>Main Source of Lighting for Households in Each Income Category</i>	132
Table 7.26	<i>Sensitivity of Cultural Heritage Resources</i>	140
Table 8.1	<i>Summary of Project Impacts and Risks</i>	141
Table 8.2	<i>Pre-Mitigation Impact Assessment</i>	145
Table 8.3	<i>Residual Impact Significance</i>	148
Table 8.4	<i>Pre-Mitigation Impact Assessment</i>	151
Table 8.5	<i>Residual Impact Significance</i>	152
Table 8.6	<i>Pre-Mitigation Impact Assessment</i>	154
Table 8.7	<i>Residual Impact Significance</i>	155
Table 8.8	<i>Pre-mitigation Impact Assessment</i>	161
Table 8.9	<i>Residual Impact Significance</i>	162
Table 8.10	<i>Pre-Mitigation Impact Assessment</i>	241
Table 8.11	<i>Residual Impact Significance</i>	242
Table 8.12	<i>Pre-Mitigation Impact Assessment</i>	164
Table 8.13	<i>Residual Impact Significance</i>	165
Table 8.14	<i>Pre-Mitigation Impact Assessment</i>	167
Table 8.15	<i>Residual Impact Significance</i>	167
Table 8.16	<i>Pre-Mitigation Impact Assessment</i>	169
Table 8.17	<i>Residual Impact Significance</i>	169
Table 8.18	<i>Pre-Mitigation Impact Assessment</i>	171
Table 8.19	<i>Residual Impact Significance</i>	172
Table 8.20	<i>Pre-Mitigation Impact Assessment</i>	174
Table 8.21	<i>Residual Impact Significance</i>	175
Table 8.22	<i>Pre-Mitigation Impact Assessment</i>	177
Table 8.23	<i>Residual Impact Significance</i>	177
Table 8.24	<i>Pre-Mitigation Impact Assessment</i>	179
Table 8.25	<i>Residual Impact Significance</i>	180
Table 8.26	<i>Pre-Mitigation Impact Assessment</i>	182
Table 8.27	<i>Residual Impact Significance</i>	183
Table 8.28	<i>Pre-mitigation Impact Assessment</i>	185
Table 8.29	<i>Residual Impact Significance</i>	187
Table 8.30	<i>Pre-Mitigation Impact Assessment</i>	188
Table 8.31	<i>Residual Impact Significance</i>	189
Table 8.32	<i>Pre-Mitigation Impact Assessment</i>	191
Table 8.33	<i>Residual Impact Significance</i>	191
Table 8.34	<i>Pre-Mitigation Impact Assessment</i>	194
Table 8.35	<i>Residual Impact Significance</i>	195
Table 8.36	<i>Pre-Mitigation Impact Assessment</i>	197
Table 8.37	<i>Residual Impact Significance</i>	198
Table 8.38	<i>Pre-mitigation Impact Assessment</i>	200
Table 8.39	<i>Residual Impact Significance</i>	201
Table 8.40	<i>Pre-mitigation Impact Assessment</i>	203
Table 8.41	<i>Residual Impact Significance</i>	203
Table 8.42	<i>Stack Parameters</i>	205
Table 8.43	<i>Emission Rates for Criteria Pollutants</i>	205

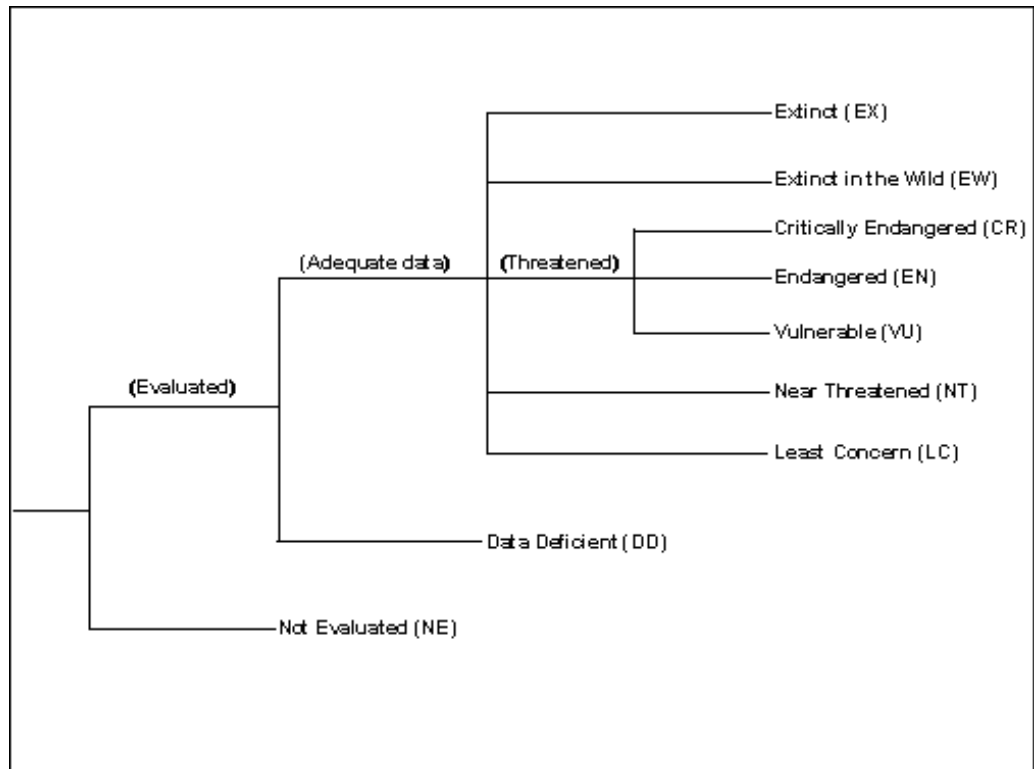
Table 8.44	<i>Parameters Used to Generate Meteorological Data</i>	205
Table 8.45	<i>Modelled Impacts at the Nearest Receptor Compared to Ambient Air Quality Guidelines ($\mu\text{g}/\text{m}^3$)</i>	206
Table 8.46	<i>Pre-Mitigation Impact Assessment</i>	207
Table 8.47	<i>Residual Impact Significance</i>	207
Table 8.48	<i>Project Phases in Scope</i>	209
Table 8.49	<i>Project GHG Emissions Sources</i>	209
Table 8.50	<i>Definition of Magnitude for GHG Emissions</i>	210
Table 8.51	<i>EBRD GHG Emissions Reporting Categories</i>	210
Table 8.52	<i>Estimated GHG Emissions arising from Project Construction</i>	212
Table 8.53	<i>Estimated Annual GHG Emissions arising from the Operation of the Kaiha Hydropower Project</i>	213
Table 8.54	<i>Magnitude scale for project-wide GHG emissions based on wider standards</i>	214
Table 8.55	<i>Estimated GHG emissions from the Kaiha Hydropower Project GHG emissions for Liberia</i>	214
Table 8.56	<i>Pre-Mitigation Impact Assessment</i>	215
Table 8.57	<i>Residual Impact Significance</i>	217
Table 8.58	<i>Results of Climate Change Risk Assessment</i>	225
Table 8.59	<i>Pre-Mitigation Impact Assessment</i>	227
Table 8.60	<i>Residual Impact Significance</i>	229
Table 8.61	<i>Avoided Costs for Households</i>	231
Table 8.62	<i>Total Economic Benefits to Households</i>	231
Table 8.63	<i>Pre-Mitigation Impact Assessment</i>	232
Table 8.64	<i>Residual Impact Significance</i>	233
Table 8.65	<i>Pre-Mitigation Impact Assessment</i>	235
Table 8.66	<i>Residual Impact Significance</i>	236
Table 8.67	<i>Pre-Mitigation Impact Assessment</i>	238
Table 8.68	<i>Residual Impact Significance</i>	239
Table 8.69	<i>Pre-Mitigation Impact Assessment</i>	247
Table 8.70	<i>Residual Impact Significance</i>	249
Table 8.71	<i>Pre-Mitigation Impact Assessment</i>	252
Table 8.72	<i>Residual Impact Significance</i>	253
Table 8.73	<i>Pre-Mitigation Impact Assessment</i>	255
Table 8.74	<i>Residual Impact Significance</i>	255
Table 8.75	<i>Noise Emission Profile for Enclosed Diesel Generators with Noise Controls</i>	259
Table 8.76	<i>Predicted Noise Levels at Nearest Noise Sensitive Receptors and Comparison to Daytime Noise Limits</i>	260
Table 8.77	<i>Predicted Noise Levels at Nearest Noise Sensitive Receptors and Comparison to World Bank Group and Liberian Night time Noise Limits</i>	261
Table 8.78	<i>Pre-Mitigation Impact Assessment</i>	262
Table 8.79	<i>Residual Impact Significance</i>	263
Table 8.80	<i>Sensitivity of Potential Cultural Heritage Resources Identified in the Baseline Study</i>	265
Table 8.81	<i>Summary of Cultural Heritage Impact Assessment Results</i>	268
Table 8.82	<i>Pre-Mitigation Impact Assessment</i>	270
Table 8.83	<i>Residual Impact Significance</i>	271
Table 9.1	<i>Summary of ESMP Requirements</i>	284
Table 9.2	<i>Monitoring During Construction</i>	330
Table 9.3	<i>Schedule of the Consultation Activities</i>	340
Table 9.4	<i>Main Issues Raised during Stakeholder Engagement</i>	341

ACRONYMS AND ABBREVIATIONS

AIDS	<i>Acquired Immune Deficiency Syndrome</i>
ALARP	<i>As Low As Reasonably Practicable</i>
AoI	<i>Area of Influence</i>
BID	<i>Background Information Document</i>
CBD	<i>Convention on Biological Diversity</i>
CBO	<i>Community Based Organisation</i>
CLO	<i>Community Liaison Officer</i>
CO ₂	<i>Carbon Dioxide</i>
EA	<i>Environmental Assessment</i>
ECO	<i>Environmental Compliance Officer</i>
EHS	<i>Environmental, Health, and Safety</i>
EIA	<i>Environmental Impact Assessment</i>
EIB	<i>European Investment Bank</i>
EMP	<i>Environmental Management Plan</i>
EMSP	<i>Environmental and Social Management Plan</i>
EPA	<i>Environmental Protection Agency (of Liberia unless specified otherwise)</i>
ERM	<i>Environmental Resources Management</i>
ESIA	<i>Environmental and Social Impact Assessment</i>
FDA	<i>Forestry Development Authority</i>
GDP	<i>Gross Domestic Product</i>
GHG	<i>Greenhouse Gases</i>
GoL	<i>Government of Liberia</i>
ha	<i>Hectare</i>
GPOBA	<i>Global Partnership on Output-Based Aid</i>
HIV	<i>Acquired Immunodeficiency Syndrome</i>
HRWL	<i>Highest Regulated Water Level</i>
IA	<i>Impact Assessment</i>
IDA - LESEP	<i>International Development Association - Liberia Electricity System Enhancement Project</i>
IFC	<i>International Finance Corporation</i>
ITCZ	<i>Inter-tropical Convergence Zone</i>
IUCN	<i>International Union for Conservation of Nature</i>
KfW	<i>Kreditanstalt für Wiederaufbau</i>
km	<i>Kilometre</i>
km ²	<i>Kilometre squared</i>
kV	<i>kilovolt</i>
LEC	<i>Liberia Electric Corporation</i>
LRWL	<i>Lowest Regulated Water Level</i>
M	<i>Metre</i>
MDG	<i>Millennium Development Goals</i>
MLME	<i>Ministry of Lands, Mines and Energy</i>
m/s	<i>Metres per Second</i>
m ³	<i>Cubic Metres</i>
mm	<i>Millimetres</i>
MPEA	<i>Ministry of Planning and Economic Affairs</i>
MW	<i>Megawatt</i>
MWh	<i>Megawatt hour</i>
Mt CO ₂ e	<i>Million Tonnes of CO₂ Equivalents</i>
NBSAP	<i>National Biodiversity Strategy and Action Plan (NBSAP)</i>
NDC	<i>Nationally Determined Contribution</i>
NGO	<i>Non-Governmental Organisation</i>
NO ₂	<i>Nitrogen Dioxide</i>
NVE	<i>Norwegian Water Resources and Energy Directorate</i>
OD	<i>Operational Directive</i>
OP	<i>Operational Policy</i>

OPN	<i>Operational Policy Note</i>
POP	<i>Persistent Organic Pollutants</i>
RPS	<i>Poverty Reduction Strategy</i>
PV	<i>Photovoltaic</i>
RAP	<i>Resettlement Action Plan</i>
RREA	<i>Rural and Renewable Energy Agency (of Liberia)</i>
SEP	<i>Stakeholder Engagement Plan</i>
SO ₂	<i>Sulphur Dioxide</i>
SREP	<i>Scaling- up Renewable Energy Program</i>
STDs	<i>Sexually Transmitted Diseases</i>
ToR	<i>Terms of Reference</i>
UK	<i>United Kingdom</i>
UN	<i>United Nations</i>
UNEP	<i>United Nations Environment Programme</i>
UNESCO	<i>United Nations Educational, Scientific and Cultural Organisation</i>
US	<i>United States</i>
USAID	<i>United States Agency for International Development</i>
WAPP	<i>West Africa Power Pool</i>
WBG	<i>World Bank Group</i>
WHO	<i>World Health Organisation</i>

***ABBREVIATIONS USED IN REFERENCE TO IUCN STATUS OF FLORA
AND FAUNA***



EXECUTIVE SUMMARY

The Rural and Renewable Energy Agency (RREA) is proposing to develop a 2.5 megawatt (MW) hydropower project on the Kaiha River in northern Liberia (the *Project*). The Project is referred to as *Kaiha 2* and is intended to provide affordable electricity supply to rural and urban communities in Lofa County, northern Liberia.

This report comprises a description of the *Environmental and Social Impact Assessment (ESIA)* of the Project. The ESIA was conducted as a combination of desktop-based and field studies and draws on information provided by the Project Proponent (RREA) and the Project's technical consultants including an ESIA of the Project as reported in the following (referred to as the *Initial ESIA*):

- *Kaiha 2 Hydropower Plant and Transmission Grid, Environmental and Social Impact Assessment, Final Report, 25 October 2016 (Multiconsult and Earthtime, 2016)*

The Initial ESIA was used as the basis of this ESIA and was updated in the basis of the updated technical design and supplemental environmental and social studies conducted as desktop studies and limited field surveys. The results were compiled and provided in this report.

PROJECT DESCRIPTION

The Project comprises a hydropower plant with associated infrastructure, an electricity transmission line, and a diesel-fuelled power plant to provide back-up electricity for periods when the hydropower plant cannot produce electricity. The transmission line will supply electricity directly to business and domestic users in about 30 towns and settlements not currently supplied by the national power grid.

A summary of the project components is as follows:

Hydropower plant and associated facilities:

- 2.5 MW run-of-river hydropower plant with a 23.2 m³/s flow capacity and 0.35 m³/s environmental flow
- Dam wall 7.5 m high
- Reservoir of 400 ha
- 49.4 m wide
- Flushing gate
- Penstocks 45 m long
- Powerhouse of 31.6 m in length and 11.2 m in width
- Tailrace
- Switchyard of 11.2m x 13.2m

- Generators totalling 1.8 MW
- Bulk fuel storage tanks

Transmission grid:

- 33 kV transmission lines totalling 115km from the hydropower plant to 30 towns including Voinjama.

KEY ENVIRONMENTAL AND SOCIAL IMPACTS AND RISKS

The potential impacts associated with the proposed Project identified in the ESIA are summarised below in *Table 0.1*.

For the hydropower plant, the key issues are impacts to biodiversity (river ecology, terrestrial ecology) and access to land and natural resources. Construction of the hydropower plant will require clearing of land. A dam wall will be built to increase the water head pressure which will increase the height of the water behind the dam and inundate a significant area of land. The loss of land will reduce available terrestrial habitat. The reduction of terrestrial habitat also reduces the availability of natural resources and land that might be used by people. In addition, the improvement of access to the hydropower plant site also opens access to previously inaccessible areas for illegal hunting and removal of timber.

The hydropower plant will be operated as 'run of river' and will maintain a minimum flow however there is the potential that river flow would be modified resulting in impacts and changes to river ecological conditions and impact on fish. The dam wall also creates a physical barrier for movement of fish.

The transmission line will for the most part follow existing road and will be installed within the limits of the right-of-way. There will be a need to clear areas where vegetation has over-grown. There will also be locations where new land will need to be acquired and cleared to route the line to population centres where users are located. Once installed, there will be little effect of the transmission line on the environment.

Table 0.1 *Summary of Project Impacts and Risks*

Resource or Receptor	Impact or Risk	Pre-mitigation	Post-mitigation
Biophysical			
Surface Water	Degradation of Surface Water Quality from Construction of Hydropower Plant, Associated Infrastructure, Transmission Line and Diesel Power Plant	Moderate (-)	Minor (-)
Surface Water	Degradation of Surface Water Quality from Operation of Hydropower Plant, Associated Infrastructure, Transmission Line and Diesel Power Plant	Moderate (-)	Minor (-)
Surface Water	Degradation of Water Quality and Indirect Negative Effects on Ecology due to Sedimentation of the Reservoir During Operations	Minor (-)	Negligible (-)
Surface Water	Changes on Downstream River Flow Volumes and Indirect Effects from Hydropower Plant, Associated Infrastructure, Transmission Lines and Diesel Power Plant during Construction and Operations	Minor (-)	Minor (-)
Public Safety	Risk of Major Flooding and Related Catastrophic Impacts Due to Dam Failure during Operations	Moderate (-)	Minor (-)
Aquatic Ecology	Alteration of Downstream Aquatic Habitat Due to Peaking during Operations	Moderate (-)	Minor (-)
Aquatic Ecology	Loss of Downstream Aquatic Habitat due to Reduced Water Quality because of Hydropower Plant Construction Activities	Moderate (-)	Minor (-)
Aquatic Ecology	Alteration of Upstream Aquatic Habitat Due to Inundation Caused by Construction and Operation of the Dam	Moderate (-)	Moderate (-)
Aquatic Ecology	Loss of Waterfall and Water Rapids Features and Fish Spawning Habitat Due to Construction and Operation of the Hydropower Plant	Moderate (-)	Minor (-)
Aquatic Ecology	Risk of Alteration of Fish Migration and Breeding Patterns Due to Construction and Operation of the Hydropower Plant	Moderate (-)	Minor (-)
Aquatic Ecology	Injury to Fish Caused by Interaction with Physical Structures including Turbines or Spillway during Operations	Moderate (-)	Minor (-)
Terrestrial Ecology	Loss of Forest Habitat due to Reservoir Inundation, Hydropower Plant Footprint, Access Road, Construction Camp and Laydown Areas during Construction and Operations	Major (-)	Major (-)
Terrestrial Ecology	Loss of Forest Habitat due to Construction of the Transmission Line	Moderate (-)	Moderate to Minor (-)
Terrestrial Ecology	Displacement and Loss of Fauna Due to Disturbance from Hydropower Plant and Access Road Construction Activities	Major (-)	Moderate (-)

Resource or Receptor	Impact or Risk	Pre-mitigation	Post-mitigation
Biodiversity	Increased Pressure on Natural Resources due to Increased Ease of Access as a Result of Construction and Operation of a New Access Road	Moderate (-)	Moderate to Minor (-)
Biodiversity	Risk of Increased Incidence of Invasive and Alien Plant Species due to Hydropower Plant, Associated Infrastructure, Access Road, Transmission Lines and Diesel Power Plant Construction	Moderate (-)	Minor (-)
Fauna	Risk of Physical Injury to Birds and Bats due to Operations of Transmission Line	Moderate (-)	Moderate to Minor (-)
Fauna	Disturbance of Fauna (excluding birds) due to Transmission Line Construction	Major (-)	Moderate (-)
Soils	Loss of Fertile Soil for the Construction of the Hydropower Plant Footprint, Access Road, Transmission Line, Construction Camp and Laydown Area	Moderate (-)	Moderate (-)
Soils	Impact of Change in Land Use and Capability for Construction and Operation of the Hydropower Plant Footprint, Access Road, Transmission Line, Construction Camp and Laydown Area	Moderate (-)	Moderate (-)
Air Quality	Reduced Air Quality due to Operation of the Diesel Power Plant	Minor (-)	Minor (-)
GHG	Increase in GHG Emissions due to the Construction of the Hydropower Plant and Access Road and Operation of Diesel Generators	Minor (-)	Minor (-)
GHG	Risk of Climate Change Related External Factors on Operation of the Hydropower Plant	See report	See report
Socio-Economic			
Macroeconomy	Increased Employment, Skills Enhancement and Local Business Due to the Construction of the Hydropower Plant, Associated Infrastructure, Transmission Lines and Diesel Power Plant	Moderate (+)	Moderate (+)
Macroeconomy	Increased Employment, Skills Enhancement and Local Business due to the Operation of the Hydropower Plant and Diesel Power Plant	Major (+)	Major (+)
Land	Land Tenure, Ownership and Use (Economic Displacement)	Major (-)	Minor (-)
Public Infrastructure	Increased Pressure on Local Infrastructure and Services	Moderate (-)	Moderate (-)
Community Health and Safety	Increased Health and Safety Risk for Community Associated with Influx of People during Construction of the Hydropower Plant and Diesel Power Plant	Moderate (-) to High (-)	Minor - Moderate (-)
Sense of Place	Increased Nuisance Factors and Changes in Sense of Place due to Hydropower Plant and Access Roads	Moderate (-)	Minor (-)

Resource or Receptor	Impact or Risk	Pre-mitigation	Post-mitigation
Visual Amenity	Loss of Visual Amenity and Sense of Place of the Waterfall due to Construction of the Hydropower Plant, Dam and Access Road	Negligible (-)	Negligible (-)
Noise	Disturbance of Local Communities due to Noise from Operation of the Diesel Generators	Minor (-)	Minor (-)
Cultural Heritage	Risk of Loss of Cultural Heritage due to Construction of Hydropower Plant Infrastructure, Access Roads and Transmission Lines	Minor (-) to Major (-)	Negligible to Moderate (-)
Resource or Receptor	Impact or Risk	Pre-mitigation	Post-mitigation
Biophysical			
Surface Water	Degradation of Surface Water Quality from Construction of Hydropower Plant, Associated Infrastructure, Transmission Line and Diesel Power Plant	Moderate (-)	Minor (-)
Surface Water	Degradation of Surface Water Quality from Operation of Hydropower Plant, Associated Infrastructure, Transmission Line and Diesel Power Plant	Moderate (-)	Minor (-)
Surface Water	Degradation of Water Quality and Indirect Negative Effects on Ecology due to Sedimentation of the Reservoir During Operations	Minor (-)	Negligible (-)
Surface Water	Changes on Downstream River Flow Volumes and Indirect Effects from Hydropower Plant, Associated Infrastructure, Transmission Lines and Diesel Power Plant during Construction and Operations	Minor (-)	Minor (-)
Public Safety	Risk of Major Flooding and Related Catastrophic Impacts Due to Dam Failure during Operations	Moderate (-)	Minor (-)
Aquatic Ecology	Alteration of Downstream Aquatic Habitat Due to Peaking during Operations	Moderate (-)	Minor (-)
Aquatic Ecology	Loss of Downstream Aquatic Habitat due to Reduced Water Quality because of Hydropower Plant Construction Activities	Moderate (-)	Minor (-)
Aquatic Ecology	Alteration of Upstream Aquatic Habitat Due to Inundation Caused by Construction and Operation of the Dam	Moderate (-)	Moderate (-)
Aquatic Ecology	Loss of Waterfall and Water Rapids Features and Fish Spawning Habitat Due to Construction and Operation of the Hydropower Plant	Moderate (-)	Minor (-)
Aquatic Ecology	Alteration of Fish Migration and Breeding Patterns Due to Construction and Operation of the Hydropower Plant	Moderate (-)	Minor (-)
Aquatic Ecology	Risk of Injury to Fish Caused by Interaction with Physical Structures including Turbines or Spillway during Operations	Moderate (-)	Minor (-)

Resource or Receptor	Impact or Risk	Pre-mitigation	Post-mitigation
Terrestrial Ecology	Loss of Forest Habitat due to Reservoir Inundation, Hydropower Plant Footprint, Access Road, Construction Camp and Laydown Areas during Construction and Operations	Major (-)	Major (-)
Terrestrial Ecology	Loss of Forest Habitat due to Construction of the Transmission Line	Moderate (-)	Moderate to Minor (-)
Terrestrial Ecology	Displacement and Loss of Fauna Due to Disturbance from Hydropower Plant and Access Road Construction Activities	Major (-)	Moderate (-)
Biodiversity	Increased Pressure on Natural Resources due to Increased Ease of Access as a Result of Construction and Operation of a New Access Road	Moderate (-)	Moderate to Minor (-)
Biodiversity	Risk of Increased Incidence of Invasive and Alien Plant Species due to Hydropower Plant, Associated Infrastructure, Access Road, Transmission Lines and Diesel Power Plant Construction	Moderate (-)	Minor (-)
Fauna	Risk of Physical Injury to Birds and Bats due to Operations of Transmission Line	Moderate (-)	Moderate to Minor (-)
Fauna	Disturbance of Fauna (excluding birds) due to Transmission Line Construction	Major (-)	Moderate (-)
Soils	Loss of Fertile Soil for the Construction of the Hydropower Plant Footprint, Access Road, Transmission Line, Construction Camp and Laydown Area	Moderate (-)	Moderate (-)
Land Use	Impact of Change in Land Use and Capability for Construction and Operation of the Hydropower Plant Footprint, Access Road, Transmission Line, Construction Camp and Laydown Area	Moderate (-)	Moderate (-)
Air Quality	Reduced Air Quality due to Operation of the Diesel Power Plant	Minor (-)	Minor (-)
GHG	Increase in GHG Emissions due to the Construction of the Hydropower Plant and Access Road and Operation of Diesel Generators	Minor (-)	Minor (-)
GHG	Risk of Climate Change Related External Factors on Operation of the Hydropower Plant	See report	See report
Socio-Economic			
Macroeconomy	Increased Employment, Skills Enhancement and Local Business Due to the Construction of the Hydropower Plant, Associated Infrastructure, Transmission Lines and Diesel Power Plant	Moderate (+)	Moderate (+)
Macroeconomy	Increased Employment, Skills Enhancement and Local Business due to the Operation of the Hydropower Plant and Diesel Power Plant	Major (+)	Major (+)

Resource or Receptor	Impact or Risk	Pre-mitigation	Post-mitigation
Land	Land Tenure, Ownership and Use (Economic Displacement)	Major (-)	Minor (-)
Public Infrastructure	Increased Pressure on Local Infrastructure and Services	Moderate (-)	Moderate (-)
Community Health and Safety	Increased Health and Safety Risk for Community Associated with Influx of People during Construction of the Hydropower Plant and Diesel Power Plant	Moderate (-) to High (-)	Minor - Moderate (-)
Sense of Place	Increased Nuisance Factors and Changes in Sense of Place due to Hydropower Plant and Access Roads	Moderate (-)	Minor (-)
Visual Amenity	Loss of Visual Amenity and Sense of Place of the Waterfall due to Construction of the Hydropower Plant, Dam and Access Road	Negligible (-)	Negligible (-)
Noise	Disturbance of Local Communities due to Noise from Operation of the Diesel Generators	Minor (-)	Minor (-)
Cultural Heritage	Risk of Loss of Cultural Heritage due to Construction of Hydropower Plant Infrastructure, Access Roads and Transmission Lines	Minor (-) to Major (-)	Negligible to Moderate (-)

LEGAL AND POLICY FRAMEWORK

The Project is being developed in accordance with a legal and policy framework that includes the laws and regulations of the Republic of Liberia, environmental and social requirements of international lenders, as well as international good practice.

In terms of environmental management, the main government entity is the Liberia Environmental Protection agency. The ESIA for the Project was carried out in accordance with Liberia regulation with oversight from the Liberia EPA.

The Project is being funded by international financial institutions including the World Bank. The Project is applying relevant World Bank environmental and social Safeguard Policies. The ESIA was conducted in accordance with World Bank OP 4.10 on Environmental Assessment. Other policies that apply relate to protection of cultural resources, management of involuntary resettlement and working on international waterways.

MITIGATION MEASURES

The Project is being designed to avoid or minimise impact to the environment and there are numerous embedded controls that take into account international good practice. Project design and technological controls alternatives were considered in terms of mitigating impacts.

To address unavoidable effects the project will implement various mitigation measures in the form of operational controls to reduce impacts and risks. Clearing of land will be minimised to only the footprint required for facilities and to work safely. Work activity will be controlled to avoid other disturbance to people and the environment. Worker behaviour will be controlled and measures will be taken to prevent illegal activities in the Project area such as hunting and illegal timber removal. To minimise impacts on river hydrology and river ecology, the hydropower plant will monitor and maintain a minimum flow. The Project will monitor effects to river ecology upstream and downstream of the hydropower plant.

The Project will ensure impacts to birds and bats from the transmission line are monitored and take corrective measures if necessary such as installing visibility devices. The Project will also monitor air and noise emissions from the diesel power plant to ensure compliance with local and international standards.

The Project will not require land but there will be cases where economic and livelihood activities are disrupted. Any land take will be addressed through the process contained in the Project's Resettlement Policy Framework.

STAKEHOLDER ENGAGEMENT

The Project has engaged stakeholders through the development process. Prior to the ESIA, national and international stakeholders were engaged by RREA under the auspices of the Scaling-up Renewable Energy Program (SREP). Stakeholder consultations have been conducted as part of the Environmental and Social Management Framework (ESMF) and Resettlement Policy Framework (RPF) process for the SREP.

During the ESIA, views from stakeholders at all levels (national, local government and residents in the project area), were sought through interviews, group discussions and a number of public meetings. This included a series of meetings with people in the affected communities in March 2016 held as part of the Initial ESIA process. Further meetings were held with stakeholder representatives in November 2017 held as part of the development of this ESIA. Stakeholder feedback was considered in the ESIA process.

GRIEVANCE MECHANISM

The Project will develop and implement a grievance mechanism that will provide a means for the public to communication problems and for the Project to take corrective action. The grievance mechanism will be disclosed to the public with specific focus on the communities using land around the hydropower plant and areas along the river upstream and downstream.

MONITORING AND PERFORMANCE INDICATORS

There will be regular monitoring of the Project by the Liberia EPA in terms of compliance with national environmental laws. The Project will implement an Environmental and Social Management Plan with a plan of specific empirical and non-empirical monitoring requirements.

INSTITUTIONAL ARRANGEMENTS

The Project will have an Environmental and Social Management Team to oversee environmental and social performance and compliance with legal and policy requirements including the World Bank Safeguards. The team will include an Environmental Compliance Officer and a Community Liaison Officer. The Team will be responsible for implementing the environmental and social mitigation and management actions as well as oversee performance of contractors as prescribed in the Project's Environmental and Social Management Plan.

BUDGET FOR IMPLEMENTATION

A summary of the costs associated with implementation of the requirements of the ESIA is provided as *Table 0.2*.

Table 0.2 *Summary of Estimated Costs to Implement ESMP*

Budget Item	Cost (USD)
Construction Contractors' ESMP ¹	
Company's ESMP	
Construction Supervision ²	
Environmental Flow Release ³	
Community Health, Safety and Security Plan	10,000
Livelihood Restoration Plan	455,000
Stakeholder Engagement Plan	10,000
Construction Contractors' Monitoring ^{1, 4}	
Company's Monitoring ⁴	20,000
Environmental and Social Management Unit ⁵	
Contingency (8%)	39,600
TOTAL	534,600

1 The costs associated with the construction contractor's ESMP and monitoring have not been estimated, as the environmental and social criteria will be included in the tender package upon which the tenderers will develop their base rates. The costs of the construction-related environmental and social management and monitoring will thus be within the contract price.

2 Construction supervision, to be undertaken by the company's Environmental and Social Management Unit, is covered under the item "planning, design, administration and supervision" in the project budget (Multiconsult 2016).

3 The installation of the pipe and flow sensor for environmental flow release shall be included in the tender documents and be part of the contract price. The cost is assumed to be minimal and can be covered by the project's contingency budget. The loss of power production and revenues from releasing environmental flow should be considered in the updated economic analysis to be conducted in the detailed design phase.

4 The monitoring plan, including auditing and evaluation, is presented in Chapter 9.

5 The costs of the Environmental and Social Management Team is covered under the item "planning, design, administration and supervision" in the project budget (Multiconsult 2016).

PUBLIC CONSULTATION

Stakeholder engagement for the ESIA involved public notification of the ESIA process through newspapers. The Liberia EPA may opt to specify further public notification, disclosure and possibly hearings during the review process.

RELATED SAFEGUARDS

The other related documents that pertain to the ESIA and environmental and social management are as follows:

- Earthtime. 2015. Environmental and Social Management Framework for Scaling-up Renewable Energy Program (SREP). Final Report, October 2015. RREA, Monrovia, Liberia.
- Multiconsult. 2015. Resettlement Policy Framework for Scaling-up Renewable Energy Program (SREP). Final Report, October 2015. RREA, Monrovia, Liberia.
- Multiconsult. 2016. Pre-feasibility studies of selected mini hydropower projects in Liberia: Kaiha 2 Hydropower Plant feasibility report. Norwegian Water Resources and Energy Directorate. 1 September 2016.

INTRODUCTION

The *Rural and Renewable Energy Agency (RREA)* is proposing to develop a 2.5 megawatt (MW) hydropower project on the Kaiha River in northern Liberia (the *Project*). Project components include a 115 km transmission line and a 1.8 MW diesel power plant to provide back up power generation. The Project is referred to as *Kaiha 2* and is intended to provide affordable electricity supply to rural and urban communities in Lofa County, northern Liberia.

This report comprises a description of the *Environmental and Social Impact Assessment (ESIA)* of the Project. The ESIA was conducted as a combination of desktop-based and field studies. The ESIA draws on information provided by the Project Proponent (RREA) and the Project's technical consultants including an ESIA of the Project as reported in the following (referred to as the *Initial ESIA*):

- *Kaiha 2 Hydropower Plant and Transmission Grid, Environmental and Social Impact Assessment, Final Report, 25 October 2016 (Multiconsult and Earthtime, 2016)*

The Initial ESIA was used as the basis of this ESIA and was updated in the basis of the updated design and supplemental environmental and social studies conducted as desktop studies and limited field surveys. The results were compiled and provided in this report.

2.1

PROJECT BACKGROUND

The energy sector in Liberia is still in its infancy although reconstruction efforts have been underway for some years. At the end of 2012, less than two percent of country's population had access to grid supply with grid supply virtually absent outside the capital Monrovia.

In June 2009, the Government of Liberia (GoL) adopted a National Energy Policy (NEP) which stipulates broad sector reform and increased private sector investment. In response to the Government of Liberia's request, a program of support to the electricity sector in country was established in 2010 with funding from the Government of Norway. The support provided has significantly sped up the rehabilitation and expansion of the electricity utility. Funding for the rehabilitation and extension of the distribution network and for new connections was made available through financing from the Government of Norway, United States Agency for International Development (USAID), International Development Association - Liberia Electricity System Enhancement Project (IDA - LESEP) and Global Partnership on Output-Based Aid (GPOBA).

The GoL has confirmed its support to the development of the electricity sector and has embarked on major infrastructure projects that aim to rehabilitate the electricity sector. Additionally, GoL is pioneering the rehabilitation of the Mount Coffee hydropower plant with the support of the Government of Norway, European Investment Bank (EIB) and Kreditanstalt für Wiederaufbau (KfW). Regionally, Liberia (a member of the West Africa Power Pool (WAPP)) is in the process of implementing the Côte d'Ivoire-Liberia-Sierra Leone-Guinea (CLSG) regional transmission line.

Notwithstanding these accomplishments, the sector remains in emergency mode. Monrovia electricity supply options for the past five years have relied on donor-financed diesel generation. Given a tariff of some USD 0.50/kWh, taking the necessary steps to bring additional lower cost sources of power on stream is a pressing matter for Liberia. In this regard, the Ministry of Lands, Mines and Energy (MLME) is taking the lead in preparing an Access Action Plan and Master Plan that indicate the needs for investment for the short, medium and long-term development of the electricity sector, consistent with the GoL's objectives to provide electricity access to 70% of the population in greater Monrovia and 35 percent in the rest of the country by 2030.

MLME has initiated the preparatory work to provide a clear path forward and strategic direction on investment priorities and human capital development within the electricity sector.

With the exception of privately-owned generators and limited municipal mini-grids, Liberia's rural (ie, non- Monrovia) population has virtually no access to electricity. Even before Liberia's civil strife, access to electricity in interior areas was limited. In order to remedy this situation, Liberia's NEP foresaw the establishment of an institution especially dedicated to rural energy development. Through donor support, the establishment of this institution under the name of RREA has been achieved and the RREA was created by Executive Order in January 2010. The Act establishing the RREA was passed in June 2015 by the national Legislature and subsequently signed into law in July by the President.

At present, the GoL is embarking on a Renewable Energy Electrification Program supported by the Scaling- up Renewable Energy Program (SREP) to provide electricity services outside of greater Monrovia where two-thirds of the population live. The program will focus on the development of mini-grid systems based on small hydro and biomass, backed up by photovoltaic (PV) systems to compensate for seasonal variation, and stand-alone systems.

Under the programme of institutional cooperation between MLME and the Norwegian Water Resources and Energy Directorate (NVE), MLME and RREA are desirous to undertake studies of selected hydropower sites. NVE is therefore funding the Feasibility Study of the Kaiha 2 hydropower project located on the Kaiha River in Lofa County. The target area will not benefit

from the EU WAPP cross-border electrification project and CLSG WAPP project and its electrification is therefore dependent on off-grid solutions.

2.2

BACKGROUND TO THE ESIA

The development of the Project commenced in 2013 and under a programme of cooperation between the MLME and the NVE, the consultancy Multiconsult was contracted by NVE in June 2014 to conduct technical feasibility studies. Commencement of this work was, however, delayed due to outbreak of the Ebola virus disease in West Africa. Work finally re-commenced in March 2015.

Phase 1 of Multiconsult's work involved the pre-feasibility study of two potential hydropower sites: 0.9 MW Kaiha 1 and 1.0 MW Kaiha 2. The pre-feasibility study was completed in September 2015 and resulted in the selection of Kaiha 2 as the preferred site. The full feasibility study of the Kaiha 2 site was completed in September 2016.

Over the same time period, Multiconsult, working with the Liberia-based consultancy Earthtime Inc. of Liberia (Earthtime), was undertaking a process to conduct an ESIA for the Project. This ESIA process commenced in December 2015 with submission of a Project Brief to the Liberia Environmental Protection Agency (EPA), the first step in the national regulatory process. The Liberia EPA approved the brief in January 2016 and Multiconsult and Earthtime then prepared a Scoping Report which was submitted to the Liberia EPA and approved in July 2016. Multiconsult and Earthtime then commenced a detailed impact assessment process that ran until October 2016.

The results of that work are contained in the following:

- *Kaiha 2 Hydropower Plant and Transmission Grid, Environmental and Social Impact Assessment, Final Report, 25 October 2016 (Multiconsult and Earthtime, 2016)*

This report is hereafter referred to as the 'Initial ESIA.' This report was not submitted to the Liberia EPA.

Subsequent to the completion of the ESIA, RREA, in consultation with the World Bank, took a decision to separate the Project's design process from the ESIA as a measure to ensure the independence of the ESIA. ERM and Earthtime were thus contracted to conclude the ESIA process. This work included:

- Updating the Project description to reflect changes in the design;
- Verifying environmental and social studies carried out for the Existing ESIA;

- Conducting supplementation environmental and social studies as required (desktop);
- Conducting limited field verification studies; and
- Compiling information from the Initial ESIA and supplemental studies into a report;
- Concluding the Liberia ESIA regulatory process.

The updated ESIA was prepared in accordance with the requirements of both national regulations as well as in consideration of the requirements of Project lenders, namely those of the World Bank. The requirements are summarised in the following sections

2.2.1 *Liberia ESIA Requirements*

As part of the development of the Project, RREA is committed to carry out an ESIA process in compliance with the Environmental Protection and Management Law of Liberia (2003). The proposed Project falls under the 'Energy Industry' category (Number 7) in Annex I of the Environmental Protection and Management Law of Liberia, and as such is required to undergo an ESIA process.

The Project Brief along with a permit request was submitted to EPA on 02 December 2015. The screening was concluded on 06 January 2016 with the decision that the project could proceed with the scoping phase of the ESIA process (see *Annex 1*). Accordingly, the scoping exercise was carried out in the period from January to April 2016, and the Scoping Report and draft Terms of Reference for the ESIA was submitted to EPA on 09 May 2016. EPA's approval to proceed with the ESIA studies was received on 05 July 2016 (see *Annex 1*).

The ESIA studies were conducted between July and October 2016 and the results presented in the Initial ESIA.

This report presents the outcome of the supplemental studies and update to the ESIA. It will be submitted to the Liberia EPA for review and decision making as part of the regulated process.

2.2.2 *World Bank ESIA Requirements*

The development of the Project is being funded under the Liberia Renewable Energy Access Project (LIRENAP), a World Bank sponsored programme. In accordance with World Bank's environmental and social policies, the programme was reviewed in terms of the applicability of World Bank Safeguard Policies. A summary of those that the World Bank has determined to be applicable is provided in *Table 2.1*.

The Project is also being developed under an Environmental and Social Management Framework (ESMF) and Resettlement Policy Framework (RPF)

that was prepared for the overall programme and applied to individual activities under the programme (such as the Project).

This updated ESIA was prepared in consideration of the applicable requirements of the specified Safeguard Policies and ESMF and RPF requirements.

World Bank requirements are discussed in more detail in International Safeguard Policies.

Table 2.1 *World Bank Safeguard Policies Triggered*

Safeguard Policies Triggered by the Project	Yes	No
Environmental Assessment OP/BP 4.01	X	
Natural Habitats OP/BP 4.04		X
Forests OP/BP 4.36		X
Physical Cultural Resources OP/BP 4.11	X	X
Indigenous Peoples OP/BP 4.10		X
Involuntary Resettlement OP/BP 4.12	X	
Safety of Dams OP/BP 4.37		X
Projects on International Waterways OP/BP 7.50	X	
Projects in Disputed Areas OP/BP 7.60		X

Source: Project Appraisal Document for a Renewables Access Project (PAD1618), World Bank, December 2015)

2.3 *ESIA OBJECTIVES*

The main objective of the ESIA is to provide decision-makers with an indication of the likely consequences of the proposed Project. Specifically, the ESIA objectives are as follows:

- Document the baseline conditions prevailing before the project construction starts.
- Assess and report on the likely magnitude and significance of impacts, both positive and negative.
- Propose mitigation activities to reduce negative impacts and monitoring of important impacts during and after construction.
- Document the process undertaken to inform and engage with Project stakeholders.
- Reflect, to the extent practical, the views and wishes of stakeholders in the design of mitigation measures.
- Evaluate Project alternatives to ensure that the project is justified from a broader environmental perspective.

2.4 *ESIA REPORT STRUCTURE*

The ESIA report has been organized in eleven chapters covering all the items listed in the Liberia EIA Procedural Guidelines (EPA 2006).

The ESIA structure is summarised in *Table 2.2*.

Table 2.2 *ESIA Report Structure*

Chapter	Content
Chapter 1 - Introduction	Presents a brief background to the Project, and the purpose and structure of the report.
Chapter 2 - Project Description	Describes the Project components and Project Area as well as the need and desirability of the project.
Chapter 3 - Analysis of Alternatives	Describes the various alternatives that were assessed for the Project including; location, site layout and technology alternatives.
Chapter 4 - Approach and Methodology	The standardised approach to impact assessment in order to make the findings, conclusions and recommendations more objective and transparent.
Chapter 5 - Legal and Policy Framework	Describes the legal and policy requirements as well as the administrative structure.
Chapter 6 -Baseline Conditions	Provides a detailed baseline assessment of the receiving physical, biological and social environment.
Chapter 7 - Impact Assessment and Mitigation Measures	Presents the predicted impacts to the physical and biological environment as a result of the proposed Project and associated mitigation
Chapter 8 - Environmental and Social Management Plan	Outlines the proposed management measures, costs, timeframes and responsibilities to implement the mitigation and enhancement measures.
Chapter 9 - Environmental and Social Monitoring Plan	Outlines procedures essential for effectively monitoring social and environmental mitigation and management measures
Chapter 10 - Stakeholder Engagement	Summarises stakeholder engagement activities

3***PROJECT DESCRIPTION*****3.1*****LOCATION***

The Project's hydropower plant is located on the Kaiha River, approximately 45 km south of Kolahun Town (Kolba City) in Lofa County, in the northern part of Liberia (Figure 3.1 and Figure 3.2). The hydropower plant will be situated approximately 4.7 km from the small town of Mbaloma in the newly created Lukambeh District (sub-divided from Kolahun District) and accessed from the same town via an approximately 5.5 km access road.

A diesel-fuelled power plant will be necessary to provide power as back-up (alternative) to the hydropower plant during the dry season when river flow is not enough for hydropower generation. This plant will be located in Balawatta Town, about 3 km from the town of Voinjama on the road to Kolahun City.

The transmission mini-grid (approximately 115 km in length) will extend into Kolahun District (including the proposed new Wanhassa District) and further to Foya District and Voinjama District.

The hydropower plant, diesel power plant and transmission line area are discussed in more detail in the following Sections.

Figure 3.1 Project Location (1)

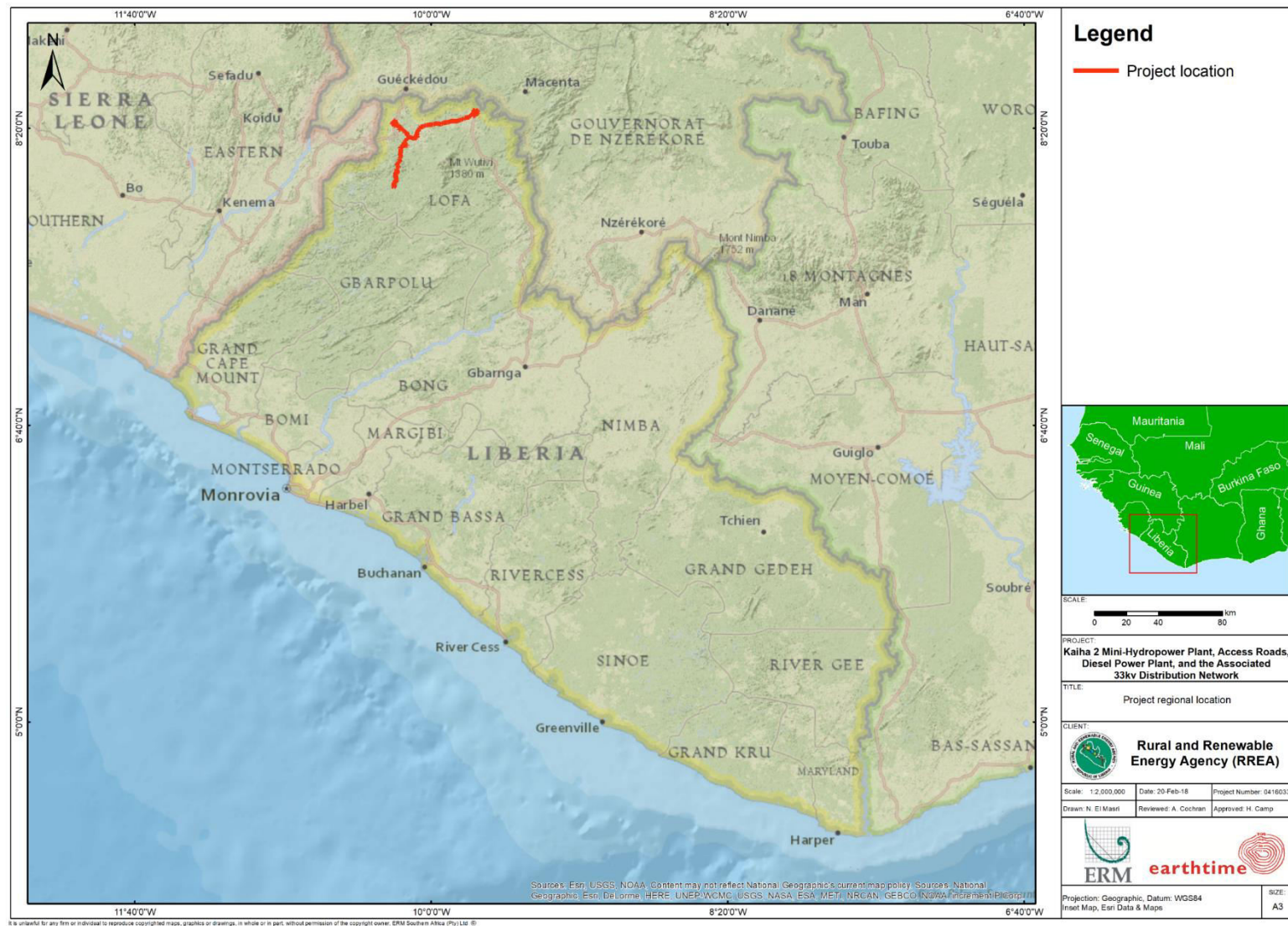
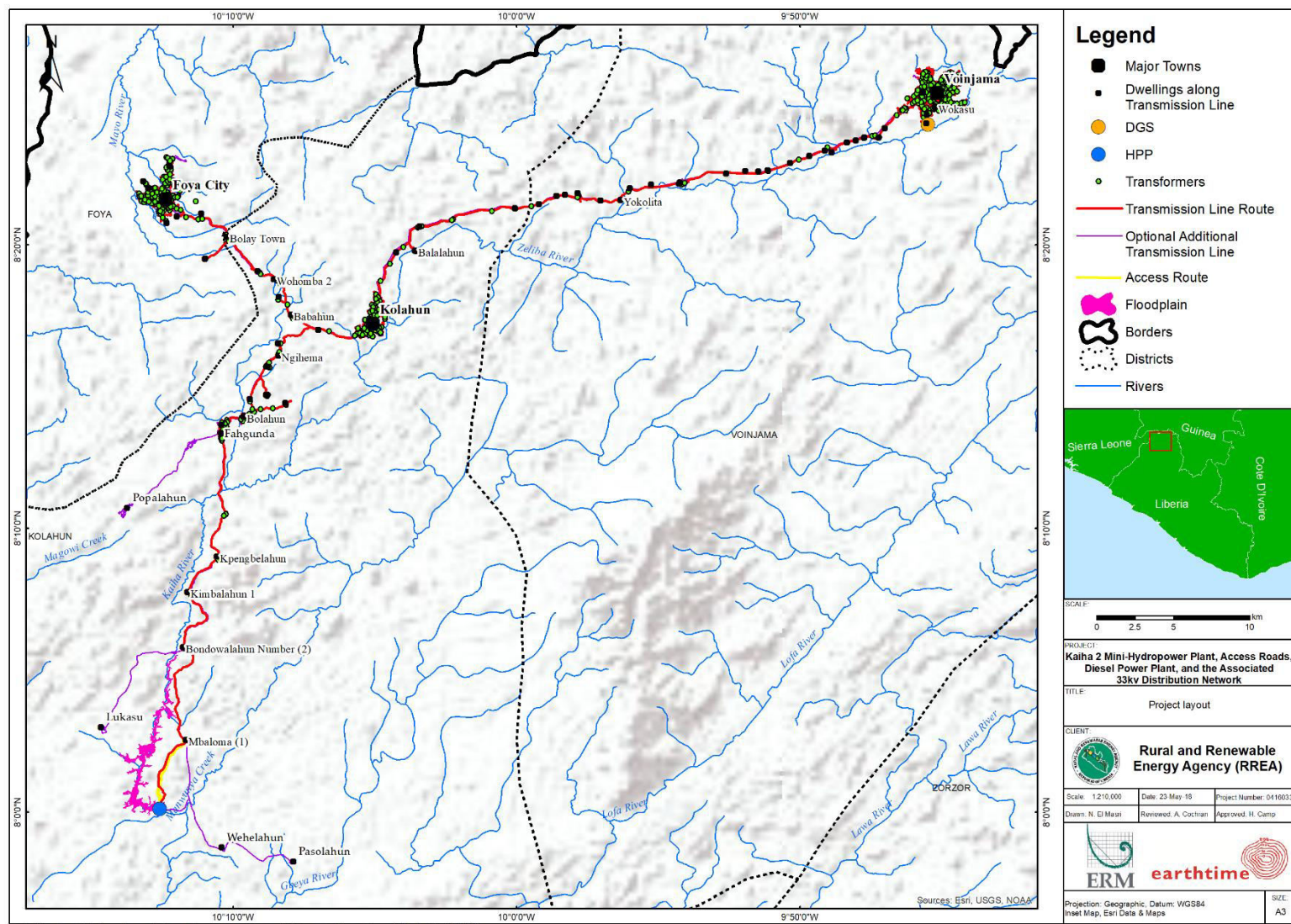


Figure 3.2 Project Location (2)



3.2

HYDROPOWER PLANT

The site proposed for the Project's hydropower plant consists of river rapids and a concentrated waterfall over a length of approximately 100 m. The total vertical drop is around 7.5 m¹.

The power plant will consist of a low dam wall and intake structure upstream of the waterfall with a short penstock and a powerhouse downstream of the waterfall (*Figure 3.3, Figure 3.4, and Figure 3.5*). The total vertical drop of the identified rapids will thus be utilised for hydroelectric generation.

With additional head created by the dam wall, the total head is 13 m. The design discharge of water through the hydropower plant will be 23.2 m³/s. The power plant will have an installed capacity of 2.5 MW (*Table 3.1*).

Table 3.1 *Summary of Hydropower Plant Design Specifications*

Main Item	Description	Value
Power production	Design discharge	23.2 m ³ /s
	Gross head	13 m
	Installation	2.5 MW
Dam and intake	Type of dam	Concrete gravity dam
	Height of dam	7.5 m
	Type of spillway	Overflow
	Crest length of spillway	49.4 m
	Number of intake bays	2
Waterway	Penstocks length	41 m and 45 m
	Penstock diameter	2 x Ø 1.85 m
Powerhouse	Type	Surface
	Number of units	4 S-turbines
	Tailrace length	8 m

¹ Project description based on Multiconsult (2016).

Figure 3.3 *Hydropower Plant Layout (schematic)*

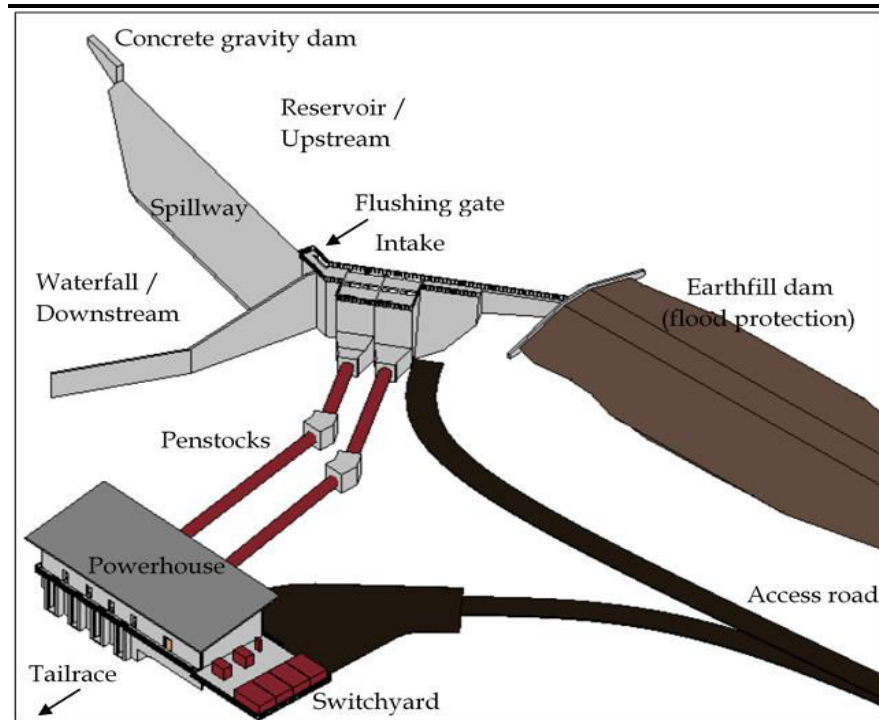


Figure 3.4 *Hydropower Plant Layout (with topography)*

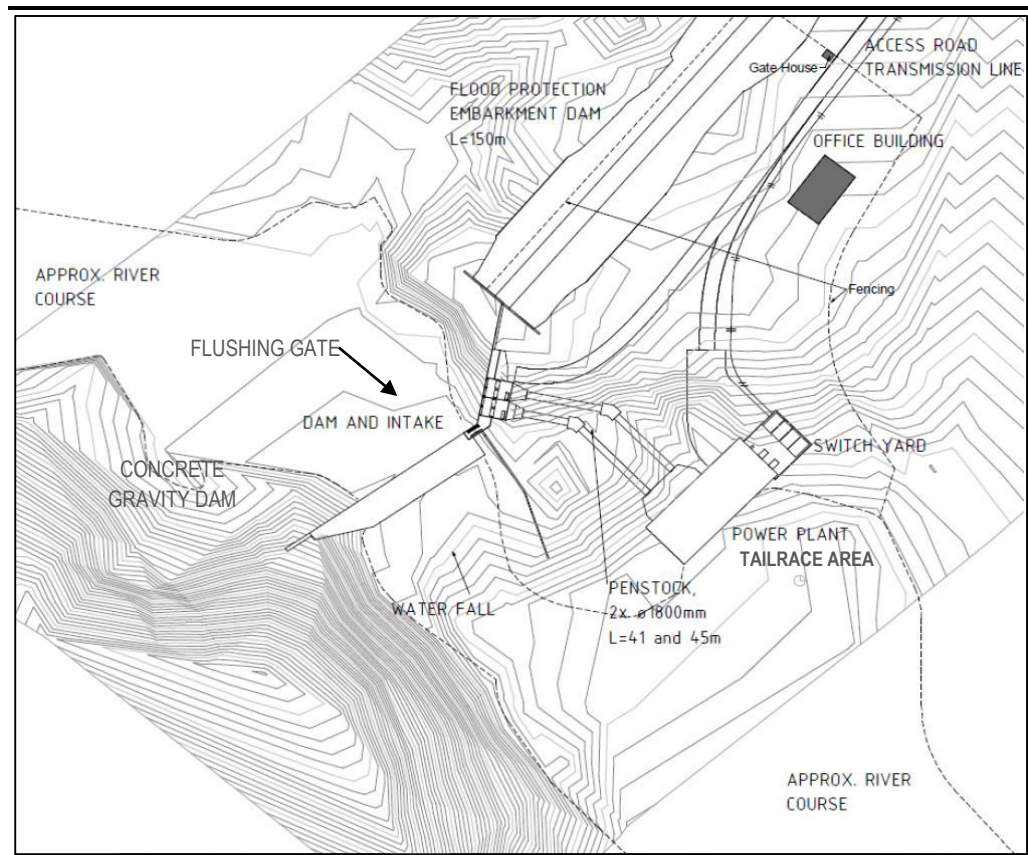
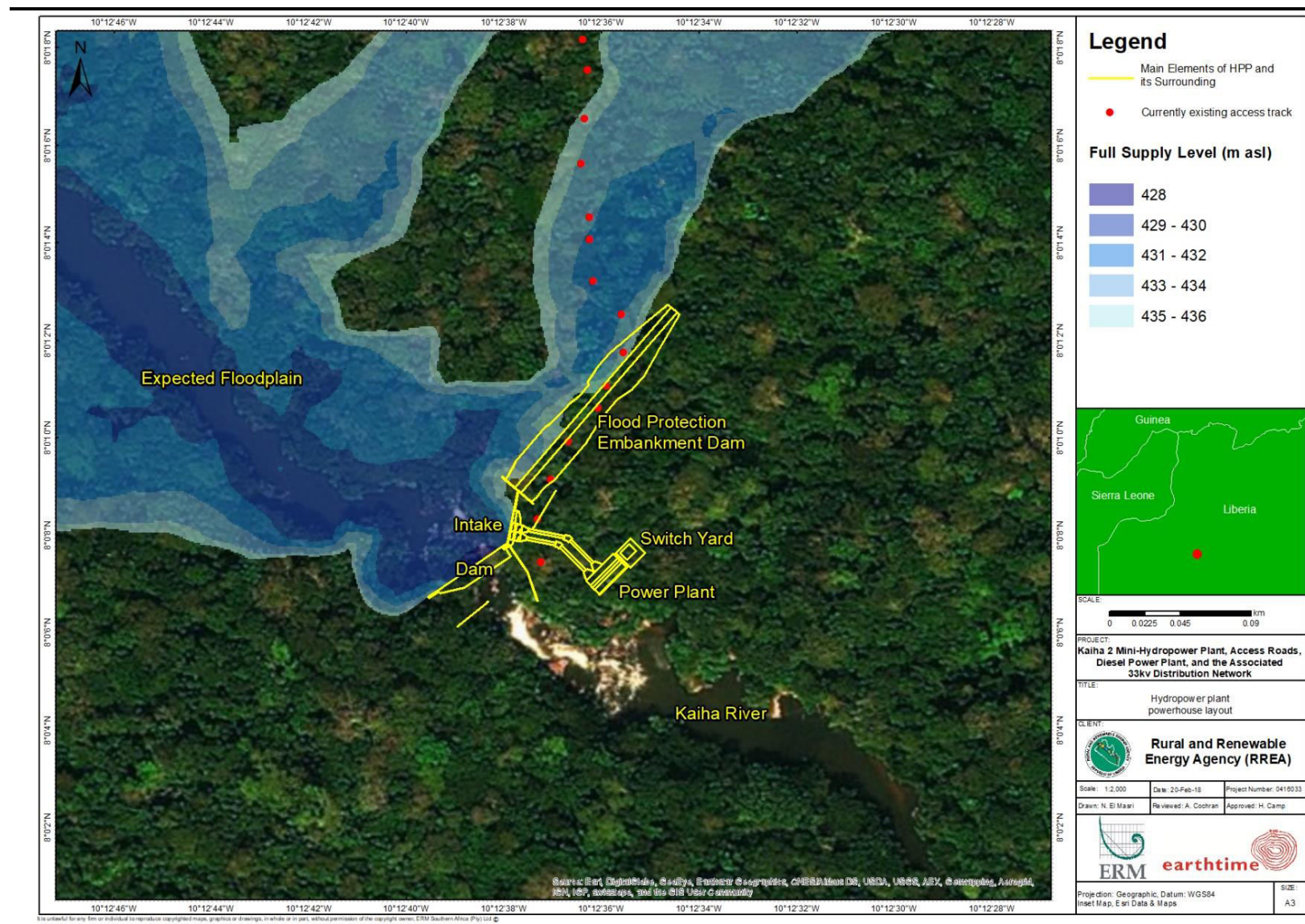


Figure 3.5 Power Plant Layout (overlay on satellite image)



3.2.1

Dam Structures and Intake

The dam and intake structure will be located 60 m upstream of the powerhouse. The intake sections will be placed on the left side of the main dam sections looking downstream.

Concrete Gravity Dam

The narrow topography and low dam height clearly favours an overflow spillway thus a concrete gravity dam has been chosen. The dam contributes 5 m head and 1 m drawdown in the reservoir for use in peaking hours. With a maximum height of 7.5 m, the dam will divert the water into the intake sections and add head, increasing the overall head to approximately 13 m.

Spillway

To accommodate safe passage of a water flood of 450 m³/s (considered to be a large flood), the overflow spillway has been designed with a length of 49.4 m. Controlled energy dissipation of the water downstream of the dam will be included in the design of the project (eg, through baffle blocks after the dam toe).

Flushing Gate

In between the spillway section and intake structure, a flushing gate section is designed in order to draw down the reservoir water level during future maintenance works, for water diversion during the construction period (including release of environmental flow during the initial filling of the reservoir) and possibly for flood diversion if needed. The flushing gate will be manually controlled.

The flushing gate section can also be used for flushing of sediments from the reservoir in periods of low river flow, but the effect of the flushing will be limited to the area immediately next to the section and thus not very efficient. Drawing down the reservoir water level by using the flushing gate section would also allow for manual removal of sediments from the reservoir (eg, by the use of excavators).

Earthfill Dam

A 'zoned' earthfill dam will be constructed on the downstream left abutment as a flood protection against over topping. This type of dam comprises zones of material with different degrees of porosity, permeability and density. In this instance the dam has a central impervious core flanked by upstream transition zones, downstream filters and drains, and then outer zones or shells composed of gravelfill, rockfill, or random fill, which are considerably stronger than the core.

Intake Structure

The dam will have two intake structures connected to separate penstocks. The structures consist of trash racks (to prevent submerged floating debris reaching the penstock), forebay and concrete cones leading the water into the penstocks. For future inspection and maintenance works, the intakes are equipped with stop log guides upstream of the trash rack and access to the structure. This will allow for separate closure of the two waterways and allow for continuous operation of one of the waterways during inspection and maintenance works on the other.

Reservoir

The dam will create a water reservoir lifting the existing water level by approximately 5 m at the dam location and with gradually reducing depths for approximately 13.5 km length of river upstream of the dam, to a point approximately 10 km north of the hydropower site. In the transition periods between the wet and dry seasons, the reservoir will act as a peaking pond (ie, a storage pond used during peaking hours of high electricity demand) with 1 m regulation between LRWL (Lowest Regulated Water Level) and HRWL (Highest Regulated Water Level). For the rest of the year, the reservoir will be maintained at HRWL.

The total surface area is approx. 495,000 m² (49.5 ha) at HRWL and 455,000 m² (45.5 ha) at LRWL, while the total volume of the reservoir is approximately 700,000 m³ (at HRWL), of which 370,000 m³ will be used for generating power during peak demand.

3.2.2 *Penstock*

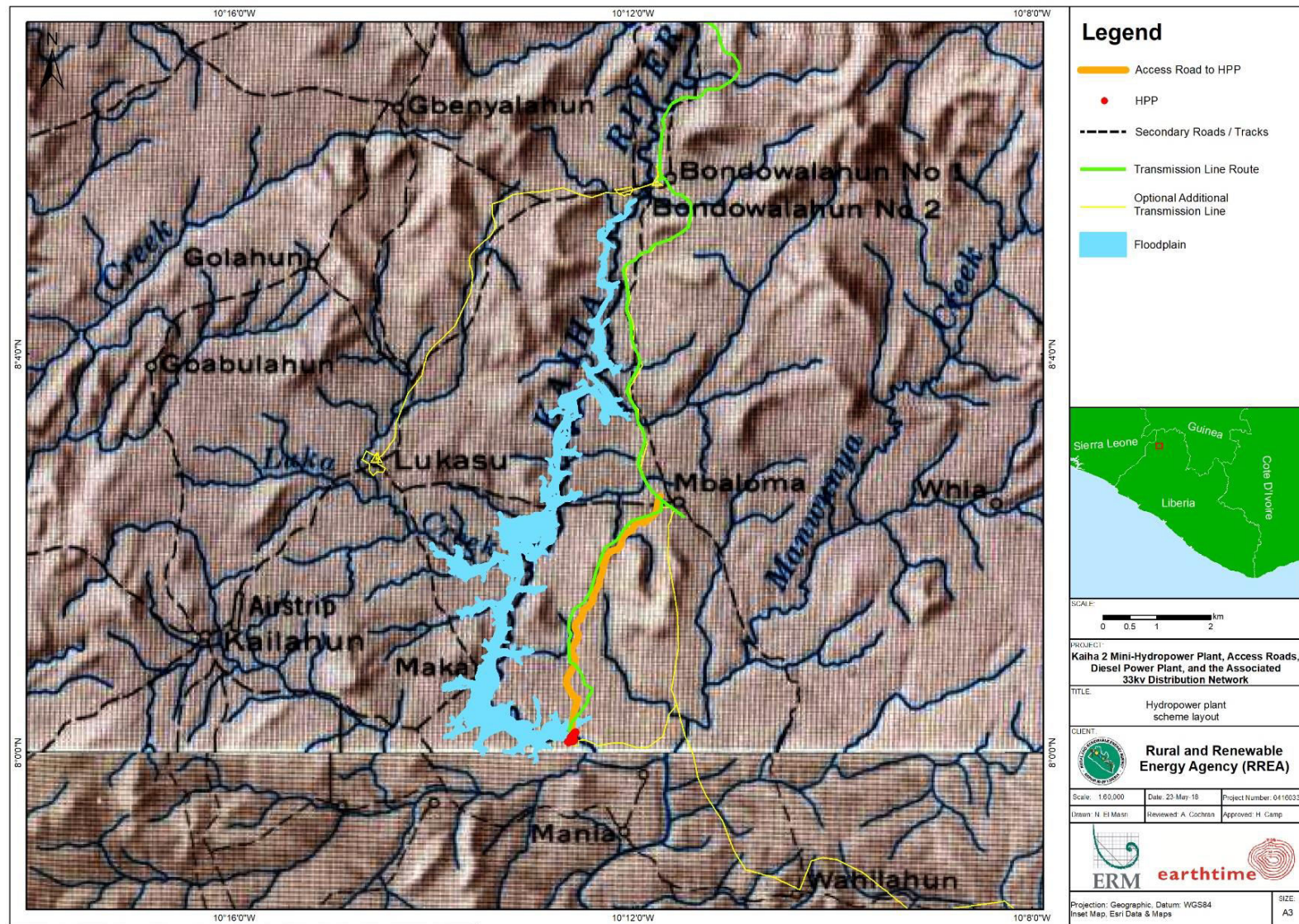
Two penstock pipes will be installed as supported pipes on concrete foundations from the intake to the powerhouse. At the end of each penstock, a bifurcation will separate the water in two smaller pipes, each leading to a turbine. The diameter of the penstock pipes will be 1,850 mm whilst the lengths of the two penstocks are approximately 41 m and 45 m.

3.2.3 *Powerhouse*

The powerhouse will be constructed as a surface structure on the left river bank looking downstream. The building will mainly be constructed in concrete on a concrete slab foundation. The dimensions of the power house, including the machine hall and the control and storage rooms, is 31.6 m in length and 11.2 m in width (*Figure 3.7*)

An overhead gantry crane with the capacity for placing or replacing the heavy parts of machinery will be installed. Openings in the walls and ceiling of the powerhouse is intended for natural ventilation of the machine hall without the need for air-condition systems. The control room will, however, require a cooling equipment.

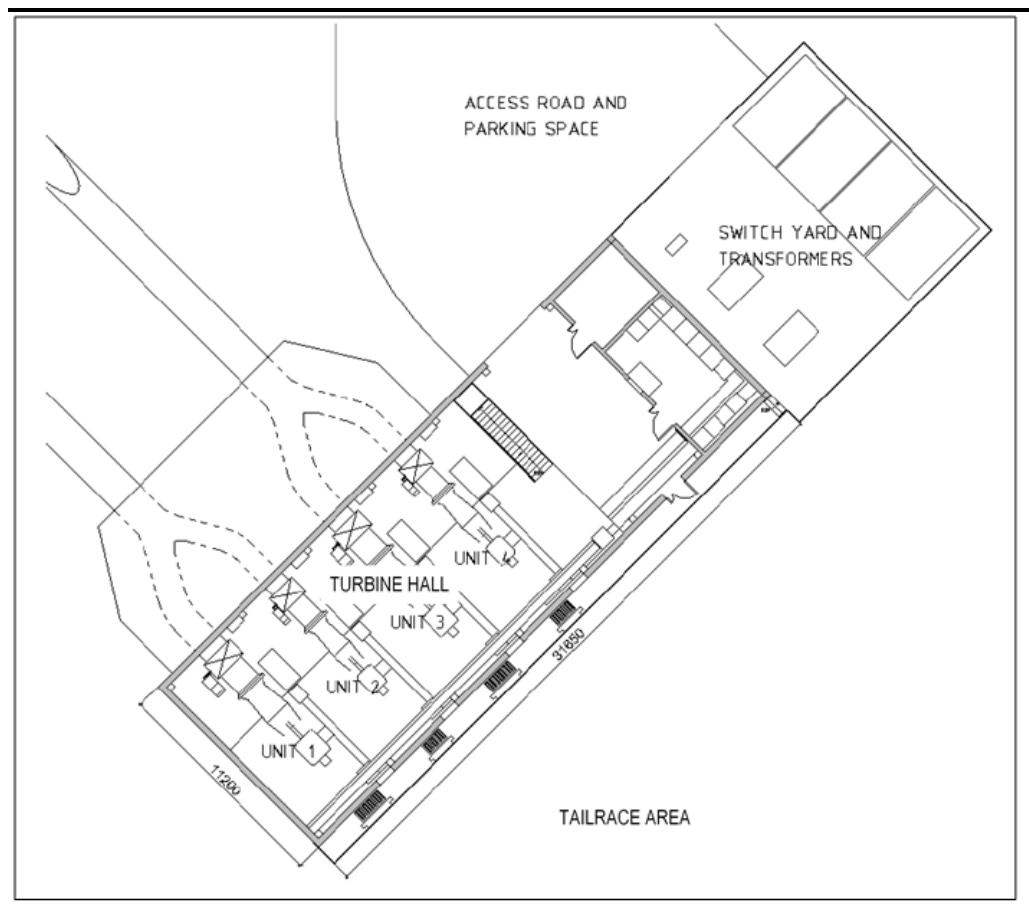
Figure 3.6 Approximate Extent of Potential Change in River Water Level



The electromechanical installations will include four double-regulated Kaplan turbines (two small and two large), each connected to a penstock pipe after the bifurcation pipe, and directly coupled to synchronous generators. The mechanical installations will include turbine inlet valves as well as other necessary auxiliary equipment. The exact technical specifications of the turbines have not yet been decided.

A drainage system will be installed in the powerhouse to handle any leakage from the turbines as well as keeping the machine hall floor free from water in the event of major flood. The system will gravity drain to a sump with two electrical pumps.

Figure 3.7 *Hydropower Plant Layout*



3.2.4 *Switchyard*

The 11.2 x 13.2 m switchyard is where the electricity will be stepped up to 33 kV via two transformers. The transformers will be of conventional outdoor design, core type with tank and radiators and oil cooled. The transformers are heavy (and probably the largest) components to be transported to site.

3.2.5 *Emergency generator*

The powerhouse will be designed for a black start ie, based on power from an emergency diesel generator connected to the stations electrical supply. The 50kVA emergency generator will be installed in the powerhouse site.

Electrical power would be supplied by the hydropower plant itself during operation.

Equipment that cannot be allowed to shut down after a short break in power supply will be supplied via 110V DC batteries, stored in two battery banks in the powerhouse.

3.2.6 *Tailrace*

From the outlet of the power plant and the bottom of the construction pit, a tailrace canal will be excavated towards the river channel. The length of the tailrace canal will be approximately 8 m.

3.2.7 *Access Road*

In order to access the Project site, a new road will be constructed from the end of the main road at Mbaloma Town, mainly following an existing footpath. This road will be gravel with a length of approximately 5.5 km and a maximum width of 8 m. The final alignment of the road will be determined in the detailed design phase of the project and will be built to minimise cut and fill areas and also avoid wetland areas. Careful attention will need to be paid to drainage of the road, including culverts for wetter sections of the road, in order to maintain accessibility to the site year round.

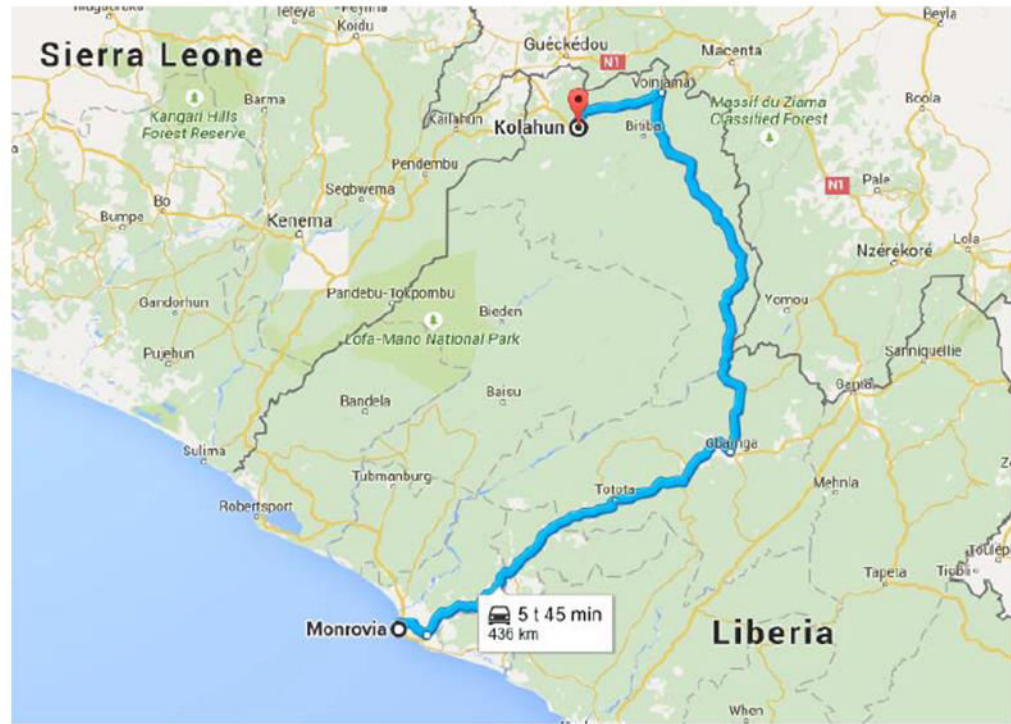
While to exact location of the road is not yet determined, the land between Mbaloma Town and the hydropower plant site is a mosaic of various land cover including patches of active and fallow farm land, isolated areas of forest, and bush.

The total land required for the road would be a about 44,000 m² (4.4ha). The amount could be higher if the final route were longer than envisioned, or lower if the road width were reduced. Land rights for the land through which the road would pass have not yet been determined.

In addition, the existing 40 km road between Mbaloma Town and Kolahun Town will need to be upgraded and maintained during and after rainy seasons in order to manage runoff during construction and operation.

Access to the site from Liberia's capital Monrovia, where large components (turbines, transformers, among others) are likely to be delivered from will be as shown in *Figure 3.8*.

Figure 3.8 **Route for Transport of Large Equipment to Project Site**



Source: Multiconsult (2016).

3.2.8 *Auxiliary Structures*

Temporary structures and facilities will be built to support Project construction. These will be built within the footprint of the site (and are captured in the impact assessment) with the final location to be determined by the construction contractor. Temporary facilities are expected to include:

- Housing camp for construction workforce
- Concrete batching plant
- Crushing plant for stone used in construction
- Storage yards and building for materials and fuels
- Workshop facility
- Offices
- Camp

The ESIA will be updated when the sites are determined or better still a standing-alone ESMP will be developed for these facilities and structures once the site are identified. The ESMP will be developed by the Contractor to manage the associated risks and impacts.

Permanent structures for plant operation will be established along the access road, upstream of the powerhouse, out of flood prone areas. The following permanent structures will be constructed for use during the construction period.

- Fencing of the project site;
- Entrance gate with gate house; and
- Office building (approximately 80 m x 140 m, single storey) used as site office until commissioning of the power plant. The office building will be equipped with water treatment, telecommunication systems, and sanitary facilities.

3.3

DIESEL POWER PLANT

The Project design includes diesel-fuelled power generation system to act as an alternative power source for base load supply during the dry season when the river flow is not enough for hydropower generation.

The Project intends to locate the diesel power plant on an undeveloped plot of land in Balawatta Town, about 3 km from the town of Voinjama on the road to Kolahun City (8°23'34.56"N, 9°48'25.22"W).

The exact location and layout has not been finalised. Based on previous version of the design of the facility, the plot of land will be approximately 40m x 40m (0.16 ha).

The diesel plant will match the electricity demand each dry season to provide stable electricity supply all year round. The plant will initially be equipped with power units each generating 600 kW or power for a total rated output of 1.8 MW.

At the moment, the layout of the facility has not been finalised. Based on previous designs, the following will be installed:

- Three (3) diesel storage 'day' tanks of 3,000 L each;
- Workshop equipped with a bench and hand tools;
- Control room including the control panels;
- Sanitary facilities;
- Generator water cooling system with external heat exchanger (closed loop);
- Eight (8) fuel storage tanks of 50,000 L each with pumps, piping system, filters and meters;
- Waste oil storage pit; and
- Accommodation for personnel.

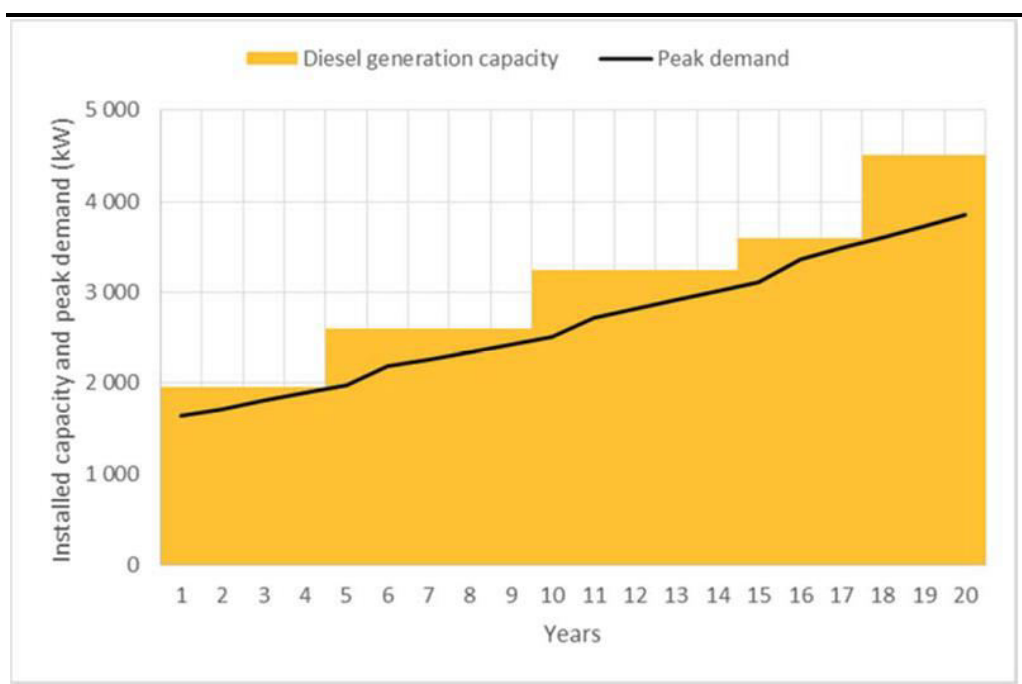
The diesel power plant will have a small switchyard to house transformers similar (or smaller) to the hydropower plant's switch yard.

The plant may be expanded in later phases as the estimated load demand reaches a peak of 2.5 MW after 10 years and 3.9 MW after 20 years. In exceptionally dry periods, the hydropower plant might have to completely shut down for weeks or operate at extremely low capacity. Thus, in order to

ensure uninterrupted power supply, the diesel plant will need to eventually be sized to 4 MW to meet the peak demand at any time.

Figure 3.9 shows how the installed diesel generating capacity can be stepped up in order to meet peak demand during a 20-year period, in order to reduce upfront capital expenditure. The power plant will start at approximately 2 MW installed capacity for the initial year and progressively increase with the development of electricity demand up to approximately 4 MW in year 20. This will be done by adding additional generators as required and based on demand forecasts.

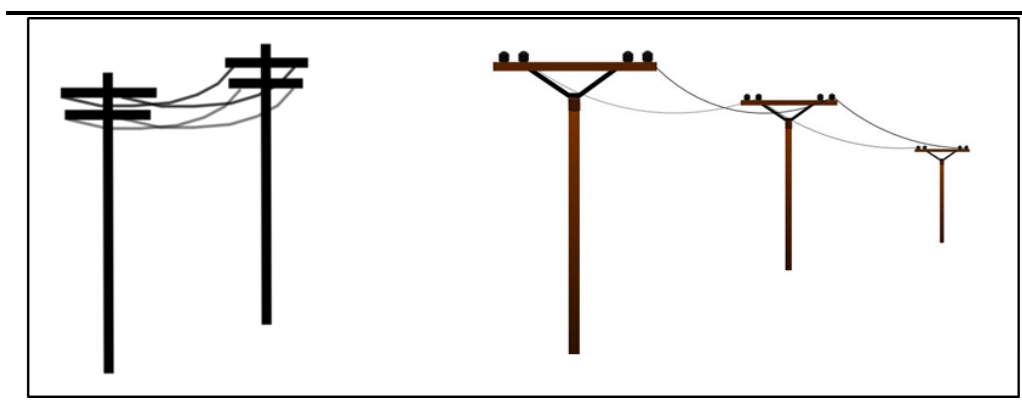
Figure 3.9 *Phasing of Increase in Diesel Power Plant Capacity*



3.4 TRANSMISSION LINE

A 33 kV electricity transmission network (mini-grid) will connect the hydropower plant to the towns of Masambolahun, Bolahun, Foya, Kolahun and Voinjama. In addition, three towns located slightly outside the main grid may be connected as options, namely Lukasu, Popalahun and Pasolahun. The total length of the proposed transmission grid is 115 km.

The conductors will be strung on impregnated wooden poles or metal tubular poles of 12 m height with horizontal cross-arms (*Table 3.2*) and will look generally similar to one of the designs shown in *Figure 3.10*. A series of about 50 transformers, ranging in capacity from 25 to 300 kVA, will be placed on poles along the line route in order to allow for distribution of electricity to towns along the route.

Figure 3.10 *Transmission Line Design Concepts***Table 3.2** *Summary of Transmission Line Specifications*

Description	Recommendation
Voltage level	33 kV
Conductor	150 mm ² WOLF ACSR
Earth wire	Earth wire installed over the full length combined with fibre optic cable (ie, Optical Ground Wire or OPGW)
Pole types	Wooden poles not less than 12 m length, treated with creosote according to BS 913 with 115 kg/m ³ against rot and termites. Poles shall be not less than 150 mm diameter at the top and 240 mm diameter at 2 metres from the butt and below

The transmission lines will be routed along the main roads and within the existing road reserve (ie, right-of-way). A 10 m wide right of way (RoW) will be required for the 33 kV lines, and it is assumed that this width will fit within the existing 46 m wide road reserve (23 m on each side of the centre line of the road).

The only recent case where a RoW for power lines has been created in Liberia was for the 66 kV/133 kV transmission lines between the Mount Coffee hydropower plant and Monrovia. Within the RoW for those power lines, a minimum vertical clearance of 7 m was required between the conductors and any structure or tree crop. It is proposed that a similar minimum clearance be adopted for the Project transmission grid, although it should be possible to avoid having any structures within the RoW by minor adjustments of pole locations in the towns (ie, re-routing of the transmission line in order to bypass the settlements/buildings).

Detailed line routing and profiling of the transmission line, including exact siting of poles, electrical clearance, wind spans, angles of deviations will be decided by the contractor during the final design stage.

According to the Initial ESIA, public concerns were raised that radiation of the electromagnetic field (EMF) from power lines and substations might cause health impacts on people living or working close to such structures, particularly leukaemia in children. The World Bank Group Environmental, Health, and Safety Guidelines for Electric Power Transmission and Distribution (2007) recommends limits for the general public of 5000 V/m (electric field) and 100 μ T (magnetic field). Maintaining average and peak exposure levels below these limits is recommended, otherwise additional measures should be considered to minimize exposure.

The electric and magnetic fields from a 33 kV transmission line are approximately 700 V/m and 7 μ T¹, well below the recommended limits. As such no design changes are required to the proposed transmission lines to limit health impacts.

3.5 *PROJECT ACTIVITIES*

The Project will be developed in the following phases:

- Final Planning
- Site Preparation
- Construction
- Operations
- Decommissioning phase

3.5.1 *Final Planning*

Final planning activities are mainly desktop activities with some limited site work related to determining site geotechnical and physical conditions to inform final design. In this stage the Project will obtain the required authorisations and permits for Project development. The Project will also complete the process of obtaining land rights and concluding any compensation requirements. The main contractors for construction of the Project will be selected.

3.5.2 *Site Preparation*

Initial site preparation activities will involve improvement and extension of the access road to the site and vegetation clearing at the hydropower plant site.

¹ Taken from Table "Typical ground-level UK field levels from overhead power lines", <http://www.emfs.info/sources/overhead/> accessed 19/05/2018.

Vegetation will be also cleared where necessary along the transmission line route within the defined ROW.

Organic waste generated by clearing will be disposed in place or removed and reused.

3.5.3 *Construction Phase*

Temporary structures required for construction of the hydropower plant will include the following:

- River diversion;
- Construction management camp;
- Batching plant;
- Crushing plant;
- Stores (cement, fuel, other materials);
- Workshops;
- Offices; and
- Staff houses.

River Diversion

River diversion, through the use of temporary cofferdams along the banks of the river at various stages, will be created to enable the construction of the hydropower plant.

For the dam and intake site, the river diversion will be carried out in two main stages (*Figure 3.11*). Stage 1 allows for construction on the left bank of the river looking downstream and Stage 2 allows construction on the right bank, with the river being diverted through the newly constructed flushing gate.

In Stage 1 a cofferdam will also be erected to allow for the parallel construction of the powerhouse (*Figure 3.11*). The foundation for the powerhouse has to be relatively deep, with a high risk of water leakages from the river and ground water into the construction pit and hence will require dewatering.

After building the powerhouse to a safe elevation, the cofferdam will be partly removed in Stage 2 and modified to allow for excavation of the tailrace canal.

Figure 3.11 *Stages of River Diversion for the Construction of the Hydropower Plant*



Source: Multiconsult (2016).

Construction Management Camp

A construction management camp, batching plant, crushing plant, stores, workshop and offices will be required during construction. The camp will have temporary housing for construction workers.

The location and size of these will be determined prior to construction by the appointed contractor and will need to be in line with requirements and processes contained in the ESMP.

Construction Materials

Construction materials for the hydropower plant concrete works and the access road will be sourced from any existing quarries in the area, rocks, gravels and sands along the riverbanks and on site and re-use of spoil material excavated during construction.

The impervious material required for the earthfill dam is available around the site as a reddish clayey silty sand or sandy silt.

Water will be obtained from the river for construction of the hydropower plant and the 5.5 km access road. It is likely that water will be obtained from boreholes in the existing small towns on route of the 40 km road requiring upgrading and from boreholes in Voinjama for construction of the diesel power plant.

Where electricity is required for construction this will be provided by portable generators.

Waste Management

The non-hazardous waste generated is expected to include the following:

- Organic waste from the camps and canteens;
- Paper and cardboard;
- Plastics;
- Wood;
- Metals;
- Vegetation; and
- Inert wastes from construction and demolition (spoil unsuitable for re-use, concrete, scrap iron, bricks).

The typical hazardous waste generated from a hydropower scheme, diesel power plant and transmission lines includes the following:

- Engine oils and used hydraulic fluids;
- Residues of paint, solvents and resins;
- Fluids from transformers;
- Medical wastes from first aid stations;
- Sludge from septic tanks; and
- Various concrete additives.

Workforce

For the hydropower plant construction, the number of workers will be decided by the construction contractor but is likely to peak at 150 workers. Based on experience from similar projects, typically 80% of the jobs are non-technical in nature.

In addition, there will probably be two work teams working in parallel on the installation of the transmission lines and transformers, each comprising an estimated 20 to 25 workers (technical and non-technical).

Construction Schedule

Table 3.3 shows the preliminary schedule for the Project. Due to the expected construction challenges during the rainy seasons, a three-year construction period is envisaged, with an earliest possible start in 2018.

Table 3.3 Preliminary Implementation Schedule

Project Phase	Year 1				Year 2				Year 3				Year 4				Year 5			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Feasibility Study and ESIA																				
Financing																				
Tendering																				
Construction phase																				
Commissioning																				X

Source: Multiconsult (2016). Adapted.

Because of the variability in river water level and restricted accessibility to the Project site between the dry and wet seasons, the main construction activities are scheduled during the dry season (June to November).

Necessary precautions, such as sufficient height of cofferdams and securing of potentially flooded areas, need to be carried out before the rainy season. For the hydropower plant, an important milestone during the first dry season will be to complete the roof works and exterior walls to secure flood water level, so that indoor works can be carried out during the subsequent wet season.

During the first year of construction, the mobilisation period will include construction of the access road and preparatory works for cofferdams around the intake and powerhouse in order to allow commencement of civil works immediately after the rainy season.

3.5.4 Operational Phase

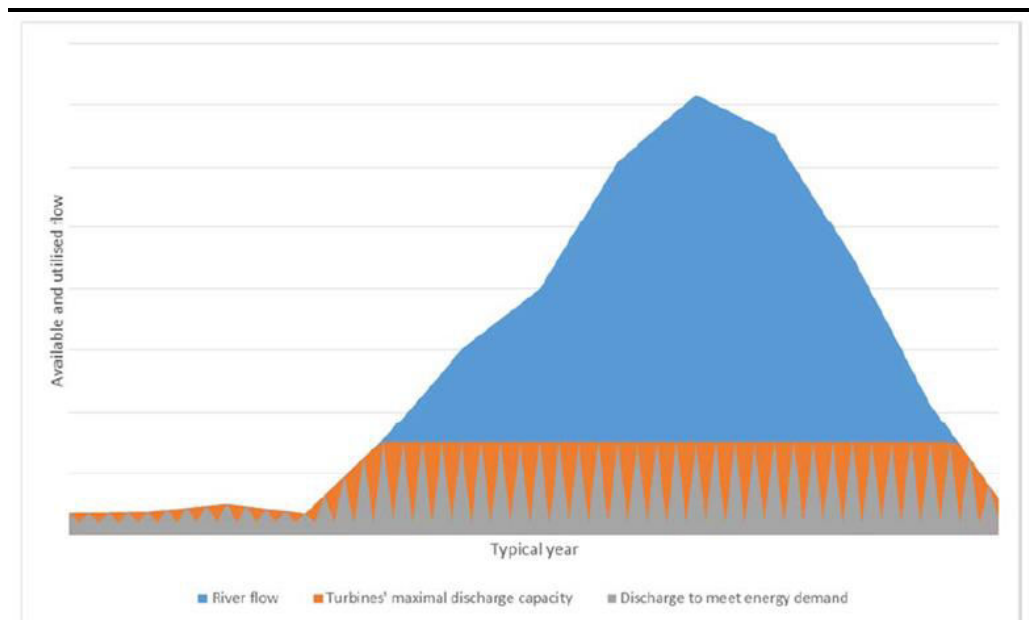
Overview

Energy production (and hence operational flows) for the hydropower plant will have to follow the energy demand in the mini-grid and not the hydrological potential.

The river flow in the rainy season has more than adequate volume for power generation (Figure 3.12) and excess will flow over the dam and not be used by the turbines. Secondly, the turbines will not operate at their theoretical capacity all the time but only generate power to match the energy demand, which will vary through the day. Thirdly, the energy demand the first year of the operation is much lower than energy demand after 20 years. The installed capacity of the turbines and power plant needs to match the 20 year maximum demand hence the turbines will operate well below their maximum capacity

for the first years, unlike the diesel power plant where it will be possible to increase installed capacity over the 20 year period (*Figure 3.12*)

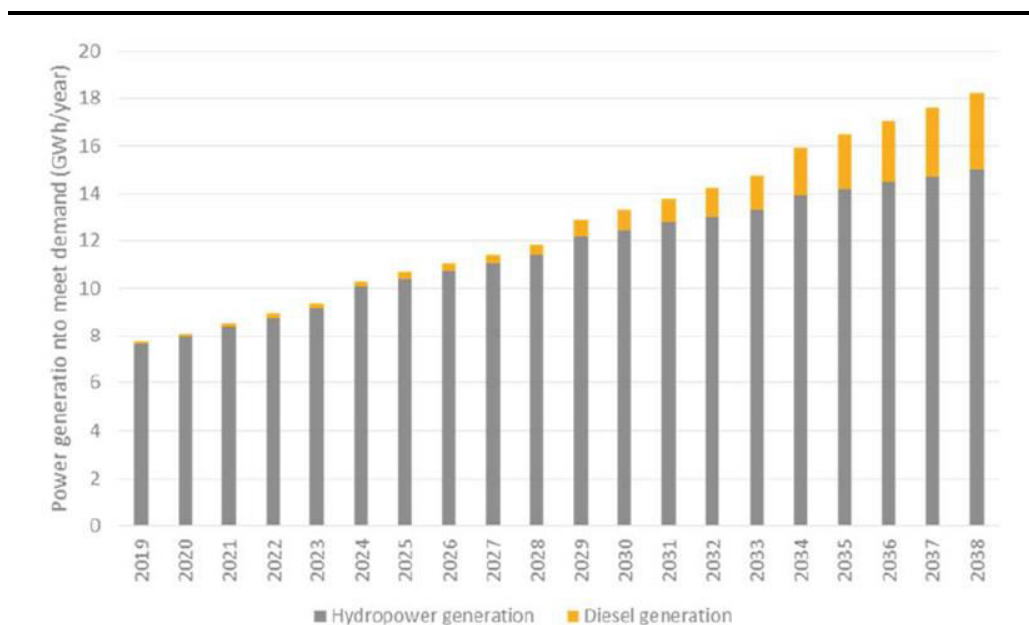
Figure 3.12 *Theoretical Generation Capacity vs Generation to Meet Demand*



Source: Multiconsult (2016).

The diesel power plant will provide the unmet demand during the dry periods and intermediate periods as shown in *Figure 3.13*.

Figure 3.13 *Projected Hydropower and Diesel Power Generation*



Source: Multiconsult (2016).

Water Flow Management Strategy

The plant will maintain a flow of 0.35 m³/s through the flushing gate during all periods in order to maintain the environmental conditions of the river system (ie, the 'environmental flow').

In dry season periods when the daily mean river flow is less than 8.2 m³/s, the hydropower production cannot sustain the demand alone as the river is unable to re-fill the reservoir. Hence, diesel power generation will be needed on a daily basis. In such a case, the hydropower plant will be operated at maximum head (HRWL) to obtain best efficiency of the water (1 m extra head gives 8% more energy production), while the diesel generation takes care of the peaking hours. This period would typically extend from about 1 January to 15 May but can vary several weeks from year to year.

During the wet season, the hydropower plant will operate at maximum head as the river flow exceeds the maximum plant flow capacity of 23.2 m³/s. This period is typically from July to November, but also varies from year to year.

During transition periods, the reservoir can be used in periods when the daily average demand matches the river inflow (8-13 m³/s) to the maximum turbine discharge. The hydropower plant can manage the peaking as long as the peak is within the capacity of the hydropower plant. The unmet power demand will be covered by alternative generation (diesel). The transition period is typically in June and again in December but varies with the rainfall variation and the demand for each year.

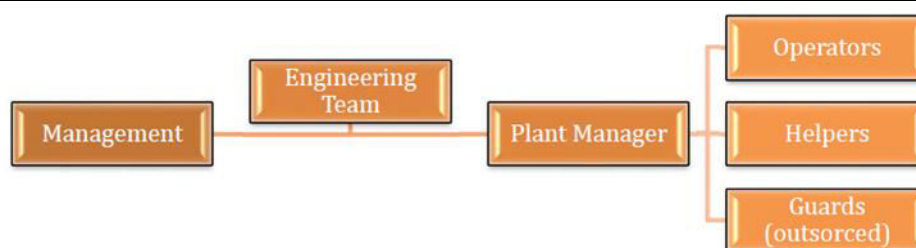
Workforce

The permanent staff on site will operate and maintain the hydropower plant on a regular basis, while an engineering team of experts from suppliers, consultants or other will assist in the first year of operation and on major maintenance tasks.

The staff based on the hydropower plant will consist of:

- Plant Manager;
- Civil and Mechanical engineers and an Electrical engineer;
- Plant Operators;
- Helpers; and
- Guards.

The electrical engineer will work for both the power plant and the transmission operator. An organogram of the operational staff for the hydropower plant is shown in *Figure 3.14*.

Figure 3.14 *Hydropower Plant Management Organisation*

Source: Multiconsult (2016).

3.5.5 *Decommissioning Phase*

It is anticipated that the lifespan of the Project will be at least 30 years (economic life) and probably a much longer technical lifespan. In fact, very few hydropower schemes have so far been decommissioned due to age. The civil infrastructure can last up to 100 years and will be a long-term asset for the country.

The approach for decommissioning will be decided at some later point in time depending on technical and economic factors. It is possible that the dam will be left *in situ* after decommissioning or it may be removed and the river banks rehabilitated so that natural flows return. If removed the steps would involve the following:

- Restoration of sites through levelling and re-vegetation measures;
- Removal of obsolete equipment and associated equipment parts;
- Demobilisation and return of imported labour force after the project;
- Grievance management mechanisms with the host communities before site closure;
- Repairs of damaged roads and restoration of access routes and route deviations; and
- Removal of construction debris and unused materials.

3.5.6 *Estimated Total Land Required*

An estimate of the land required (footprint) for the main Project components is provided in Table 3.4.

Table 3.4 *Estimate of Land Required for Project Components*

	Length (m)	Width (m)	Total (m2)	Total (ha)
Access road	5500	8	44000.0	4.40
Office building	140	80	11200.0	1.12
Dam and inundated area				400.00
Power house	31.6	11.2	353.9	0.04
Transmission line	115000	10	1150000.0	115.00

	Length (m)	Width (m)	Total (m2)	Total (ha)
Diesel power plant	40	40	1600.0	0.16
			Total	520.72

3.6 *PROJECT CONTRACTING*

The Project will engage external parties for construction. Construction will be through an Engineering, Procurement and Construction (EPC) contract or as individual contracts for major components (eg, design, civil works, electromechanical works). Splitting the works in to individual contracts could be used to attract regional contractors and specialist suppliers.

3.7 *PROJECT COST*

The cost for the Project, estimated in US Dollars (USD), is approximately USD 20.8 M broken down as follows:

- Hydropower plant and related facilities: USD 14.9 million. With an installed capacity of 2.5 MW, the generation cost is 5.98 USD/MW.
- Transmission line (including extension options): USD 5.9 million.

4

ANALYSIS OF ALTERNATIVES

4.1

INTRODUCTION

This Chapter describes the various alternatives which were available and considered as part of the development proposals. The Scoping Report listed a series of potential alternatives considered at the early design stage.

These options have been considered more fully by the Project, as discussed below and were assessed to consider the following criteria:

- Environmental;
- Social;
- Financial (including life cycle costs balanced against initial capital expenditure and operational costs); and
- Technical (considering whether the options are viable and whether can be implemented, maintained and operated).

Generally, a comparison of alternatives can help to determine the best method of achieving project objectives while minimising environmental and social impacts.

4.2

ALTERNATIVE SOURCES FOR ELECTRICITY GENERATION

The GoL is embarking on a Renewable Energy Electrification Program supported by the SREP to provide electricity services outside of greater Monrovia where two-thirds of the population live. The program will focus on the development of mini-grid systems based on small hydropower and biomass fuelled power generation, backed up by solar photovoltaic (PV) systems to compensate for seasonal variation, and stand-alone systems. Under the programme of institutional cooperation between MLME and the NVE, MLME and RREA are desirous to undertake studies of selected hydropower sites. NVE is therefore funded the feasibility study of the Project.

An economic evaluation was undertaken to compare two alternatives namely electricity supply from diesel generation or from a diesel-hydropower combination (Multiconsult 2016c). It was determined that the cost of the hydropower plant would be offset by the fuel saving from lowered diesel use and hence the combination was the preferred alternative.

It was also strongly recommended that a combination of hydro-electric, solar, battery and diesel based power generation in Lofa County be considered. The investment costs for solar power plants have been considerably reduced in recent years, and are now in the range of USD 6 million per MW (solar and a small battery installation). Operating costs for solar power plants are also relatively low. Solar power plants can normally be located close to load

centres (and thus require shorter transmission lines) and be developed in phases tailored to the gradually increasing demand, thereby reducing the initial investment cost. The environmental and social impacts and risks associated with solar PV power generation are normally also significantly lower than those of diesel plants and hydropower stations.

In any case, specific to the goal of this particular development and the use case of the target customer base, the combination of hydropower and diesel fuel power generation plant in hybrid operation was the best option to provide uninterrupted power.

4.3 *PROJECT-SPECIFIC ALTERNATIVES*

4.3.1 *Project Location*

Hydropower Plant and Access Road

During the Project's feasibility studies, two site alternatives were considered, namely Kaiha 2 (the selected location) and Kaiha 1 (about 30 km upstream of Kaiha 2). Another third potential site upstream of Kaiha 1, referred to as Kaiha 3, was also briefly assessed but it was concluded that this site was much less attractive than the two other project alternatives.

Evaluation of the two sites during pre-feasibility studies indicated that the biophysical and social settings of both sites is very similar. Both are farm-bush areas with a strip of about 100 meters on both sides of the river of disturbed natural forest still present. In both cases, no important wildlife exists in the area. There are no sensitive fauna in the wider project area and no endemic or endangered species present. Both locations will require the same amount of land and both will affect a limited amount of land being used for farming from inundation.

The analysis of alternatives showed that Kaiha 2 had lower investment and operation costs as well as higher power production potential than Kaiha 1. The main advantages of Kaiha 2 over Kaiha 1 include:

- A shorter diversion reach (ie, the distance between dam and intake and the powerhouse);
- Potential for greater rural electrification (due to greater output potential allowing longer transmission to more villages); and
- Avoidance of an impact on an existing irrigation scheme (Wanwoma irrigation scheme) located between Kaiha 2 and Kaiha 1.

In addition to locations on the Kaiha River, locations on the nearby Makona River were evaluated. A total river stretch of approximately 46 km was investigated along the border between Liberia and Guinea. Three potential sites for hydropower development were identified. No environmental/social 'red flag' issues were identified, but it was noted that Makona River carries

more water than Kaiha River and possibly a higher diversity of fish and other aquatic organisms. The trans-boundary nature of the Makona River also requires the involvement of a foreign government in project development and approval. Due to the increased complexity development of the hydropower plant on the Makona River was not considered further.

The routing of the access road is proposed to follow an existing footpath from Mbaloma to the hydropower plant site. Alternative routes from Kolahun Town to the other site of the Kaiha River were assessed but it was found to be less feasible than the proposed route. The access road still needs further design to optimise the route and minimise cut and fill and also to avoid wet areas. As such no alternatives are put forward for the access road but the final routing will be determined by design requirements as well as avoidance of environmental and potentially socially sensitive areas.

Diesel Power Plant

The location of the diesel power plant was selected as Voinjama as this is the town with the highest electricity demand hence electrical losses in transmission are minimised and maintenance costs can be reduced. There was also an existing parcel of land and structure that could be rehabilitated and re-used.

Transmission line

The configuration of the transmission grid was determined based on the location of locations where there is demand for electricity namely Kolahun/Kolba, Foya and Voinjama cities. With the recent sub-division of Kolahun District, the Project will be located in the new Lukambeh District. The administrative centre of Lukambeh District is Pasolahun Town, which was not originally planned to be supplied with electricity from Project. An extension of the transmission network to Pasolahun has therefore been added to the Project design. Connections to other small towns (eg, Lukasu and Popalahun) may also be considered, depending on demand, the available financing and political priorities.

The locality (routing) of the transmission line follows close to existing roads, for ease of installation and vicinity to possible future load increase. This is also considered to be a better environmental option as the environment has already been converted by construction of the existing roads. As such no other routing options were considered.

4.3.2

Project Layout

Penstock versus Canal

For alternative layouts of the scheme, variation of the water levels over the year and the short distance between the dam and powerhouse does not favour

any canal structures between intake and powerhouse. As such only the use of penstocks was considered.

Dam Wall Location

An initial hydropower plant layout consisting of a *combined* dam structure and power plant located in the downstream part of the rapids was considered. However, no suitable dam location with narrow topography and suitable geological conditions were identified on site and the initial cost comparisons indicated this alternative would be more expensive.

An upstream location was also considered for the dam location based on topography, foundation and possibility for water diversion during construction. However, this alternative was considered less favourable based on topographic and geological assessments. It also entailed longer penstocks than the currently proposed location hence would be more expensive.

The proposed dam wall location is preferred considering topography, ease of access and cost.

Location of Intake, Penstock and Power Plant

Although it would be possible to locate the intake, penstock and power plant on the south side of the river, the north side was determined to be more favourable for this based on topographic assessments as well as ease access by road.

4.3.3 Project Operations

Peaking Operation

The Project can either be operated as:

- Peaking plant¹;
- Run-of-river plant; or
- Combination.

From an environmental perspective, the main advantage of peaking operation is that air emissions (from diesel-based power generation to serve the unmet demand) can be reduced, while the main disadvantage is the environmental impacts associated with water level fluctuations both in the reservoir and downstream. From an economic point of view, peaking operation is only of value to offset diesel generator emissions and fuel costs in the transition

¹ Peaking power plants are power plants that generally run only when there is a high user demand (known as peak demand) for electricity. Peaking power plants are used in combination with 'base load' power plants, which supply a dependable and consistent amount of electricity, to meet the minimum demand.

periods between the wet and dry seasons (*Section 2.7.4*) when the river flow is too low for the plant to operate at capacity¹.

The peaking operation is considered to have minimal impact on environmental conditions due to:

- Relatively small difference between maximum and minimum turbine flow (15 m³/s and 5 m³/s, respectively);
- Narrow drawdown zone in the reservoir (1 m difference between HRWL and LRWL); and
- Short duration of the peaking operations (a few weeks in June and December).

Overall, the environmental risks and impacts of the proposed hydropower peaking are assumed to be less than the economic benefits, and the Project has therefore been designed to allow for peaking operations ie, the only alternative assessed involves peaking power.

When considering the dam height, three different heights were analysed: 11 m, 12 m and 13 m gross head. The 11 m alternative (with a dam height of 3 m), left limited space for the intake structure and it would not be possible to use the reservoir for peaking power. The terrain on the left (north) side of the hydropower plant site is relatively flat so the cost to construct a dam above 13 m gross head increased exponentially. This is because the freeboard (the distance from the reservoir water surface to the top of the dam wall) needs to be adequate to allow for a large flood.

The 12 m and 13 m gross head options were both considered to be feasible and the 13 m option was chosen to allow higher output in the transition seasons for greater offset of diesel power generation (and decrease fuel use).

Environmental Flow

The Project originally considered a design that did not include release of a constant environmental flow into the bypassed reach mainly because of the distance between the intake and outlet (approximately 60 m) and the relatively limited ecological and aesthetic benefits of reducing the volume to the turbine in the dry season. The feasibility study considered the critical period for maintaining river flow in the waterfall and rapids to be in the wet season, when there would be no need for releasing environmental flow because there would be adequate spilling of excess water from the dam.

¹ Accordingly to feasibility studies, the use of the peaking pond has little benefit to the overall energy production. This is due to the fact the energy volume is small and that the head will be reduced by the regulation of the peaking pond (up to 1 m or 8% less head). However, if the demand is less than forecast, the peaking pond will have a bigger relative contribution. The feasibility studies therefore concluded that peaking operation be part of the project design.

This approach was re-evaluated and the operational strategy includes the objective to not cause the river reaches to become completely dry. The Project has therefore been designed to allow a minimum environmental flow 0.35 m³/s.

Environmental flow is widely considered as a standard requirement in modern hydropower development and dams should not dry out even a small part of the river, waterfalls in particular. The provision of a continuous environmental flow will help maintain a certain degree of ecological connectivity and contribute to maintaining some of the aesthetic value of the waterfall and rapids during the dry season. As such, only the alternative inclusive of the environmental flow will be pursued.

4.4 ***NO PROJECT ALTERNATIVE***

Under the 'no project alternative, the proposed Project would not be constructed and operated, and hence, the identified environmental and social impacts would not occur. On the other hand the direct and indirect benefits of increased access to electricity would not be realised.

5.1**INTRODUCTION**

The purpose of this ESIA is to examine how the Project will lead to a measurable difference in the quality of existing physical, natural and social environment. Over the past decades, environmental impact assessments have expanded to include social impact assessments as well as public participation/consultation in the planning and decision-making process to avoid, reduce, or mitigate adverse impacts and to maximise the benefits of the proposed project. More recently, the emphasis has moved to the ESIA process producing robust social and environmental management conditions, which can effectively be implemented during the life of the project and culminating with an effective decommissioning plan.

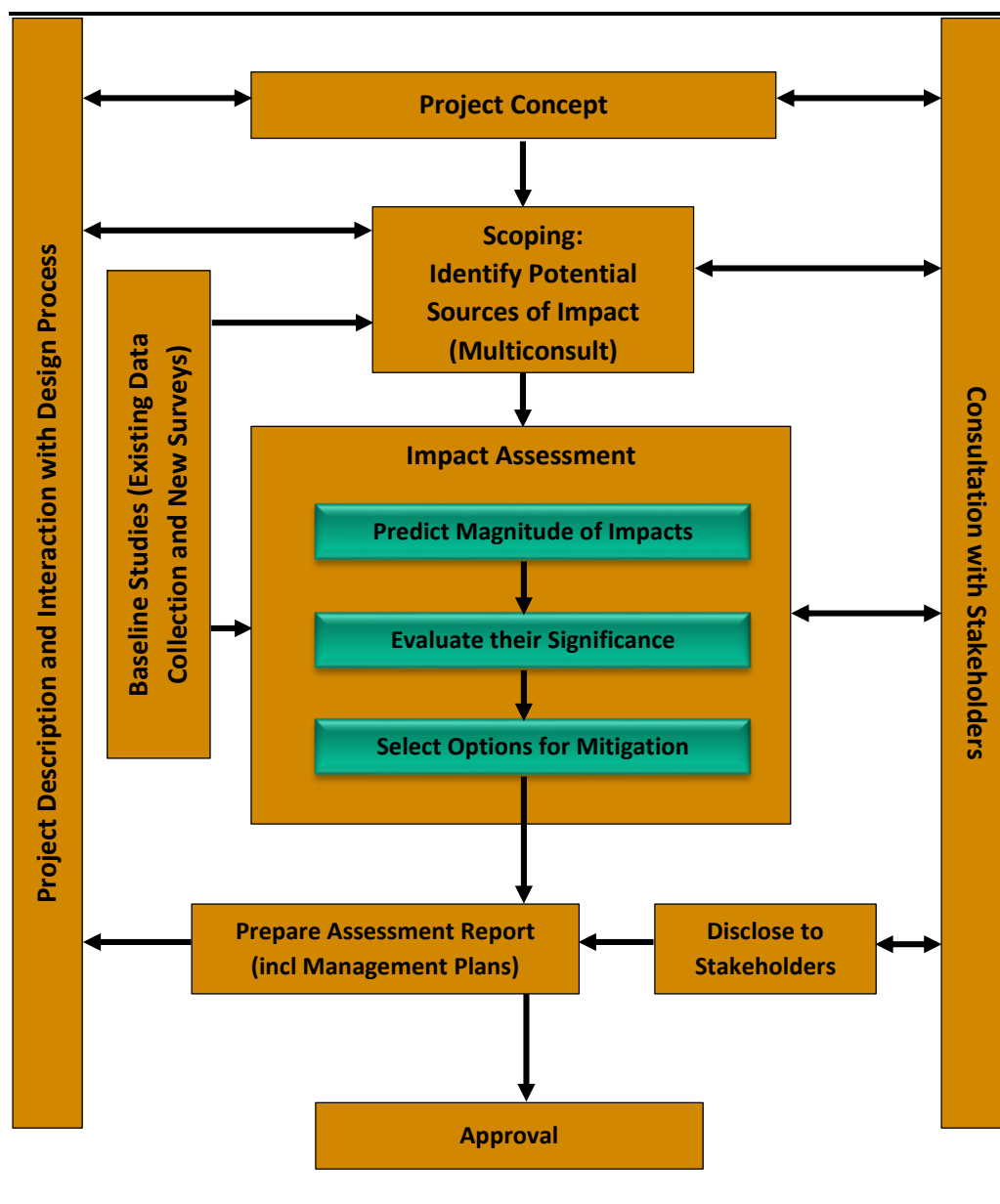
The key stages in the ESIA process are:

- Scoping;
- Stakeholder engagement;
- Determination of existing environmental and social conditions (ie, baseline);
- Project description and interaction with design and decision-making;
- Identification and evaluation of alternatives;
- Identification and assessment of impacts (direct, indirect, cumulative)
- Identification of mitigation and management measures;
- Development of a monitoring programme;
- Disclosure.

Figure 5.1 illustrates a generic overview of the ESIA process. This is, however, not a linear process, but one where several stages are carried out in parallel and where the assumptions and conclusions are revisited and modified as the proposed Project and ESIA progress.

The following sections provide detail on how each stage of the ESIA process was carried out. Specifics of the regulated Liberia ESIA process and requirements of financiers are discussed in further detail in *Chapter 5*.

Figure 5.1 Overview of the ESIA Process



5.2

SCOPING

The purpose of the scoping is to identify key sensitivities and those activities with the potential to contribute to, or cause, significant impacts or risks to environmental and socio-economic receptors and resources and to evaluate siting, layout and technology alternatives for the proposed Project. The key objectives of scoping are:

- Identify the potentially most significant impacts;
- Obtain the views of stakeholders through engagement; and
- Develop the Terms of Reference for detailed assessment.

During scoping key stakeholders are identified and engaged to understand concerns with the proposed Project.

In terms of the Liberia regulated process, the Project Brief was approved and accepted by the Liberia EPA in January 2016. The Scoping Report with ESIA Terms of Reference was submitted to the Liberia EPA in 9 May 2016. The Scoping Report was approved by the Liberia EPA in July 2016.

5.3 STAKEHOLDER ENGAGEMENT

The key principle of stakeholder engagement in the ESIA process is to ensure that the views of the interested and affected people are taken into account in the ESIA. The objective is to ensure the assessment is robust, transparent and has considered the full range of issues or perceptions, and to an appropriate level of detail.

Stakeholder engagement started during the ESIA scoping phase and is continuing throughout the assessment ensuring that legislative requirements and best practices are followed, that public concerns are addressed in the assessment and that sources of existing information and expertise are identified.

An overview of the consultation programme that has been undertaken is described in *Chapter 10*.

5.4 DETERMINATION OF BASELINE CONDITIONS

The description of the baseline environmental and socio-economic conditions provides information on receptors and resources that have been identified during scoping as having the potential to be *significantly* affected by the proposed Project. It also describes baseline conditions that have been used to make the assessment. The description of the baseline is aimed at providing sufficient detail to meet the following objectives:

- Identify the key conditions and sensitivities in areas potentially affected by the proposed Project.
- Provide a basis for extrapolation of the current situation, and development of future scenarios without the proposed Project.
- Provide data to aid the prediction and evaluation of possible impacts of the proposed Project.
- Understand stakeholder concerns, perceptions and expectations regarding the proposed Project.
- Support the development of mitigation and management measures
- Provide a benchmark to assess future changes and to assess the effectiveness of mitigation measures.

The description of baseline conditions is provided in *Chapter 6*.

5.5 PROJECT DESCRIPTION AND ALTERNATIVES

The interaction between the ESIA and the Project's design and decision-making process is one of the areas in which an ESIA process can act to influence how a project develops. It includes involvement in defining the Project and identifying those activities with the potential to cause environmental and social impacts. Project planning, decision-making and refinement of the Project description continue throughout the assessment process as a result of the development of the proposed Project and in response to the identified impacts.

The description of the Project and the main activities with environmental or social aspects is provided in *Chapter 2*. The description was prepared using technical reports and information provided by the Project. The list of the key sources of information used in the execution of the ESIA is provided in this report's *References* section.

The analysis of alternatives is described in *Chapter 3*.

5.6 ASSESSMENT OF IMPACTS

The impact assessment stage comprises a number of steps that collectively assess the manner in which the proposed Project will interact with elements of the physical, biological, cultural or human environment to create effects (impacts) on resources and receptors. The steps involved in the impact assessment stage are described in in this Section.

The environmental and social impact assessment detailed below is an approach that combines *Impact Magnitude* and *Receptor Sensitivity* to determine **Impact Significance**.

The overall approach that specialists (associated with the ESIA for the proposed Project) adopted towards the rating and evaluation of impacts is the same to what is detailed in *Section 5.6.1*.

5.6.1 Impact Assessment

The impact characteristic terminology to be used is summarised in *Table 5.1*.

Table 5.1 *Impact Characteristics*

Characteristic	Definition	Designations
Type	A descriptor indicating the relationship of the impact to the Project (in terms of cause and effect).	Direct Indirect Induced

Characteristic	Definition	Designations
Extent	The “reach” of the impact (e.g., confined to a small area around the Project Footprint, projected for several kilometres, etc.).	Local Regional International
Duration	The time period over which a resource / receptor is affected.	Temporary Short-term Long-term Permanent
Scale	The size of the impact (e.g., the size of the area damaged or impacted, the fraction of a resource that is lost or affected, etc.).	[no fixed designations; intended to be a numerical value]
Frequency	A measure of the constancy or periodicity of the impact.	[no fixed designations; intended to be a numerical value]

In the case of *type*, the designations are defined universally (ie, the same definitions apply to all resources/receptors and associated impacts). For these universally-defined designations, the definitions are provided in *Table 5.2*.

Table 5.2 *Impact Types*

Designation	Definition
Type	
Direct	Impacts that result from a direct interaction between the Project and a resource/receptor (e.g., between occupation of a plot of land and the habitats which are affected).
Indirect	Impacts that follow on from the direct interactions between the Project and its environment as a result of subsequent interactions within the environment (e.g., viability of a species population resulting from loss of part of a habitat as a result of the Project occupying a plot of land).
Induced	Impacts that result from other activities (which are not part of the Project) that happen as a consequence of the Project (e.g., influx of camp followers resulting from the importation of a large Project workforce).
Extent	
Local	Defined on a resource/receptor-specific basis.
Regional	
International	
Duration	
Temporary	Defined on a resource/receptor-specific basis.
Short-term	
Long-term	
Permanent	

In the case of *extent* and *duration*, the designations themselves (shown in *Table 5.1*) are universally consistent, but the definitions for these designations will vary on a resource/receptor basis (eg, the definition of what constitutes a short term duration for a noise-related impact may differ from that of a short term duration for a habitat-related impact). This concept is discussed further below.

In the case of *scale* and *frequency*, these characteristics are not assigned fixed designations, as they are typically numerical measurements (eg, number of acres affected, number of times per day, etc.).

The terminology and designations are provided to ensure consistency when these characteristics are described in an impact assessment deliverable. However, it is not a requirement that each of these characteristics be discussed for every impact identified.

An additional characteristic that pertains only to unplanned events (eg, traffic accident, non-routine release of gas, community unrest) is *likelihood*. The likelihood of an unplanned event occurring is designated using a qualitative (or semi-quantitative, where appropriate data is available) scale, as described in Table 5.3.

Table 5.3 ***Likelihood Definitions***

Likelihood	Definition
Unlikely	The event is unlikely but may occur at some time during normal operating conditions.
Possible	The event is likely to occur at some time during normal operating conditions.
Likely	The event will occur during normal operating conditions (i.e., it is essentially inevitable).

Likelihood is estimated on the basis of experience or evidence that such an outcome has previously occurred.

It is important to note that likelihood is a measure of the degree to which the unplanned event is expected to occur, *not* the degree to which an impact or effect is expected to occur as a result of the unplanned event. The latter concept is referred to as *uncertainty*, and this is typically dealt with in a contextual discussion in the impact assessment deliverable, rather than in the impact significance assignment process.

In the case of impacts resulting from unplanned events, the same resource or receptor-specific approach to concluding a magnitude designation is utilised, but the likelihood factor is considered, together with the other impact characteristics, when determining magnitude. There is an inherent challenge in discussing impacts resulting from (planned) Project activities and those resulting from unplanned events. To avoid the need to fully elaborate on an impact resulting from an unplanned event prior to discussing what could be a very low likelihood of occurrence for the unplanned event, this methodology incorporates likelihood into the magnitude designation (ie, in parallel with consideration of the other impact characteristics), so that the likelihood-factored magnitude can then be considered along with the resource and receptor sensitivity/vulnerability/importance in order to assign impact

significance. Rather than taking a prescriptive approach to factoring likelihood into the magnitude designation process, this is one based on professional judgment, assisted by quantitation where feasible (eg, modelling, frequency charts).

Once the impact characteristics are understood, these characteristics are used (in a manner specific to the resource and receptor in question) to assign each impact a *magnitude*.

In summary, magnitude is a function of the following impact characteristics:

- Extent;
- Duration;
- Scale;
- Frequency; and
- Likelihood.

Magnitude essentially describes the degree of change that the impact is likely to impart upon the resource or receptor. As in the case of extent and duration, the magnitude designations themselves (ie, negligible, small, medium, large) are universally used and across resources and receptors, but the definitions for these designations will vary on a resource and receptor basis, as is discussed further below. The universal magnitude designations for adverse impacts are:

- Negligible;
- Small;
- Medium; and
- Large.

The magnitude of impacts takes into account all the various dimensions of a particular impact in order to make a determination as to where the impact falls on the spectrum (in the case of adverse impacts) from *negligible* to *large*. Some impacts will result in changes to the environment that may be immeasurable, undetectable or within the range of normal natural variation. Such changes can be regarded as essentially having no impact and should be characterised as having a *negligible* magnitude. Positive impacts are also identified but are not ranked due to various reasons, mainly because of the uncertainty associated with predicting positive effects.

In addition to characterising the magnitude of impact, the other principal step necessary to assign *significance* for a given impact is to define the sensitivity/vulnerability/importance of the impacted resource/receptor. There are a range of factors to be taken into account when defining the sensitivity/vulnerability/importance of the resource/receptor, which may be physical, biological, cultural or human. Where the resource is physical (for example, a water body) its quality, sensitivity to change and importance (on a local, national and international scale) are considered. Where the resource/receptor is biological or cultural (for example, the marine

environment or a coral reef), its importance (for example, its local, regional, national or international importance) and its sensitivity to the specific type of impact are considered. Where the receptor is human, the vulnerability of the individual, community or wider societal group is considered.

Other factors may also be considered when characterising sensitivity/vulnerability/importance, such as legal protection, government policy, stakeholder views and economic value.

As in the case of magnitude, the sensitivity/vulnerability/importance designations themselves are universally consistent, but the definitions for these designations will vary on a resource or receptor basis. The sensitivity/vulnerability/importance designations are:

- Low;
- Medium; and
- High.

Once magnitude of impact and sensitivity/vulnerability/importance of resource/receptor have been characterised, the significance can be assigned for each impact.

Impact significance is designated using the matrix shown in *Table 5.4*.

Table 5.4 *Impact Significances*

		Sensitivity/Vulnerability/Importance of Resource/Receptor		
		Low	Medium	High
Magnitude of Impact	Negligible	Negligible	Negligible	Negligible
	Small	Negligible	Minor	Moderate
	Medium	Minor	Moderate	Major
	Large	Moderate	Major	Major

The matrix applies universally to all resources and receptors, and all impacts to these resources and receptors, as the resource and receptor- or impact-specific considerations are factored into the assignment of magnitude and sensitivity designations that enter into the matrix.

Box 5.1 provides a context for what the various impact significance ratings signify.

Box 5.1***Description of Impact Significance***

An impact of *negligible* significance is one where a resource/receptor (including people) will essentially not be affected in any way by a particular activity or the predicted effect is deemed to be 'imperceptible' or is indistinguishable from natural background variations.

An impact of *minor* significance is one where a resource/receptor will experience a noticeable effect, but the impact magnitude is sufficiently small (with or without mitigation) and/or the resource/receptor is of low sensitivity/ vulnerability/ importance. In either case, the magnitude should be well within applicable standards.

An impact of *moderate* significance has an impact magnitude that is within applicable standards, but falls somewhere in the range from a threshold below which the impact is minor, up to a level that might be just short of breaching a legal limit. Clearly, to design an activity so that its effects only just avoid breaking a law and/or cause a major impact is not best practice. The emphasis for moderate impacts is therefore on demonstrating that the impact has been reduced to a level that is as low as reasonably practicable (ALARP). This does not necessarily mean that impacts of moderate significance have to be reduced to minor, but that moderate impacts are being managed effectively and efficiently.

An impact of *major* significance is one where an accepted limit or standard may be exceeded, or large magnitude impacts occur to highly valued/sensitive resource/receptors. An aim of impact assessment is to get to a position where the Project does not have any major residual impacts, certainly not ones that would endure into the long term or extend over a large area. However, for some aspects there may be major residual impacts after all practicable mitigation options have been exhausted (i.e. ALARP has been applied). An example might be the visual impact of a facility. It is then the function of regulators to weigh such negative factors against the positive ones, such as employment, in coming to a decision on the Project.

5.7***MITIGATION AND MANAGEMENT***

Once the significance of a given impact has been characterised using the above mentioned methodologies, the next step is to evaluate what mitigation measures are warranted. In keeping with the Mitigation Hierarchy, the priority in mitigation is to first apply mitigation measures to the source of the impact (i.e., to avoid or reduce the magnitude of the impact from the associated project activity), and then to address the resultant effect to the resource/receptor via abatement or compensatory measures or offsets (i.e. to reduce the significance of the effect once all reasonably practicable mitigations have been applied to reduce the impact magnitude).

It is important to have a solid basis for recommending mitigation measures. The role of any given ESIA is to help develop a sustainable project, and to help clients meet their business objectives in a responsible manner. Impact assessment is about identifying the aspects of a project that need to be managed, and demonstrating how these have been appropriately dealt with. As key influencers in the decision making process, the role of the impact assessment is not to stop development or propose every possible mitigation or compensatory measure imaginable, but rather to make balanced judgements as to what is warranted, informed by a high quality evidence base.

Additional mitigation measures should not be declared for impacts rated as not significant, unless the associated activity is related to conformance with an

'end of pipe' applicable requirement. Further, it is important to note that it is not an absolute necessity that all impacts be mitigated to a not significant level; rather the objective is to mitigate impacts to an as low as reasonably practicable (ALARP) level.

Embedded controls (ie, physical or procedural controls that are planned as part of the project design and are not added in response to an impact significance assignment), are considered as part of the project (prior to entering the impact assessment stage of the impact assessment process).

5.7.1 *Residual Impact Assessment*

Once mitigation measures are declared, the next step in the impact assessment process is to assign residual impact significance. This is essentially a repeat of the impact assessment steps discussed above, considering the assumed implementation of the additional declared mitigation measures.

5.7.2 *Dealing with Uncertainty*

Even with a final design and an unchanging environment, impacts are difficult to predict with certainty, but in projects such as that proposed where the design process is currently in progress, uncertainty stemming from on-going development of the design is inevitable, and the environment is typically variable from season to season and year to year. Where such uncertainties are material to ESIA findings, they are clearly stated and are approached conservatively (ie, using a precautionary approach) in order to identify the broadest range of likely residual impacts and necessary mitigation measures.

Potential impacts may be assessed using tools ranging from quantitative techniques such as hydrodynamic modelling to qualitative techniques based on expert judgment and historical information. The accuracy of these assessment tools depends on the quality of the input data and available information. Where assumptions have been made, the nature of any uncertainties associated with the assumption is discussed. For qualitative predictions/assessments, some uncertainty is removed through consultation.

5.7.3 *Cumulative Impacts*

Cumulative effects and impacts are those that arise as a result of an impact and effect from the Project interacting with those from another activity to create an additional impact and effect. These are termed cumulative impacts and effects.

The impact assessment process predicts cumulative impacts/effects to which the proposed Project may contribute. The approach for assessing cumulative impacts and effects resulting from the proposed Project and another activity affecting the same resource/receptor is based on a consideration of the

approval/existence status of the 'other' activity and the nature of information available to aid in predicting the magnitude of impact from the other activity.

5.7.4 *Change Management*

As the Project design is finalised, a greater level of certainty regarding the impacts of the proposed Project will emerge. Accordingly, Project design changes may occur that need to be accommodated by the Project. Similarly, the organisational structure and roles and responsibilities may also change as the Project progresses.

The ESIA process does not stop with submission of the reports. At times these changes may be material, potentially influencing the original findings of the ESIA, and hence, the basis for its approval. Such a mechanism to manage change, or a change management system, must ensure that changes to the scope of the proposed Project are subjected to a robust assessment process. Any changes to Project scope will be evaluated for their degree of significance, and will be addressed as follows:

- Minor changes in Project design will be reflected in updates or amendments to the ESMP; and
- Substantive changes that might potentially alter the ESIA process findings (ie, those that result in major changes to the predicted significance of environmental and social impacts) will be subject to re-assessment, further stakeholder consultation, supplementary reporting and revision of the Project's ESMP.

6.1 LIBERIAN ENVIRONMENTAL ADMINISTRATIVE FRAMEWORK

6.1.1 Environmental Protection Institutional Framework

Environmental Protection Agency

The Liberia Environmental Protection Agency (EPA) is an autonomous statutory body, established under the Act creating the Environmental Protection Agency of the Republic of Liberia 2003 (GOL, 2003a), and hereafter referred to as the EPA Act, to address the country's environmental issues. The EPA became a fully functioning entity in 2006, with the appointment of a board of directors and establishment of a Policy Council.

The EPA was established to:

'coordinate, monitor, supervise and consult with relevant stakeholders on all activities in the protection of the environment and sustainable use of natural resources.'

As the lead national environmental agency it is charged with executive authority for all environmental activities and programs relating to environmental management in Liberia. The EPA also has a key responsibility for matters relating to the issuing of environmental impact assessment licenses and for compliance monitoring relating to environmental regulations and standards.

County and District Environmental Committees

To decentralize environmental management, the Environmental Protection Agency Act authorizes the establishment of County and District Environmental Committees and directs the National Environmental Policy Council to provide guidelines for their establishment. Each County Committee is composed of county and district officials, traditional leaders, private citizens, and two local representatives to the national legislature. The Committee is staffed by a County Environment Officer, hired by the EPA, but responsible to the County Committee.

The District Environment Committees are to be established by and report to the relevant County Environment Committee. They are charged with promoting environmental awareness and mobilizing the public to manage and monitor activities within the district to ensure that they do not have any significant impact on the environment. The District Committees are composed of district officials, mayors, chiefs, and private citizens and are staffed by a District Environment Officer hired by the EPA.

In addition to assisting the County and District Committees in the fulfilment of their responsibilities, the County and District Environment Officers are responsible for compiling reports to the EPA, promoting environmental awareness, and conducting public hearings on environmental impact assessment in the County and the District.

At present, two County Environmental Committees have been established; One in Sinoe County and another in Nimba County. However, EPA has established outstation offices in eight counties. The offices are staffed by Environmental Inspectors.

Once the County Environment Committees are established, some of the Inspectors may be reassigned as County Environment Officers.

EPA has an office in Lofa County.

Ministry of Land, Mines and Energy

The Ministry of Lands, Mines and Energy has the statutory responsibility for the development of mineral, water and energy resources in Liberia. It is in charge of land surveys in all parts of the country and coordinates, administers and regulates the use of public and private lands in Liberia, including mineral resources through granting of operation licenses as well as regulating beach sand mining. It also works in combination with the Ministry of Agriculture and the University of Liberia to conduct training and research on land rehabilitation. Energy provision is administered through the same Ministry by the National Energy Committee, while water resources are the responsibility of the National Hydrological Service.

Ministry of Agriculture

The Ministry of Agriculture regulates forestry (as related to plant quarantine, agro-forestry and food crop related plantations), fishery and agriculture sectors and has specific responsibilities for soil conservation. It plans, executes, administers, manages and supervises agriculture programs and provides extension services, trains local farmers in improved cultural practices, and supplies farm inputs to enhance food security.

Forestry Development Authority

The Forestry Development Authority (FDA), established in 1976, was historically the government agency with primary responsibility for environmental management in Liberia. Now an autonomous body, and mandated by the National Forestry Reform Law of 2006, the FDA has responsibility for the protection, management and conservation of government-owned forests and wildlife on a sustainable basis. It manages commercial, conservation and community uses of Liberia's forests. It provides long- and middle- range planning in the forestry sector as well as preparing forestry policy, law and administration. It exercises control of the commercial

use of state-owned forests through the granting of concessions, supervises adherence to forest legislation and concession agreements, calculates and determines forestry fees, evaluates investment proposals, executes reforestation and forest research and training and monitors activities of timber companies. The 2006 law revised the institutional framework of the FDA and created a Department of Conservation which is made up of the Division of National Parks and the Division of Wildlife with the responsibility for development and management of protected areas and wildlife respectively.

Ministry of Planning and Economic Affairs

The Ministry of Planning and Economic Affairs (MPEA) is responsible for intersectoral coordination for the development of policies, plans and programs for the economic, financial, social, cultural and physical development of Liberia.

In fulfilling its various duties, it serves as the direct link between implementing Ministries/ Agencies, NGOs, private voluntary organizations, and the international community. Coordination occurs at the national, sectoral and regional planning levels and also involves the implementation of crosscutting initiatives.

Rural and Renewable Energy Agency

The Rural and Renewable Energy Agency (RREA) was established in January 2010 to facilitate and accelerate the economic transformation of rural Liberia by promoting the commercial development and supply of modern energy products and services to rural areas through the private sector and community initiatives with an emphasis, but not necessarily exclusive reliance, on locally available renewable resources.

Liberia Electricity Corporation

The Liberia Electricity Corporation was created in 1973 to generate, transmit, distribute, and sell electricity throughout the country at economically reasonable rates.

Other Relevant Governmental Institutions

Other governmental institutions with environment-related responsibilities include the Ministry of Education, Ministry of Public Works, Ministry of Health and Social Welfare, Ministry of Foreign Affairs, and the Liberia Water and Sewer Corporation.

6.1.2 *Environmental Inspectors and Courts*

To provide for enforcement of environmental requirements and standards, the Environmental Protection Agency Act provides for the appointment of Environmental Inspectors and the establishment of an Environmental Court system.

Environmental Inspectors

The Act authorizes the EPA to ‘...*designate its officers and duly qualified public officers/civil servants to be environmental inspectors within such Counties and District limits.*’ Thus, Environmental Inspectors do not have to be EPA employees, but can also be designated officers or civil servants in other branches of the government. Environmental Inspectors are authorized to enter premises, inspect activities, take samples, and review records to ensure compliance with environmental rules and regulations.

The exact nature of the inspector’s enforcement authority is not defined in the Act, but the Act does state that the EPA is to ‘...*establish the conditions, rules and regulations governing the qualifications, performance, powers and duties of the Environmental Inspectors.*’ The Environment Protection and Management Law (EPML) confirms that Environmental Inspectors can write Restoration Orders to correct an activity deemed to be noncompliant with environmental rules and regulations.

Environmental Courts

The Environmental Protection Agency Act defines a two-tiered court system to hear and rule on compliance with environmental rules and regulations.

The first tier is the Environmental Administrative Court. This court is to hear and rule on complaints relating to the environment. The complaints may concern the actions or decisions of the EPA or an Environmental Inspector, or may be brought by a member of the public to stop activities they believe are damaging the environment.

The second tier is an Environmental Appeals Court, established at the Judicial Circuit level.

At present, the Environmental Court system has not been formally established. EPA’s five-year strategic plan (starting July 2011) provides for an administrative court to handle environmental issues for an intermediate period before the full establishment of an environmental court under the judicial system.

6.2

NATIONAL LEGISLATIVE FRAMEWORK

Table 6.1 describes the main categories of legislation in Liberia and *Table 6.2* and *Table 6.3* provide a summary of relevant Liberian environmental legislation, policies and strategies. *Table 6.4* lists the relevant international environmental conventions signed/ratified by the Government of Liberia.

Table 6.1 *Categories of Legislations in Liberia*

Law	Laws are passed by the National Legislature of Liberia comprising of the Senate and the House of Representatives. Any citizen or group of citizens, Cabinet Ministers, Managing Directors of public corporations or agencies can propose a bill to the National Legislature for enactment. The draft bill is first passed over to the appropriate Steering Committee of the Legislature. In case of an environmental bill, this committee is generally the Committee on Natural Resources and the Environment. The Committee reviews, assesses and presents the bill to the Legislative Plenary with appropriate amendments for debate, public hearing and subsequent enactment by the Legislature.
Executive Order	The Executive Branch of government headed by the President can issue an Executive Order without the approval of the National Legislature. The Executive Orders have the power of the law provided that they do not contravene the existing law. The power of such orders has a limited time of existence.
Regulation	The national Legislature has empowered Cabinet Ministers and Managing Directors of public corporations and agencies to issue regulations for their respective functionaries without legislative approval or supervision, provided that such regulations are consistent with the statutory laws and the constitution of Liberia.

Table 6.2 *Summary of Applicable Environmental Laws*

Categories	Title	Year	Description	Aspect Relevant to the Project
General	Constitution of the Republic of Liberia	1986	Article 7 of the Constitution sets the fundamental basis for the constitutional, legislative, and institutional frameworks for the protection and management of the environment. It also encourages public participation in the protection and management of the environment and the natural resources in Liberia.	General protection of the environment Public participation in environmental matters
	The Environment Protection Agency (EPA) Act	2003	The Act provides the EPA with the authority of government for the protection and management of the environment in Liberia. It provides for an Environmental Administrative Court to hear from aggrieved parties and requires that an ESIA be carried out for all activities and projects likely to have an adverse impact on the environment.	Establishment of EPA as authority for environmental matters
	The Environment Protection and Management Law (EPML)	2003	The law enables the EPA to protect the environment through the implementation of the Law. It arranges the rules, regulations, and procedures for the conduct of ESIA's and establishes regulations for environmental quality standards, pollution control and licensing, among others.	Establishes ESIA as a process for environmental planning and decision-making
Forestry	Conservation of the Forests of the Republic of Liberia	1953	These Acts provided for the establishment of the Bureau of Forest Conservation within the Department of Agriculture and Commerce and describe the basic legal framework for forest and wildlife management in Liberia.	Establishes framework for management of forests
	Supplementary Act for the Conservation of Forests	1957		
	The Act that Created the Forestry Development Authority (FDA)	1976	These two acts established the FDA and defined its responsibilities, outlined forest offences and penalties, made provisions for an Advisory Conservation Committee and specified powers of forest officers with regard to trees in reserve areas. They gave the FDA the power to establish Government Forest Reserves, Native Authority Forest Reserves, Communal Forests and National Parks.	Establishes framework for categorisation of types forest resources
	Amendment to the FDA Act	1988		

Categories	Title	Year	Description	Aspect Relevant to the Project
	National Forestry Law	2000	This Act makes provision for the management and conservation of forest resources of Liberia, defines ownership rights and other rights in forests, provides for the protection of the environment and wildlife in forests, regulates the trade in forest products and provides for various other matters relative to forestry and wildlife.	Defines ownership rights for types of forest resources
	National New Forestry Reform Law	2006	This act amends the national forestry law of 2000 and the act creating the FDA. The administration of this Act provides for the FDA to exercise power under the law to ensure sustainable management of the Republic's forestland, conservation of the forest resources, and protection of the environment. It also has provisions for sustainable economic development with the participation of and for the benefit of all Liberians to contribute to poverty alleviation in the country.	Re-establishes framework for management of forest resources
	Act to Establish the Community Rights Law with respect to Forest Lands	2009	The law creates a legal framework that defines and supports community rights in the management and use of community and traditional lands and forest resources.	Establishes traditional rights to forest resources
Biodiversity & Conservation	Wildlife and National Parks Act	1988	The Act identifies a number of protected areas and specifies policies and objectives regarding wildlife and conservation in the country.	Designates protected natural areas
	Protected Forest Areas Network Law	2003	The Act for the Establishment of a Protected Forest Areas Network required a biologically representative network of protected areas to be established covering at least 30 percent of the existing forest area, comprising about 1.5 million hectares.	Designates protected forested areas
	FDA Draft Hunting Regulations	Undated	These regulations include a list of "Fully Protected Animals of Liberia".	Designates protected animals
	National Wildlife Conservation and Protected Areas Management Act	2014	The law updates the 1988 law on wildlife and national parks. It includes a number of important provisions relating to biodiversity and protected areas.	Re-establishes protected natural areas
Health and Safety	Public Health Law	1976	This Law provides a framework for the management of public health and health systems in Liberia. The 1976 Law is currently being updated in order to effectively govern the decentralized health sector and accommodate the changes that have taken place since its promulgation. For example, in 2010 a new chapter was added to the Law to manage HIV / AIDS. ¹	Defines the framework for managing public health

¹ Liberia Ministry of Health and Social Welfare. 2010. An Act to Amend the Public Health Law, Title 33, Liberian Code of Laws Revised (1976). Accessed from the GOL website: <http://legislature.gov.lr/sites/default/files/Public%20Health.pdf>

Categories	Title	Year	Description	Aspect Relevant to the Project
Various	Liberia Land Commission Act	2009	The objective of this act is to propose, advocate and coordinate reforms of land policy, laws and programs in Liberia. It does not have adjudicatory or implementation role. The goal of the commission is “to develop comprehensive national land tenure and land use system that will provide equitable access to land and security of tenure so as to facilitate inclusive sustained growth and development, ensure peace and security and provide sustainable management of the environment”.	Establishes framework for land rights reform

Table 6.3 *Relevant National Policies, Strategies and Plans*

Title	Year	Description
National Environmental Policy	2003	The policy provides a systematic and logical framework by which to address environmental issues. Section 4.7 of the policy calls for an ESIA on all major developmental, socioeconomic and land use activities in any form that may have adverse effects/impacts on the environment to one degree or another.
National Biodiversity Strategy and Action Plan (NBSAP)	2004	The policy implements the United Nations (UN) Convention on Biological Diversity, of which Liberia is a member, on the national level.
National Forestry Policy	2006	The policy describes the main directions for the future of forestry development in Liberia, and updates earlier policies so they take into account the new Forestry Reform Law.
National Forest Management Strategy	2007	The strategy summarizes the FDA's approach to managing the national forest endowment. It includes objectives, goals, and management actions in pursuit of the overall aim to "conserve and sustainably manage all forest areas so that they will continue to produce a complete range of goods and services for the benefit of all Liberians and contribute to poverty alleviation in the nation" (FDA 2007, 4).
National Health Policy and National Health Plan ¹	2007	The document is a framework for health sector reforms in Liberia. The goal of the policy is to make health care delivery services throughout the country effective and efficient, thereby enhancing the quality of life of the population.
Land Rights Policy	2013	The policy aims at addressing historic inequalities based on the principal that "practice has become the law and policy, rather than the law and policy guiding the practice". It defines Public Land, Government Land, Customary Land, and Private Land, as well as Protected Areas that will be conserved for the benefit of all Liberians.

¹ Liberia Ministry of Health and Social Welfare. 2007. National Health Policy and National Health Plan. Accessed from the ILO website: http://www.ilo.org/wcmsp5/groups/public/---ed_protect/---protrav/---ilo_aids/documents/legaldocument/wcms_126728.pdf

Table 6.4

Relevant International Environmental Conventions Signed/Ratified by Liberia

Convention	Liberia Year of Ratification	Objectives
African Convention on Conservation of Nature and Natural Resources	1978	To encourage individual and joint action for the conservation.
Convention of International Trade in Endangered Species of Wild Fauna and Flora (CITES)	1981	To prevent trade of endangered or threatened species.
Convention Concerning the Protection of the World Cultural and Natural Heritage	2002	To recognize and protect cultural and natural heritage for future generations.
Framework Convention on Climate Change and the Kyoto Protocol	2002	To achieve stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climatic system. To strengthen the commitment of developed country parties with a view to reduce their overall emissions.
Ramsar Convention on Wetlands of International Importance	2003	To manage wetland systems so that the human uses of these areas are undertaken in such a way as to retain their natural capital for future generations. To encourage and support countries to develop and implement national policy and legislative frameworks, education and awareness raising programs, as well as inventory, research and training projects.
Convention on Biological Diversity (CBD)	2000	Promote conservation of biological diversity. Sustainable use of its components. Fair and equitable sharing arising out of the utilization of genetic resources.
Convention on the Conservation of Migratory Species of Wild Animals	2004	Aims to conserve terrestrial, marine and avian migratory species throughout their range.
Convention on Desertification	1998	To combat desertification and mitigates the effect of drought in countries experiencing serious droughts and/or desertification.

Convention	Liberia Year of Ratification	Objectives
International Tropical Timber Agreement	2008	Requires sustainable management of timber resource base, simultaneously encouraging the timber trade and the improved management of the forests.
International Covenant on Economic, Social and Cultural Rights	2004	ICESCR commits to work toward the granting of economic, social, and cultural rights to individuals, including labour rights and rights to health, education, and an adequate standard of living. ICESCR is part of the International Bill of Human Rights, along with the Universal Declaration of Human Rights (UDHR) and the International Covenant on Civil and Political Rights (ICCPR).

6.2.1

Constitution of Liberia

Article 7 of the 1986 Constitution of the Republic of Liberia sets the fundamental basis for the constitutional, legislative, and institutional frameworks for the protection and management of the environment. It also encourages public participation in the protection and management of the environment and the natural resources in Liberia.

With respect to acquisition of land, Article 24 gives the principles under which the government can expropriate land. These are as follows:

- Reasons for such expropriation are given;
- Prompt payment of just compensation;
- Expropriation or the compensation offered may be challenged freely by the owner of the property in a court of law with no penalty for having brought such action; and
- When property taken for public use ceases to be so used, the Republic shall accord the former owner or those entitled to the property through such owner, the right of first refusal to reacquire the property.

6.2.2

The Environmental Protection Agency Act

'An Act to establish a monitoring, coordinating and supervisory authority for the sustainable management of the environment in partnership with regulated Ministries and organizations and in a close and responsive relationship with the people of Liberia; and to provide high quality information and advice on the state of the environment and for matters connected therewith.'

The EPA was created by the Act creating the Environment Protection Agency of the Republic of Liberia, known as the Environment Protection Agency Act. The Act was approved on 26 November 2002 and published on 30 April 2003. The establishment of the EPA marked a significant step forward in the protection and management of the environment of Liberia.

Section 5 of the Act designates the EPA as the principal Liberian authority for environmental management which shall co-ordinate, monitor, supervise, and consult with relevant stakeholders on all the activities for environmental protection and the sustainable use of natural resources. Section 6 (b) of the Act stipulates that the EPA should propose environmental policies and strategies to the Policy Council and ensure the integration of environmental concerns in the overall national planning. Moreover, the EPA is empowered to carry out, among other things, the following aspects of environmental protection and management in Liberia:

- Establish environmental criteria, guidelines, specifications, and standards for production processes and the sustainable use of natural resources for the health and welfare of the present generation, and in order to prevent environmental degradation for the welfare of the future generations;

- Identify projects, activities, and programs for which environmental impact assessment must be conducted under this Law;
- Review and approve environmental impact statements and environmental impact assessments submitted in accordance with this Act;
- Monitor and assess projects, programs, and policies including activities being carried out by relevant ministries and bodies to ensure that the environment is not degraded by such activities and that environmental management objectives are adhered to and adequate early warning and monitoring on impending environmental emergencies is given;
- Review sectoral environmental laws and regulations and recommend for amendments and to initiate proposals for the enactment of environmental legislations in accordance with this Act or any other Act;
- Encourage the use of appropriate environmentally sound technologies and renewable sources of energy and natural resources; and
- Function as the national clearinghouse for all activities relating to regional and international environment-related conventions, treaties and agreements, and as national liaison with the secretariat for all such regional and international instruments.

6.2.3

Act Adopting the Environmental Protection and Management Law of the Republic of Liberia

'An Act to establish a legal framework for the sustainable development, management and protection of the environment by the Environment Protection Agency in partnership with regulated Ministries and organizations and in a close and responsive relationship with the people of Liberia; and to provide high quality information and advice on the state of the environment and for matters connected therewith.'

Section 15 of the EPML states that business investors should present an environmental mitigation plan to the EPA, which should include the following sections:

- Objectives;
- Description of activities to be carried out by the project to mitigate any adverse effects on the environment;
- Period within which the mitigation measures shall be implemented; and
- Proven efficacy of the mitigation measures of indicating their experimental nature.

Section 12 of the EPML requires environmental review for projects or activities that may have a significant impact on the environment. The project proponent shall submit to the EPA their plans for improving environmental performance, including:

- Identification of the major environmental effects; and
- A comprehensive mitigation plan in accordance with section 15 of this Law.

Section 6 of EPML requires an Environmental Impact Assessment license or permit for the commencement of such projects, and Section 13 requires the preparation of an environmental impact study for such a project.

Section 24 of the EPML requires that the EPA should ensure that projects comply with their environmental mitigation plan through monitoring of operations. Where evidence of non-compliance occurs, the EPA shall impose remedial measures and may bring action before the Environmental Court or through the Ministry of Justice to enforce compliance.

Section 25 of the EPML gives responsibility to the EPA carrying out periodic environmental audits of activities or projects that are likely to have adverse effects on the environment.

Section 58 of the EPML requires that a license must be obtained from the EPA for any type of effluent discharge into the sewage system, also in case of operation of a sewage system. This license is provided by the EPA for a period that does not exceed 1 year.

Section 61 of the EPML prohibits pollution of all Liberian Waters. In case of water pollution, a sentence and/or a fine could be imposed on the polluting party. The latter is also responsible for the cost of the removal of the pollutant and the restoration, restitution or compensation as determined by a court of law.

Section 62 of the EPML bans pollution by solid waste of any land, coastal zone or surface water, street, road or site in or on any place to which the public has access, except in a container or at a place which has been specially indicated, provided or set apart for such purpose. In case of such pollution, a fine or a prison term is imposed on the polluting party. The latter is also responsible for the clean-up of the solid waste pollution it caused.

Section 64 of the EPML requires that a 'Solid and Hazardous Waste Disposal License' be acquired in case of generation, storage, handling, transport or disposal of hazardous waste, or ownership or operation of a waste disposal site. The EPA provides this license for a period of not more than one year. This license entails the party who is generating the waste to take up waste management measures such as treatment, determination or recycling and re-mediation.

Section 71 of the EPML requires that a “Pollution Emission License” is acquired for any project or activity which is likely to pollute the environment in excess of any standards or guidelines issued under the EPML. This license is provided by the EPA for a period of not more than one year.

Section 75 of the EPML prohibits the following activities in relation to a river, lake or wetland that are declared as protected areas by the EPA. These activities include:

- Use, erect, construct, place, alter, extend, remove or demolish any structure in, on, under, or over the bed;
- Excavate, drill, tunnel or disturb the bed otherwise;
- Introduce or plant any part of a plant, plant specimen or organism whether alien or indigenous, dead or alive in a river, lake or wetland;
- Introduce any animal or micro-organism whether alien or indigenous, dead or alive in a river, lake or wetland;
- Deposit any substance in a river, lake, or wetland or in or under the bed, which is likely to have adverse environmental effects on the river, lake or wetland;
- Direct or block a river, lake or wetland from its natural and normal course; and
- Drain any river, lake or wetland.

Section 80 of the EPML, provides an outline framework for the Protection of Wild Animals and Birds and includes conservation areas. It differentiates wildlife protected areas in section 80 (4) – national park, wildlife reserve, and nature reserve – from wildlife management areas in section 80 (5) – wildlife sanctuary, and community wildlife area – while also stating that the Line Ministry can designate any other area as either as it sees fit.

Sections 83, 84 and 85 of the EPML, provide for the enabling environment for the conservation of biodiversity, charging the EPA with responsibility for a wide range of measures from preparing national conservation strategies to selecting and managing buffer zones to protected areas, to issuing guidelines for botanical gardens.

Section 91 of the EPML, states that the EPA may impose on the party that has caused or is likely to cause harm to the environment an “Environmental Restoration Order” requiring it to remedy/prevent the harm within 21 days of the service of the order. Section 92 allows the party to request the Agency to reconsider that order by giving reasons in writing within the same period. Section 107 states that non-compliance with the restoration order convicts the responsible party to imprisonment and/or a fine.

6.2.4

National Energy Policy

In February 2007, the GOL, through the Ministry of Lands, Mines and Energy (MLME), with the support of the United States Agency for International Development (USAID) published the National Energy Policy (NEP). The principal objective of the NEP is to ensure universal access to modern energy services in an affordable, sustainable and environmentally-friendly manner in order to foster the economic, political, and social development of Liberia.

The NEP recognizes the fact that energy is essential towards GOL Poverty Reduction Strategy (PRS) and the achievement of the Millennium Development Goals (MDGs).

The NEP assumes the implementation of proposed energy sector reforms founded on three essential features: (1) demonstrating the Government's resolve for good governance and ensuring financial transparency in all sector transactions; (2) overcoming the significant obstacles to private sector investment in energy supply; and (3) creating the requisite institutional and legal framework and an independent regulatory regime. In undertaking energy sector reform, the Government will also be addressing a key component of Liberia's commitment to the World Bank and other donors for debt relief under the program for Highly Indebted Poor Countries.

6.2.5

The Land Rights Policy

The Land Rights Policy (2013) concerns four land rights categories (Public Land, Government Land, Customary Land and Private Land), and a cross-cutting sub-category called Protected Areas, which must be conserved for the benefit of all Liberians.

For Public Land and Government Land, the Policy sets forth critical policy recommendations regarding: how the Government transfers such land, and how the Government acquires land, especially through the exercise of eminent domain (i.e. forced acquisition).

With respect to the new category of Customary Land, there are several significant recommendations: Customary Land and Private Land are equally protected; and communities will self-define, be issued a deed, establish a legal entity, and strengthen their governance arrangements to make them fully representative and accountable. The Government also undertakes to support communities in implementing these recommendations.

The policy recommendations are designed to ensure the Government exercises eminent domain consistent with international best practices and in a manner that balances the Government's constitutional powers with the fundamental constitutional right of Private Land and Customary Land.

6.2.6

National Environmental and Occupational Health Policy

The Ministry of Health and Social Welfare has a Division of Environmental and Occupational Health; however, the Division lacks standards and policies specific to industries and/or occupational hazards. The National Environmental and Occupational Health Policy (NEOHP) was developed in 2007 to provide a framework for identifying policy needs and actions to improve occupational health and safety. It supplements the National Health Policy, which focuses on public health and health systems. The NEOHP identified the following key Environmental and occupational health needs:

- Environmental sanitation;
- Food Safety Services;
- Water Quality and Safety;
- Vector Control & Chemical Safety;
- Waste Management;
- Disaster Management;
- Health Promotion;
- Occupational Health Services;
- Port Health; and
- Pollution Control.

6.2.7

Liberia Land Commission Act

The objective of this Act is to propose, advocate and coordinate reforms of land policy, laws and programs in Liberia. It does not have adjudicatory or implementation role. The goal of the commission is:

'to develop a comprehensive national land tenure and land use system that will provide equitable access to land and security of tenure so as to facilitate inclusive sustained growth and development, ensure peace and security and provide sustainable management of the environment.'

6.3

LIBERIA ENVIRONMENTAL QUALITY STANDARDS

Several environmental quality standards are partly prepared by EPA. Some of these environmental quality standards are:

- Air Quality Standards
- Water Quality Standards
- Noise Level Standards
- Waste Management Standards.

Air quality standards are not complete¹ for ambient air quality. Existing ambient air quality standards are given in *Table 6.5*.

¹ Complete in terms of full guidance development and implementation and enforcement of requirements.

Water quality standards are only completed for the marine waters. Drinking, domestic, industrial, agricultural and other types of water standards are still incomplete. However the Ministry of Health Water Testing Laboratory uses the drinking water standards presented in *Table 6.6*.

Noise level standards are complete for many environments. Relevant noise standards are presented in *Table 6.7*, *Table 6.8* and *Table 6.9*. Other noise standards can be found in the EPML - Noise Pollution Control and Standards Regulations, 2009.

Table 6.5 *Liberia Ambient Air Quality Standards*

Pollutant	Time weighted Average	Industrial area	Residential, Rural & Other area	Controlled areas***
Oxides of Sulphur (SOX)	Annual Average*	80 µg/m ³	60 µg/m ³	15 µg/m ³
	24 hours**	120 µg/m ³	80 µg/m ³	30 µg/m ³
	Annual Average		0.019 ppm/50 µg/m ³	
	Month Average			
	24 hours		0.048 ppm /125 µg/m ³	
	One hour			
	Instant Peak		500 µg/m ³	
	Instant Peak (10 min)		0.191 ppm	
Oxides of Nitrogen (NOX)	Annual Average*	80 µg/m ³	60 µg/m ³	15 µg/m ³
	24 hours**	120 µg/m ³	80 µg/m ³	30 µg/m ³
	8 hours			
	Annual Average		0.2 ppm	
	Month Average		0.3 ppm	
	24 hours		0.4 ppm	
	One hour		0.8 ppm	
	Instant Peak		1.4 ppm	
Nitrogen Dioxide	Annual Average		0.05 ppm	
	Month Average		0.08 ppm	
	24 hours		0.1 ppm	
	One hour		0.2 ppm	
	Instant Peak		0.5 ppm	
Suspended particulate matter (SPM)	Annual Average*	360 µg/m ³	140 µg/m ³	70 µg/m ³
	24 hours**	500 µg/m ³	200 µg/m ³	100 µg/m ³
	mg/kg			
	Annual Average****		100 µg/m ³	
	24 hours***		180 µg/m ³	
Suspended Particulate matter (<10 µg/m ³) (RPM)	Annual Average*	120 µg/m ³	60 µg/m ³	50 µg/m ³
	24 hours**	150 µg/m ³	100 µg/m ³	75 µg/m ³
Lead (Pb)	Annual Average*	1.0 µg/m ³	0.75 µg/m ³	0.50 µg/m ³
	24 hours**	1.5 µg/m ³	1.00 µg/m ³	0.75 µg/m ³
	Month Average		2.5	
Carbon monoxide (CO)/ carbon dioxide (CO ₂)	8 hours**	5.0 mg/m ³	2.0 mg/m ³	1.0 mg/m ³
	1 hour	10.0 mg/m ³	4.0 mg/m ³	2.0 mg/m ³

Pollutant	Time weighted Average	Industrial area	Residential, Rural & Other area	Controlled areas***
Hydrocarbons (HC)	24 hours**			
VOC	24 hours**			
Ozone	1 hour		0.12 ppm	
	Instant Peak		1.25 ppm	

Source: Environment Protection and Management Law- Air Quality & Standards Regulations; 2009)

* Annual Arithmetic mean of minimum 104 measurements in a year taken twice a week 24 hourly at uniform interval.

** 24 hourly/8 hourly values should be met 98% of the time in a year. However, 2% of the time, it may exceed but not on two consecutive days. The 24-hour limit may not be exceeded more than three times in one year.

*** Not to be exceeded more than once per year average concentration

Table 6.6

Liberian Drinking Water Quality Standards

Parameter	Unit	WHO	Class I	Class II	Class III
pH	-logH	-	6.5 - 8.0	6.0 - 9.0	5.5 - 9.0
Chloride	mg Cl/l	350	250.0	350.0	450.0
Sulphate	mg SO ₄ /l	250	150.0	200.0	250.0
Hardness	CaCO ₃ mg/l	100-500	190.0	300.0	600.0
Iron Total	Fe mg/l	0.1	0.1	1.5	2.0
Manganese	Mn mg/l	0.1	0.1	0.3	0.8
Zinc Total	Zn mg/l	5	1.0	2.0	5.0
Coliform Bacteria	n/ml	0	0	0	5
Bacteria Total	n/ml	0	0	10	50
Dissolved Substance	mg/l	500	500.0	1000.0	1200.0
Suspended Solids	mg/l	-	10.0	30.0	50.0
Ammonia	mg NH ₄ /l	0.5	1.0	3.0	6.0
Nitrate	mg NO ₃ /l	50	40.0	60.0	80.0
Nitrite	mg NO ₂ /l	-	0.1	0.5	1.0
Phosphate	mg PO ₄ /l	-	0.01	0.02	0.05
Phenols	mg/l	0.001	0.001	0.02	0.05
Detergents	mg/l	-	1.0	2.0	3.0
Fluoride	F mg/l	1.5	1.5	1.5	2.0
Cyanide	Cn mg/l	0.05	n.d.	0.02	0.05
Lead	Pb mg/l	0.1	0.1	0.1	0.1
Mercury	Hg mg/l	0.01	n.d.	0.005	0.01
Copper	Cu mg/l	0.05	0.01	0.01	0.2
Cadmium	Cd mg/l	0.01	n.d.	0.001	0.01
Chromium Trivalent	Cr mg/l	-	0.5	0.5	0.8
Chromium Hexavalent	Cr mg/l	0.05	0.05	0.1	0.1
Nickel	Ni mg/l	-	1.0	1.0	0.1
Silver	Ag mg/l	0.05	0.01	0.01	0.01
Vanadium	V mg/l	-	1.0	1.0	1.0
Boron	B mg/l	-	1.0	1.0	1.0
Arsenic	As mg/l	0.05	0.05	0.05	0.2
KEY					
mg	milligram				
L	Liter				
ml	milliliter				
n	count				
n.d.	non detectable				
Water Classification	Water can be used as				
Class I	Drinking water for the population, Water Supply for industry requiring drinking water.				
Class II	For Fisheries, Cultivated fisheries, Organized public bath, Recreational water sports.				
Class III	Industry supply except for industry requiring drinking water, irrigation or agricultural land.				

Prepared for the Government of Liberia by UN Department of Technical Cooperation for
UNDP New York 1987

Source: Ministry of Health and Social Welfare

Table 6.7 *Maximum Permissible Noise Levels for General Environment*

Facility	Noise Limits B (A) (Leq)	
	Day	Night
Any building used as hospital, convalescence home, home for the aged, sanatorium and institutes of higher learning, conference rooms, public library, environmental or recreational sites.	45	35
Residential buildings	50	35
Mixed residential (with some commercial and entertainment)	55	45
Residential + industry or small-scale production + commerce	60	50
Industrial	70	60

Time Frame: use duration Day : 6.00 a.m. 10.00 p.m.

Night : 10.00 p.m. 6.00 a.m.

The time frame takes into consideration human activity

Source: Environment Protection and Management Law- Noise Pollution Control and Standards Regulations, 2009

Table 6.8 *Maximum Permissible Noise Levels (Continuous or intermittent noise) from a Factory or Workshop*

Leq dB (A)	Duration (Daily)	Duration (Weekly)
85	8 hours	40 hours
88	4 hours	20 hours
91	2 hours	10 hours
94	1 hour	5 hours
97	30 minutes	2.5 hours
100	15 minutes	1.25 hours
103	7.5 minutes	37.5 minutes
106	3.75 minutes	18.75 minutes
109	1.875 minutes	9.375 minutes

Source: Environment Protection and Management Law- Noise Pollution Control and Standards Regulations, 2009

Noise Levels shall not exceed a Leq of -

- (i) Factory/Workshops 85 dB (A)
- (ii) Offices 50 dB (A)
- (iii) Factory/Workshop Compound 75 dB (A).

Table 6.9 *Maximum Permissible Noise Levels for Residential & Commercial Areas*

Facility	Limit Value in dB(C)
For any building used as a hospital, school, convalescent home, old age home or residential building.	109 dB (C)
For any building in an area used for residential and one or more of the following purposes: Commerce, small-scale production, entertainment, or any residential apartment in an area that is used for purposes of industry, commerce or small-scale production, or any building used for the purpose of industry, commerce or small-scale production.	114 dB (C)

Source: Environment Protection and Management Law- Noise Pollution Control and Standards Regulations, 2009

6.4

LIBERIA ENVIRONMENTAL IMPACT ASSESSMENT REQUIREMENTS

The regulated process associated with ESIA in Liberia is summarised in *Figure 6.1*. The steps in the process are:

- Prepare an Application for the Environmental Impact License
- Prepare Notice of Intent (NOI);
- Submit Project Brief (allow 14 working days for EPA review and feedback);
 - Conduct a scoping process;
 - Publish NOI in Media;
 - Prepare Terms of Reference (TOR);
 - Conduct Meetings with EPA Environmental Committee and District Environmental Committees, as required;
 - Conduct stakeholder engagement including public meetings with potentially affected communities; and
 - Submit Scoping Report to EPA;
- Prepare Environmental Review;
- Obtain EPA Approval of TOR and Environmental Review;
- Prepare Environmental Impact Study and Report (included in ESIA);
- Prepare Environmental Impact Statement (EIS) (included in ESIA);
- Develop Comprehensive Environmental Mitigation Plan and Implementation Strategy (included in ESIA);
- Agency Review of ESIA (within 3 months);
- Public Consultation on ESIA (within first 30 days of 3 months);
- Public Hearings (EPA to decide whether to hold these);
- Liberia Line Ministries Comment on ESIA;
- Review by EPA Environmental Assessment Committee; and
- Approval or Rejection by EPA (within 3 months of receiving ESIA).

6.4.1

Stakeholder Engagement Requirements

Involvement of the stakeholder in the ESIA commences with the launch of the ESIA process and continues throughout its course. The different requirements of the public involvement throughout the ESIA process are detailed in this section:

After the submission of an application for an environmental impact assessment permit, the project proponent is to publish a notice of intent that states the information that may be necessary to allow the stakeholders or any interested party to identify their interest in the proposed project or activity. This information is to include: the nature of the project, its related activities, its timeframe and its site of operation and the area that may be impacted.

Before preparing the ESIA document, the project proponent conducts public consultations with the potentially affected stakeholders. This procedure is called the scoping process which aims to: inform the stakeholders about the project's details, its potential impacts on the physical, biological and socio-

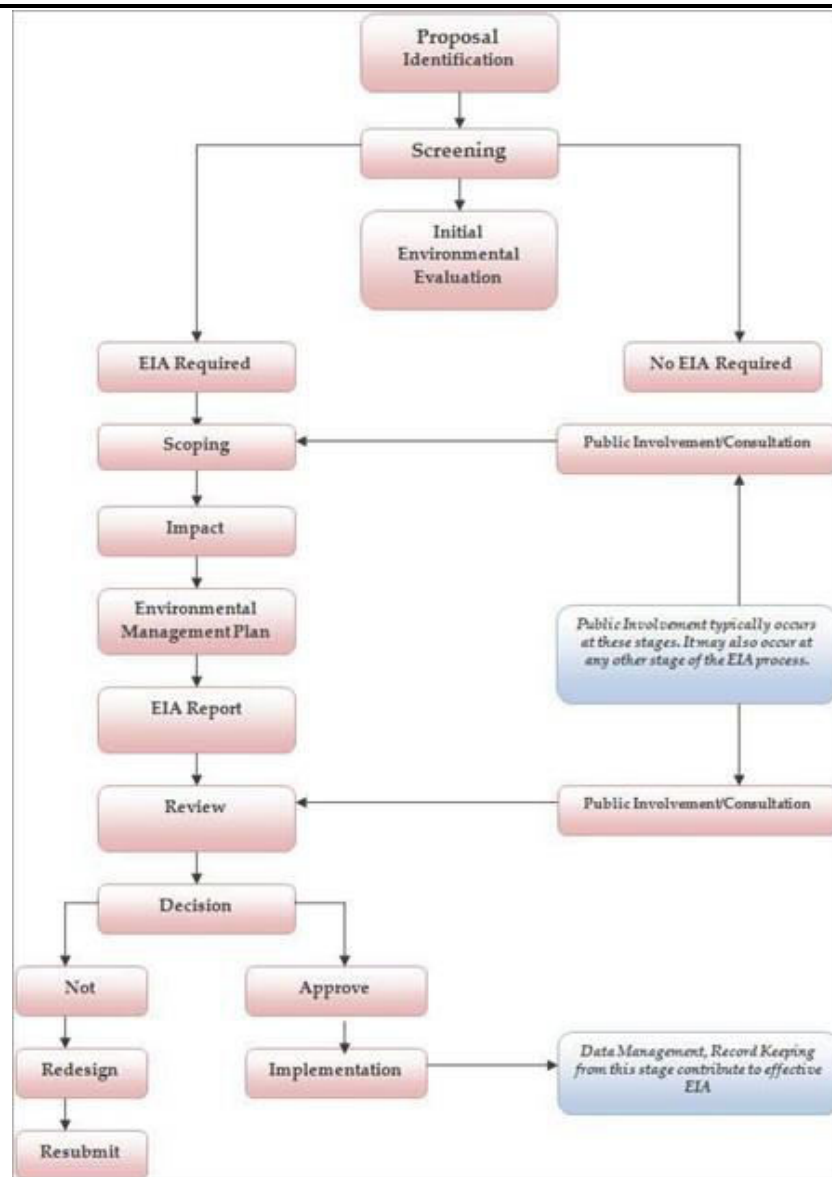
economic environments, and the mitigation measures that can be taken in order to minimize these impacts; and get the stakeholders' input on the various related issues. By achieving this, the scoping process is also a guiding tool for the project proponent and its consultants. It helps them in identifying the project's impacts, mitigation measures and alternatives, which will form an essential part of the ESIA document.

The scoping process consists of publishing the project's details in the affected district's media, holding public meetings to consult directly with the affected communities and stakeholders, and incorporating the views of these stakeholders in the scoping report which is submitted to the EPA.

On the completion of the ESIA study report, the public is invited again to participate in the ESIA review through public consultation meetings. The public's views on the ESIA are taken into consideration by the EPA when deciding on approving or rejecting the project.

In some cases, the EPA also decides to hold a public hearing about the project in order to fortify the public participation. These cases include but are not limited to: requests by the public for a public hearing, controversy about the project or expiry of the period stipulated for receipt of comments.

Figure 6.1 *Overview of ESIA Process in Liberia*



6.5 *INTERNATIONAL SAFEGUARD POLICIES*

6.5.1 *World Bank Safeguard Policies*

The development of the Project is being funded under the Liberia Renewable Energy Access Project (LIRENAP), a World Bank sponsored programme. In accordance with World Bank's environmental and social policies, the World Bank programme was reviewed in terms of the applicability of World Bank Safeguard Policies.

The Project is rated *Environmental Assessment Category B* as the proposed activities are small-scale, site-specific, and manageable. No adverse long-term impacts are anticipated.

The Project triggers four (4) Safeguard Policies: Environmental Assessment (OP 4.01), Involuntary Resettlement (OP 4.12.), Physical Cultural Resources (OP 4.11) and International Waterways (OP 7.50). The triggered and non-triggered policies are discussed in *Table 6.10*.

OP 7.50 is triggered since the Kaiha River is a tributary of Mano River, which is an international waterway since it runs along the boundary between Sierra Leone and Liberia. However, the requirement of riparian notification has been approved in accordance with the policy by the Regional Vice President on the basis of paragraph 7(c) of OP 7.50 because:

- Kaiha River is a tributary of the Mano River that runs exclusively within Liberia;
- Liberia and Sierra Leone are both the lowest downstream riparians of the Mano River; and
- Project would not cause appreciable harm to other riparian states.

The Safety of Dams Policy is also not triggered. The design of the five meter high weir will take sound engineering practices into account. Any dam safety issues, including the safe routing of an exceptional flood, have been addressed in the Environmental and Social Management Framework (ESMF, see paragraph below) and will be addressed in any Environmental and Social Impact Assessment (ESIA) undertaken for this activity.

Table 6.10 *Applicability of World Bank Safeguard Policies*

Policy	Applicable	Purpose / Objectives	Discussion
OP/BP 4.01 Environmental Assessment	Yes	This policy is considered the umbrella policy for the World Bank's environmental safeguard policies and requires that an environmental assessment be carried out before implementation of all projects that are likely to have significant adverse and irreversible environmental impacts.	The ESIA has been prepared in compliance with OP/BP 4.01 and provides a basis for the management of environmental and social impacts during the planning, construction and operation phase.
OP/BP 4.04 Natural Habitats	No	The policy seeks to ensure that infrastructure and other development projects take into account the conservation of biodiversity, as well as the numerous environmental services and products which natural habitats provide to human society. The policy strictly limits the circumstances under which projects can damage natural habitats (land and water areas where most of the native plant and animal species are still present). Specifically, the policy prohibits projects which would lead to the significant conversion or degradation of critical Natural Habitats, whose definition includes those natural habitats which are legally protected, officially proposed for protection, or unprotected but of known high conservation value. In other (non-critical) natural habitats, projects can cause significant loss or degradation only when there are no feasible alternatives to achieve the project's substantial overall net benefits; and acceptable mitigation measures, such as compensatory protected areas, are included within the project.	<p>The Project hydropower plant site is farm-bush areas. There is a strip of approximately 100 meters on both sides of the river where disturbed natural forest is still present. The impacts on this disturbed natural forest strips will be local in the area of the weir and the reservoir.</p> <p>According to available information, no important wildlife exists in the area. There are no chimpanzees in the wider Project area and no endemic or endangered species are present. For these reasons, the Natural Habitat Policy is not triggered.</p> <p>The ESIA does describes the habitat in the Project and assesses conservation value. Mitigation measures have been specified as appropriate.</p>
OP/BP 4.36 Forests	No	The objective of this policy is to assist borrowers to harness the potential of forests, to reduce poverty in a sustainable manner, integrate forests effectively into	Local people forest areas for their own daily use. There are no logging activities near the

Policy	Applicable	Purpose / Objectives	Discussion
		<p>sustainable economic development, and protect the vital local and global environmental services and values of forests.</p> <p>This policy applies to the following types of Bank-financed investment projects:</p> <ul style="list-style-type: none"> • projects that have or may have impacts on the health and quality of forests; and • projects that affect the rights and welfare of people and their level of dependence upon or interaction with forests projects that aim to bring about changes in the management, protection, or utilization of natural forests or plantations, whether they are publicly, privately, or communally owned. 	<p>hydropower plant locations. For these reasons, the Forest Policy is not triggered.</p> <p>The ESIA has conducted a biodiversity inventory of the affected forests and specified mitigation measures to minimise the impact on forest resources.</p>
OP/BP 4.11 Physical Cultural Resources	Yes	<p>These are defined as movable or immovable objects, sites, structures, groups of structures, and natural features and landscapes that have archaeological, paleontological, historical, architectural, religious, aesthetic, or other cultural significance. Physical cultural resources may be located in urban or rural settings, and may be above or below ground, or under water. Their cultural interest may be at the local, provincial or national level, or within the international community. The policy emphasizes that physical cultural resources are important as sources of valuable scientific and historical information, as assets for economic and social development, and as integral parts of a people's cultural identity and practices.</p>	Physical cultural resources have been assessed as part of the ESIA process. Affected communities have been consulted.
OP/BP 4.10 Indigenous Peoples	No	<p>The policy ensures that the development process fully respects the dignity, human rights, economies, and cultures of Indigenous Peoples. In addition, the Bank requires that developers should engage in a process of free, prior, and informed consultation with the indigenous people. The Bank recognizes that the identities and cultures of Indigenous Peoples are inextricably linked to the lands on which they live and the natural resources on which they depend. These distinct circumstances expose Indigenous Peoples to different types of risks and levels of impacts from development projects, including loss of identity, culture, and customary livelihoods, as well as exposure to disease.</p>	The project's direct impact zone is inhabited by a mix of ethnic groups, but they do not identify nor would meet the definition of indigenous, tribal or ethnic minority populations as defined in OP 4.10.
OP/BP 4.12 Involuntary Resettlement	Yes	<p>The Banks experience indicates that involuntary resettlement under development projects, if unmitigated, often gives rise to severe economic, social, and environmental risks: production systems are dismantled; people face impoverishment when their productive assets or income sources are lost; people are relocated to environments where their productive skills may be less applicable and the competition for resources greater; community institutions and social networks are weakened; kin groups are dispersed; and cultural identity, traditional authority, and the potential for mutual help are diminished or lost. This policy includes safeguards to address and mitigate these impoverishment risks.</p>	The Project will cause minor and temporary disruption of livelihoods (economic displacement), but no physical displacement. The ESIA outlines how the potential livelihood impacts and risks will be mitigated.

Policy	Applicable	Purpose / Objectives	Discussion
			Further assessment and mitigation of resettlement impacts will be addressed in a Resettlement Action Plan that will be prepared by the Project.
OP/BP 4.37 Safety of Dams	No	<p>When the Bank finances a project that includes the construction of a new dam, it requires that the dam be designed and its construction supervised by experienced and competent professionals. It also requires that the borrower adopt and implement certain dam safety measures for the design, bid tendering, construction, operation, and maintenance of the dam and associated works. For large dams (15 meters or more in height), the Bank requires:</p> <ul style="list-style-type: none"> • review by an independent panel of experts (the Panel) of the investigation, design, and construction of the dam and the start of operations; • preparation and implementation of detailed plans: a plan for construction supervision and quality assurance, an instrumentation plan, an operation and maintenance plan, and an emergency preparedness plan; • prequalification of bidders during procurement and bid tendering, and • periodic safety inspections of the dam after completion. 	The project does not involve a large dam (dam depth of approximately 5 m and head of approximately 13 m). The safety of the dam has been addressed in the engineering design and in the proposed construction schedule and operation modalities.
OP/BP 7.50 Projects on International Waterways	Yes (waiver)	<p>This policy applies to the following types of international waterways:</p> <ul style="list-style-type: none"> • any river, canal, lake, or similar body of water that forms a boundary between, or any river or body of surface water that flows through, two or more states, whether Bank members or not. <p>This policy applies to the following types of projects:</p> <ul style="list-style-type: none"> • Hydroelectric, irrigation, flood control, navigation, drainage, water and sewerage, industrial, and similar projects that involve the use or potential pollution of international waterways as described above. <p>The Bank recognizes that the cooperation and goodwill of riparian states is essential for the efficient use and protection of the waterway. Therefore, it attaches great importance to riparian's making appropriate agreements or arrangements for these purposes for the entire waterway or any part thereof.</p> <p>The Bank ensures that the international aspects of a project on an international waterway are dealt with at the earliest possible opportunity. If such a project is proposed, the Bank requires the beneficiary state, if it has not already done so, to formally notify the other riparians of the proposed project and its Project Details.</p>	<p>OP 7.50 is triggered since the Kaiha River is a tributary of Mano River, which is an international waterway since it runs along the boundary between Sierra Leone and Liberia. However, the requirement of riparian notification has been approved in accordance with the policy by the Regional Vice President on the basis of paragraph 7(c) of OP 7.50 because:</p> <ul style="list-style-type: none"> - Kaiha River is a tributary of the Mano River that runs exclusively within Liberia; - Liberia and Sierra Leone are both the lowest

Policy	Applicable	Purpose / Objectives	Discussion
			<p>downstream riparians of the Mano River; and</p> <ul style="list-style-type: none"> - Project would not cause appreciable harm to other riparian states.

6.5.2***Other World Bank Group Guidelines and Good Practice Notes***

The World Bank Group has published various guidelines and good practice notes. Those applicable to the Project and considered in the ESIA are as follows:

- General Environmental, Health, and Safety Guidelines (April 2007);
- Environmental, Health, and Safety Guidelines for Electric Power Transmission and Distribution (April 2007);

The following were published after the commencement of the ESIA but are included here for reference.

- Good Practice Handbook for Environmental Flows for Hydropower Projects (February 2018); and
- Good Practice Note Environmental, Health, and Safety Guidelines for Hydropower Projects (March 2018).

BASELINE CONDITIONS

7.1

INTRODUCTION

This Chapter describes existing (baseline) environmental, social, , economic and health conditions of the Project area. This baseline provides the basis from which potential impacts are predicted and informs the determination of significance.

Sources of Information

The description of the baseline conditions presented here was developed through a combination of desktop research and field-based surveys. The primary sources of information are as follows:

- Feasibility study (Multiconsult 2016)
- Field surveys conducted in about March 2016 as reported in the Initial ESIA
- Limited field survey conducted from 19 to 29 November 2017 for this ESIA
- Further desk-top based studies conducted for this ESIA

Area of Influence and Study Area

For the purposes of this ESIA, the definition of the Area of Influence (AoI) used is as the area likely to be effected by

- The Project and the Project's activities and facilities that are directly owned operated and managed (including contractor activities) and that are a component of the defined Project;
- Impact from unplanned but predictable effects caused by the Project that could occur at a later time of different location; and
- Indirect impacts on biodiversity or ecosystem services upon which affected communities rely for on for livelihoods.

For the Project, the **Direct AoI** is the spatial extent of the Project's physical footprint. This encompasses the hydropower plant, access road, transmission line right of way, and the diesel power plant. As example, the direct AoI would include the area of land (and vegetation and habitat) cleared to construct the hydropower plant.

The **Indirect AoI** encompasses areas that could be affected by secondary effects caused by direct effects. As example, the indirect AoI would include the spatial range of fauna that use the habitat that will be directly affected by vegetation clearing. The indirect AoI differs between various resources and receptors, for example, indirect impacts to social resources may extend to nearby communities.

Indirect impacts to surface water ecology may extend for long distances upstream and downstream of the dam.

In describing the Project baseline, the term Study Area is sometimes used. The Study Area encompasses the area covered by a particular environmental or social study and is usually sized to cover both the direct and indirect AoI. Where possible, the baseline description focusses on the direct and indirect AoI but in some cases, information for a specific location is not available and in these cases the description may cover a broader area.

7.2 *PHYSICAL ENVIRONMENT*

7.2.1 *Topography and Landscape*

The terrain immediately surrounding the Kaiha River is characterised by undulating hills with thick vegetation consisting of both primary and secondary forest. In the upper catchment the soil cover is generally sparse, with exposed dome shaped rock formations being visible in many places. The hydropower plant is located at an altitude of 425 masl and the highest point in the catchment is at about 850 masl.

The rapids and waterfall at the hydropower plant site form a conspicuous landscape element, although it is not visible from afar because of the thick vegetation cover. The waterfall is probably located at an old fault that has been eroded. Two waterfalls of roughly similar size are located upstream of the Project site (Kaiha 1 and Kaiha 3 described previously).

The landscape around the diesel power plant site is flat and peri-urban, with houses, farms, slash and burn agriculture and occasional trees prevalent.

The landscape surrounding the transmission line route is a mix of natural vegetation (near the hydropower plant site) and for the most part areas influenced by human activities (towns, farms, slash and burn agriculture and occasional trees).

Selected photographs of the project area are shown in *Figure 7.1*, *Figure 7.2*, and *Figure 7.3*.

The aesthetic qualities of the Project's AoI are typical of the surrounding landscapes and not unique. The rapids and waterfall at the hydropower plant site can be considered to add a certain aesthetic value to the landscape. Overall, the aesthetic value is rated as low-medium.

Figure 7.1 *Rapids and Waterfall at Hydropower Plant Site (viewed looking downstream)*



Figure 7.2 *Rapids and Waterfall at Hydropower Plant Site (viewed looking upstream)*



Figure 7.3 *Typical Landscape along the Road between Kolahun and Foya*

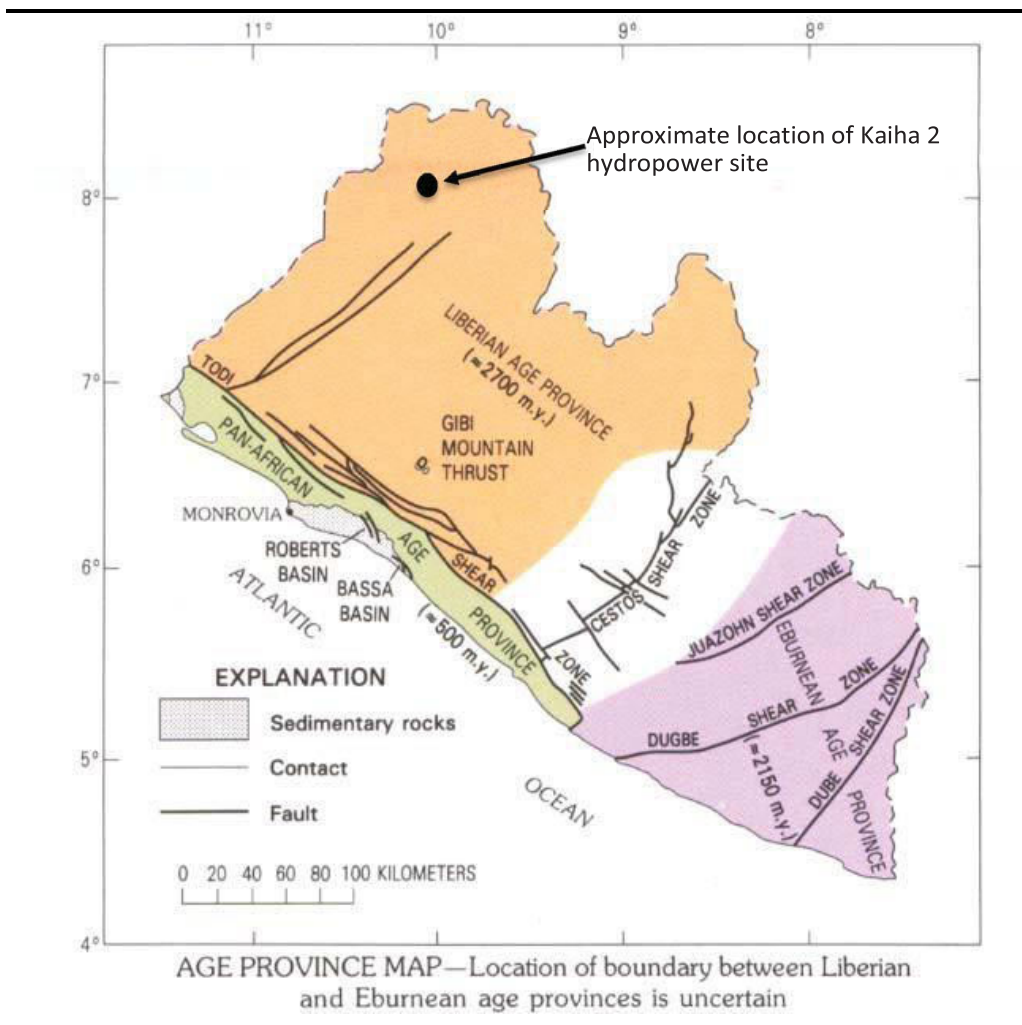


7.2.2 Geology and Soils

Geologically, the Project area is located in the Liberian age province (Figure 7.4) which can be dated back to 2700 million years ago (Tysdal and Thorman 1983). The Liberian age province is generally structurally stable today with little recorded earthquake activities. In Lofa County, it typically consists of massive and competent granite, metamorphosed granite, gneiss and intrusive diabase dyke.

At the hydropower plant site the observed granite and gneiss in the river bed outcrops was considered suitable for a concrete gravity dam and bedrock is generally expected within 1 m to 3 m of superficial deposits.

Figure 7.4 Geology in the Project AoI



Liberian soil consist of three major groups: latosols, lithosols and regosols.

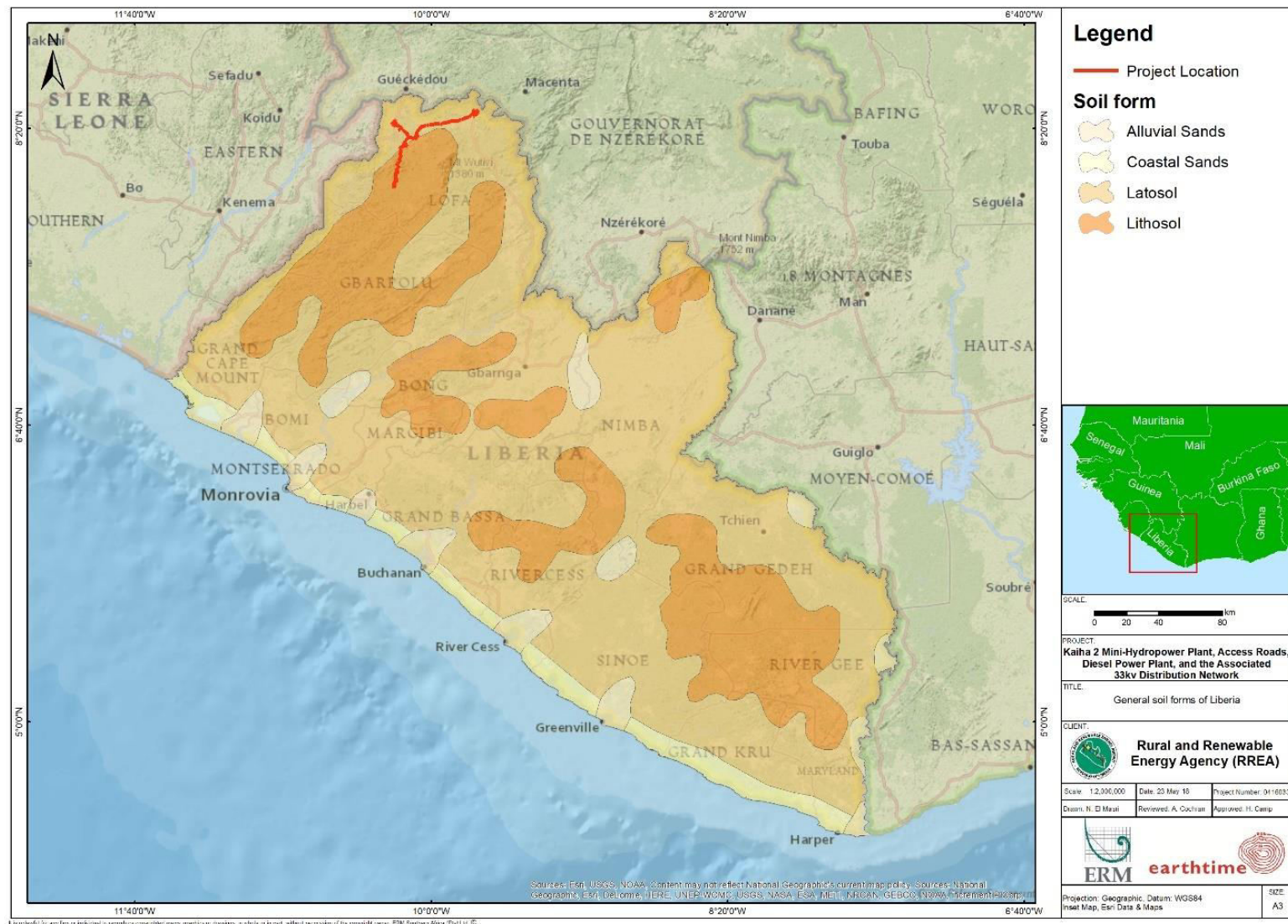
Figure 7.5 indicates that the project area consists of a combination of latosols and lithosols. Lithosols (USDA classification system) refer to soils that are limited in depth and are underlain by solid rock and weathering rock. It is by definition a younger soil as a result of less weathering but with the limitations with regards to rooting depth make it less suitable for crop production. In tropical regions, this soil type is more ideal for construction purposes as the volume of potentially erodible soil is smaller and the surface more stable. However, soil management measures still needs to be applied strictly as these areas may consist of steep slopes and which increase the risk of erosion, especially in the rainy season.

However, when the project area was superimposed on the digital soil data for Liberia as obtained from the Soil Atlas of Africa, the entire area is classified as Haplic Ferralsols (*Figure 7.6*). The Soil Atlas of Africa makes use of the World Reference Base Soil Classification system and in this system, Ferralsols are the equivalent of Latosols (FAO system) or Oxisols (USDA classification system). Lithosols in the FAO system correlates with Leptosols in the WRB system.

Haplic Ferralsols (African Soil Atlas) are found in high rainfall areas and on tertiary (very old) land surfaces. As a result of the extensive leaching caused by these conditions, there is an absence of weatherable minerals. These soils are dominated by the presence of stable compounds such as aluminium oxides, iron oxides and kaolinite which provides the distinctive red and yellow colours associated with these soils. The terminology 'Haplic' refers to an absence of any specifiers of the Ferralsols in the project area. The Haplic Ferralsol is therefore a typical example of a deeply weathered yellow and/or red tropical soil that can erode away easily once the vegetation cover has been removed.

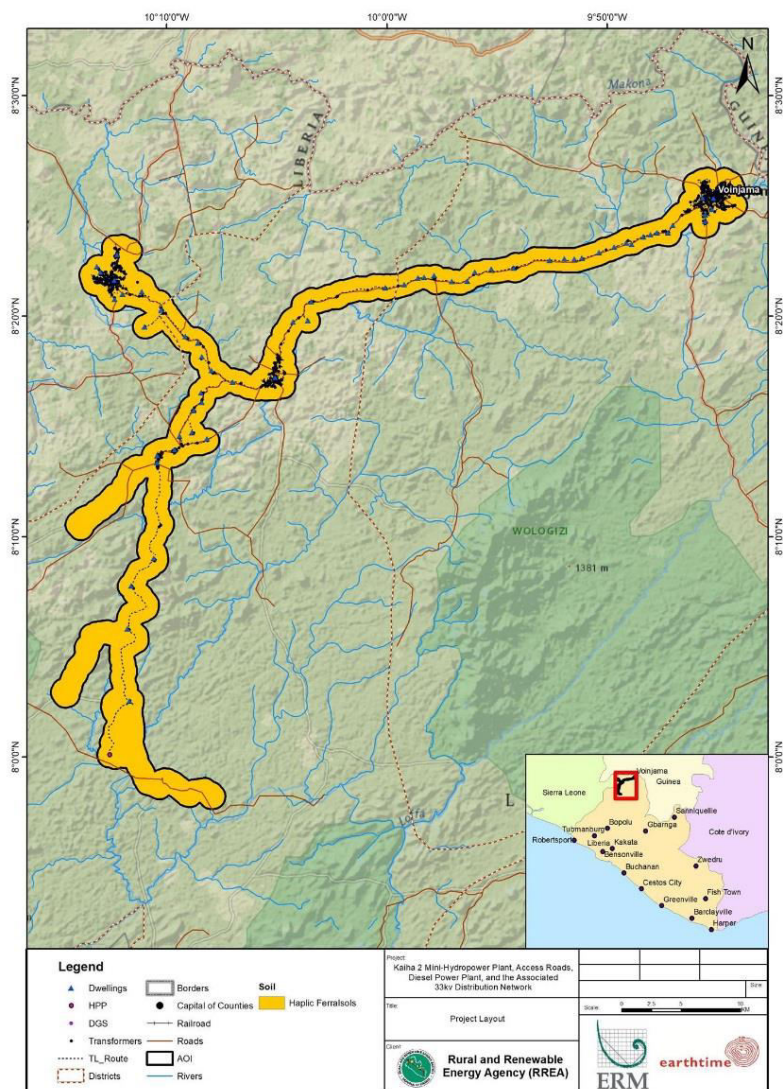
The majority of the transmission line route overlies latosol. The soil is described as heavily leached with silica, nutrients and humus mostly washed out. Iron and aluminium minerals have accumulated as permanent residual materials, forming hardpans and cemented layers within the subsoil, while on the surface hard and rounded iron oxides can be observed.

Figure 7.5 Map of Soil Types in Liberia



Source: Digitised From Original Map in Tysdal and Thorman, 1983

Figure 7.6 Map of Soil Types in the Project AoI



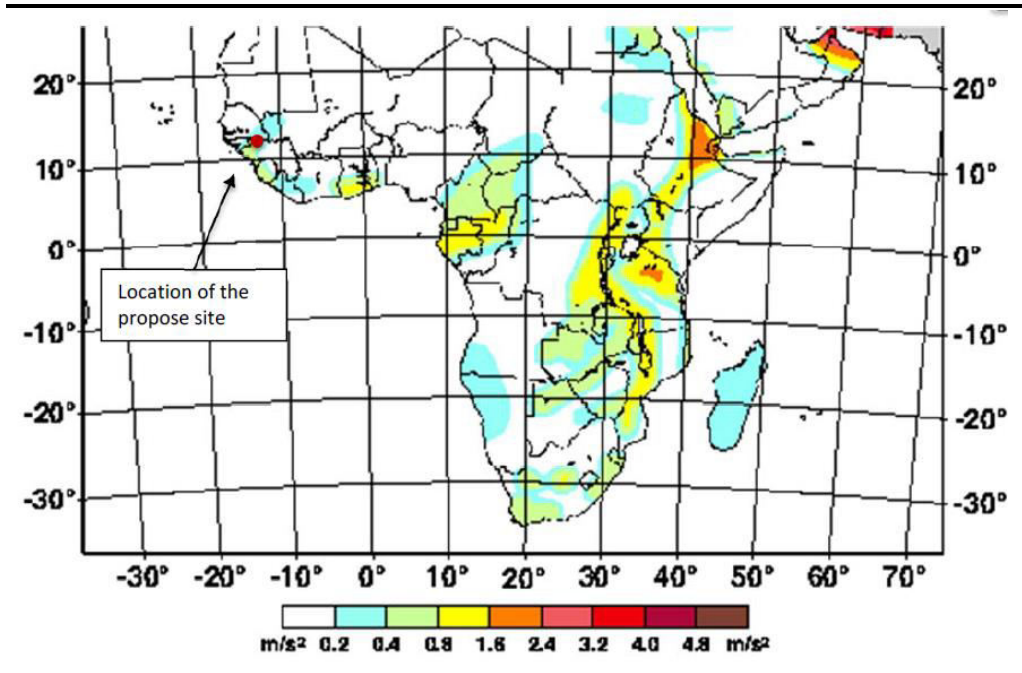
Source: Soil Atlas of Africa, JCR

7.3

SEISMOLOGY

According to Grunthal et al. (1992), the 475 years return period peak ground acceleration earthquake (a_g) is 0.4m/s^2 (Figure 7.7). It should be noted that seismic design of the Project's dam is not required according to Eurocode 8, as $a_g \times S < 0.5\text{m/s}^2$ (S is the soil type; for bedrock foundation $S=1$). Furthermore, the ICOLD guidelines are also not applicable to the dam, as the proposed dam is lower than 15 m and with a low failure consequence.

Figure 7.7 GSHAP Seismic Acceleration Map



7.3.1

Climate

The climate of Liberia is determined by the equatorial position and the distribution of low and high-pressure belts along the African continent and the Atlantic Ocean. There is a fairly warm temperature throughout the year with very high humidity because of the moderating influence of the ocean and the equatorial position.

Meteorological data including primarily precipitation, ambient temperature, as well as wind direction and speed, are necessary for understanding part of the environmental conditions in the region and consequently for adequately assessing environmental impacts in a comprehensive approach. Unfortunately, meteorological records in Liberia are scarce, and currently there are no operating stations.

The climatic information in the project region consists of historically measured data at the different meteorological stations located within or in the proximity of the project area.

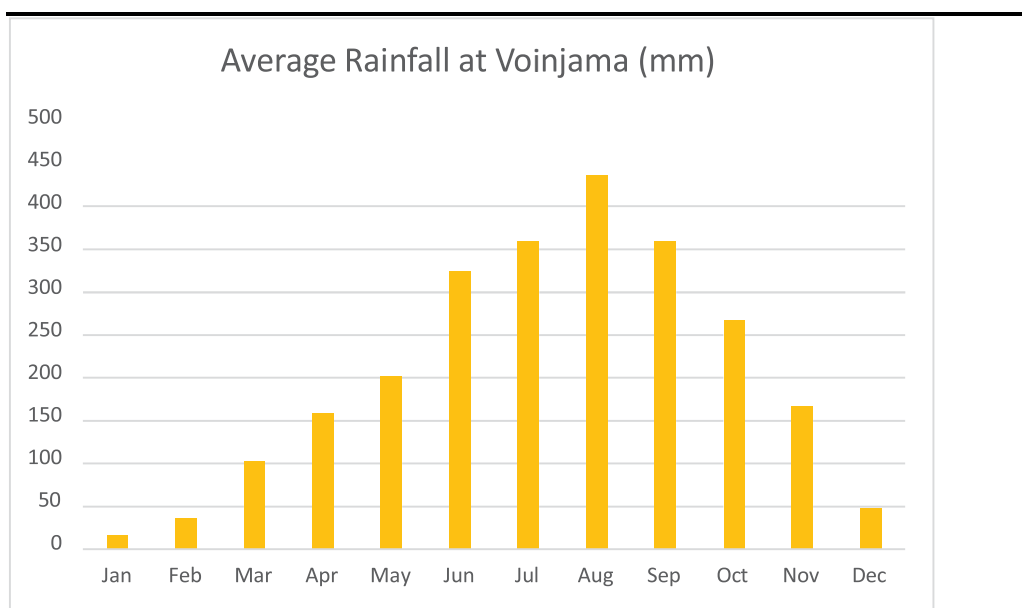
The reported data are those obtained from available records at different weather stations in the proximity of the study area (Kolahun and Voinjama in the middle and end of the transmission line some 34 and 66 km from the hydropower site).

Precipitation

The climatic regime is characterised by a very clear seasonal variation in rainfall. The rainy season starts in April or May and generally lasts until November. The dry season then lasts from December to March, but the onset of the rainy season can vary from year to year. Dry years are identified not so much by the amount of rainfall but rather by the time of onset of the rainy season. Late rains result in unusually low river flows in the Kaiha River. There is also a significant delay from the onset of rains until the river flow starts rising as the catchment soils first soak up the rain before rainfall runs off into the rivers (MultiConsult 2016).

Figure 7.8 presents the variation of the rainfall throughout the year in the nearest weather station with available rainfall data: Voinjama weather station, Mano River Basin (latitude: 8°25'N; longitude: 9°45'W). The average monthly rainfall data presented in Figure 7.8 are the averages of data recorded between the years 1952 and 1981. The mean annual rainfall is approx. 2,500 mm.

Figure 7.8 *Average Monthly Rainfall (mm) at Voinjama (1952 to 1981)*



Source: Multiconsult (2016).

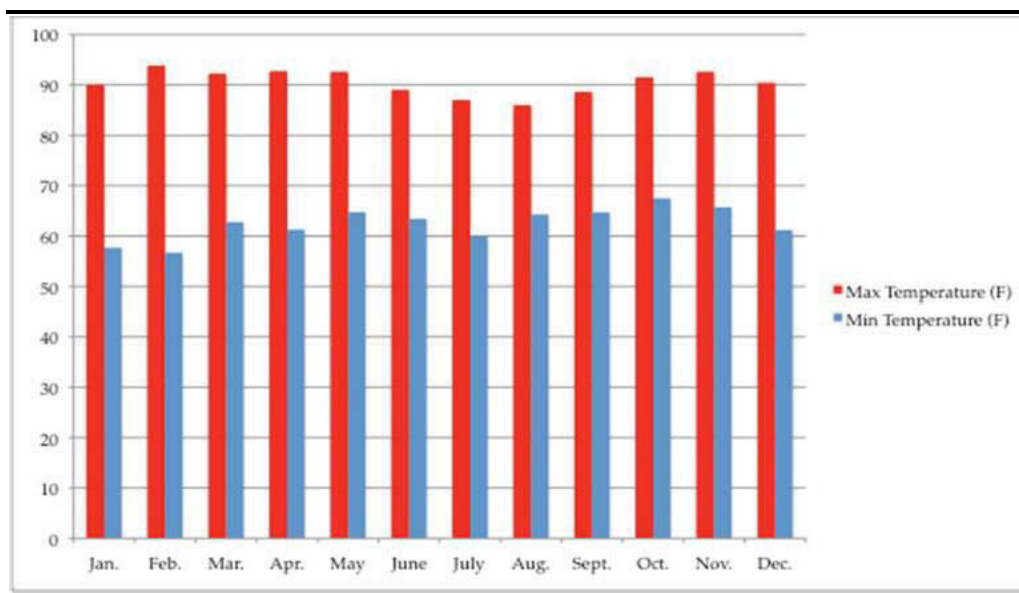
Temperature and Sunshine

Generally, temperature remains warm throughout the country and there is little change between seasons. The temperature over the country ranges from 27°C to 32°C during the day and from 21°C to 24°C at night.

The highest temperature occurs between January and March and the lowest is between August and September. The sun is overhead at noon throughout the year, giving rise to intense insolation (solar radiation that reaches the earth's surface) in all parts of the country, thus resulting in high temperatures with little monthly variations. Temperature would be much higher without cloud cover, winds, humidity and rainfall, which are influenced by the vegetation cover of the country. The days with the longest hours of sunshine fall between December and March. Daily sunshine hours are at a minimum during July, August and September.

Figure 7.9 shows average minimum and maximum temperatures throughout the year, recorded at the Kolahun weather station, the nearest weather station to the project with available temperature data (years 1953-1963).

Figure 7.9 *Average Monthly Minimum and Maximum Temperatures (in Fahrenheit degree) at Kolahun (1953 to 1963)*



Source: Multiconsult (2016).

Wind

The seasons in Liberia mainly result from the movement of two air masses:

- The Inter-Tropical Convergence Zone (ITCZ) from the northern hemisphere, and
- Cool air masses over the South Atlantic Ocean from the southern hemisphere.

Pressure shifts between the air masses force the dry continental air mass and the moist south-equatorial maritime air mass to replace each other every six months (UNDP 2006). No specific wind data exist for the Project location.

Relative Humidity

Relative humidity is generally high throughout the year in Liberia. A relative humidity of 90% to 100% is common during the rainy season. During the dry season, it decreases to as low as 65% (UNDP 2006). Along the coast, it does not drop below 80% and on the average is above 90%. There is a wider variation in the interior and humidity may fall below 20% during the harmattan period (characterised by dust laden winds from the Sahara Desert).

7.3.2 *Air Quality*

Direct air quality measurements were not measured directly because the airshed over the hydropower plant and access roads project area is not considered to be degraded. The proposed location for the diesel power plant is greenfield and with low level of activity that would involve emissions to air. The only sources of air pollution (and greenhouse gas emissions) would be from forest fires, mainly caused by human activity such as slash-and-burn agriculture. However, any background concentrations would be extremely low.

7.3.3 *Greenhouse Gas (GHG) Emissions*

Data on Liberia's annual GHG emissions was sourced from the World Resources Institute (WRI)'s Climate Analysis Indicators Tool (CAIT 2.0). CAIT 2.0 draws on key climate-relevant data from research centres, government agencies, and international bodies, and contains sector-level GHG emissions data for 185 countries for the period 1990 to 2011. In the absence of actual emissions data, GDP growth has been used as a proxy to estimate annual emissions between 2019 and 2040.

It is important to note that the extent of the increase in national emissions is not directly linked to GDP growth. GHG emissions are instead influenced by a number of factors, including: national policies (including any future GHG reduction policies and regulations); legislative frameworks; the type of economic development the country undergoes (eg, growth in manufacturing, mining, oil and gas, agriculture); future trends in land use change; and GDP growth; and the timing of these factors.

Information in relation to one of these aspects affecting the national emissions trajectory, namely national policies relating to GHG mitigation, was disclosed through Liberia's Nationally Determined Contribution (NDC), submitted to the UNFCCC in advance of the 21st Conference of Parties (COP) in October 2015, when 148 countries worldwide submitted GHG reduction pledges to the UN setting out the extent to which they intend to reduce their GHG emissions. Liberia has committed to:

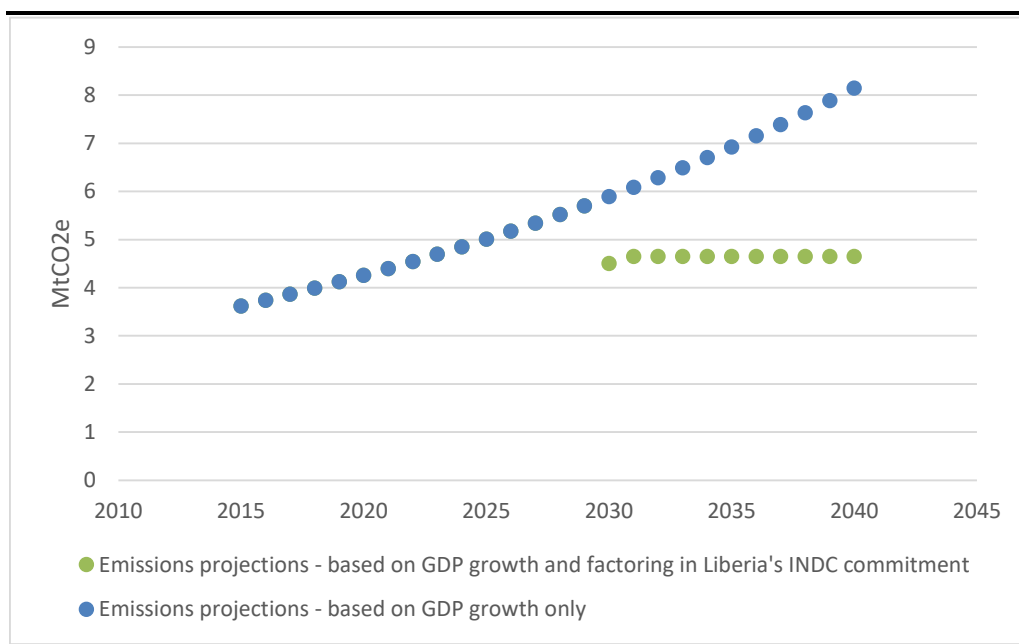
*'...setting a target of 4.5 MtCO_{2e} by 2030 having implemented the following mitigation efforts: i) 30% renewable energy efficiency, ii) firewood and cook stove distribution, iii) biofuel use, and iv) Monrovia Landfill Gas Plant.'*⁸

The baseline from which these reductions are to be achieved is not specified; however these reductions can be compared relative to a 'business as usual' emissions trajectory.

Based on Liberia's historic (2013-2015) and projected (2019-2040) GDP rates, and the country's GHG emission reduction pledge submitted to the UNFCCC, two emissions trajectories are presented in *Figure 7.10* below, which provides a 'best estimate' of Liberia's national annual emissions up to 2040 from a 2015 baseline. It should however be noted that there are significant uncertainties surrounding future climate change mitigation policies, efficiency improvements, land use change trends, economic development, and GDP growth in Liberia - all of which will be important in influencing the country's emissions, and which will act to increase the uncertainty of future changes in emissions over time.

⁸ Republic of Liberia Intended Nationally Determined Contributions (INDC) Available online at (<https://www.climatewatchdata.org/ndcs/country/LBR/full>) [Accessed 20.04.2018]

Figure 7.10 *Liberia Total National GHG Emissions (Mt CO₂e) (projected based on GDP growth, with and without NDC commitments taken into consideration)*



Noting the inherent uncertainties in projecting forward national emissions, and alternative method for understanding the magnitude of project GHG emissions and therefore the significance of the Project's GHG impacts, based on wider standards, is discussed below.

7.3.4 *Noise*

Ambient noise levels at the hydropower plant site were not directly measured, however, due to the remoteness of the hydropower plant site, the low traffic volumes on the main roads, and the absence of any major industrial activities, anthropogenic noise sources and thus levels are considered to be very low.

Ambient noise levels at the diesel power plant would be expected to be relatively higher due to proximity to a relatively large town and presence of anthropogenic sources such as vehicles and normal human activity.

7.3.5 *Hydrology*

The majority of the project is located within the Kaiha River catchment; however, a portion of the transmission line extends into the Mayo River catchment, contributing to the Moa River (also called the Makona River).

The Kaiha River forms the upper part of the Mano River basin and drains the Liberian Northern Highlands and marginally into Guinea. The Kaiha River flows

in a general south-west direction over a low gradient and with a meandering shape, contributing to the Mano River. The Mano River forms the Liberia – Sierra Leone border for a distance of about 70 km before it empties into the Atlantic Ocean at Mano Salija. The Kaiha River contributes to the Mano River about 180 km from the coast.

Based on available aerial imagery (Google Earth, 2017) the only major dam (and only major water user) upstream of the hydropower plant site is an irrigation dam 25 km north-northeast of site (Wanwoma irrigation scheme). According to Multiconsult (2016) the scheme was constructed in the 1970's and is currently being rehabilitated with funding from the Swiss Agency for Development and Cooperation. The rehabilitation works involve a new weir across the river *Figure 7.11* which will raise the water level by approximately a metre, allowing water to enter an intake to irrigation canals. The abstraction is estimated at 300 l/s and although the intake is equipped with a gate it is likely that the abstraction would be constant throughout the year (Multiconsult 2016). The scheme is intended for swamp rice (paddy cultivation).

Figure 7.11 *Rehabilitation Works at the Wanwoma Irrigation Scheme*



Source: Multiconsult (2016).

Contributions to the Kaiha River includes three broad catchment areas:

- Sagarkor Creek in the Northern Highlands, becoming the Seliba River near the town of Kambolahun;
- Manwunya Creek, with origins near Mount Wuteve; and
- Gbeya River, with origins near Mount Wuteve.

The Moa River (Makona River) arises in the highlands of Guinea and flows southwest, forming parts of the Guinea–Liberia and the Guinea – Sierra Leone borders. It flows into the Southern Province of Sierra Leone, discharging to the Atlantic Ocean at Sulima, southern Sierra Leone.

The hydropower site and the majority of the transmission lines are within the Kaiha River catchment; however, portions extend into the Gbeya River and Manwunya Creek catchments (which contribute to the Kaiha River catchment) as well as into the Mayo River catchment.

The total catchment area at hydropower plant site is approx. 1,129 km², as determined from the 30 m resolution Shuttle Radar Topography Mission data set from NASA (*Error! Reference source not found.*).

Figure 7.12 *Catchment in Project AoI*

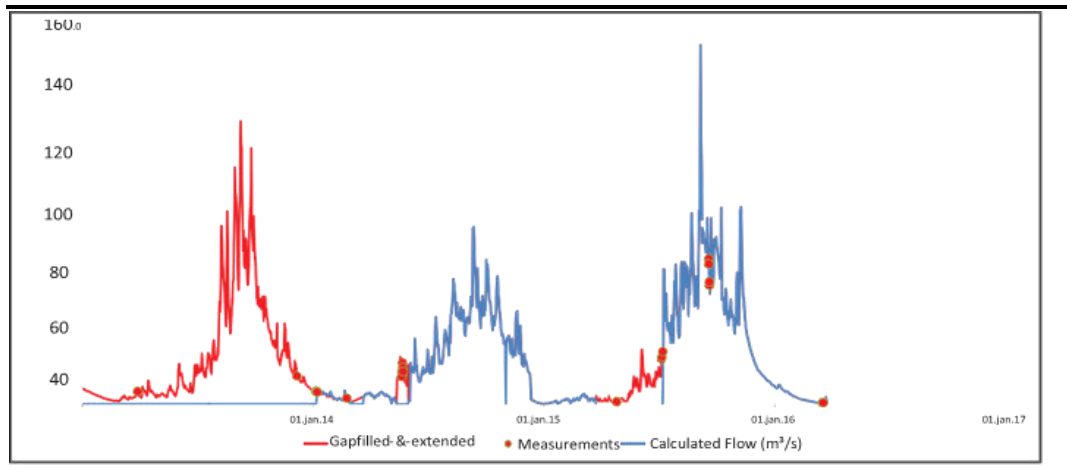


Source: Multiconsult (2016).

River flow at the hydropower plant site varies considerably within the year and from year to year (Multiconsult 2016). Based on the flow series prepared for the gauging station 01MA001, located near Kolahun Town upstream of the proposed hydropower plant site (Figure 7.13) the hydrological data for hydropower plant site have been determined by scaling the runoff from the gauging station Table 7.1.

The minimum, average and maximum monthly river flow at the site is 3.4 m³/s, 33.9 m³/s and 105.9 m³/s respectively (Table 7.1 and Figure 7.14). The design flood is 450 m³/s.

Figure 7.13 *Calculated Flow at Gauging Station 01MA001 at Kolahun*

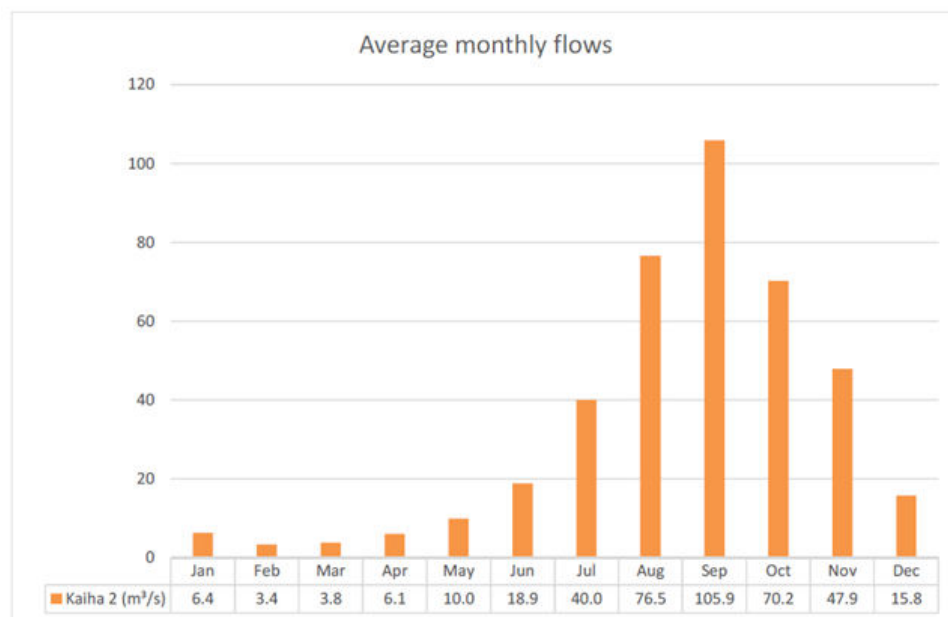


Source: Multiconsult (2016).

Table 7.1 *Hydrological Data for Kaiha 2 Hydropower Plant*

Site	Area	Annual Runoff	Average Flow		1% Low Flow	
	km ²		m ³ /s	l/s/km ²	m ³ /s	l/s/km ²
01MA001	673.4	637	20.2	30.0	0.20	0.30
Hydropower Plant Site	1,129	891	33.9	30.0	0.34	0.30

Source: Multiconsult (2016).

Figure 7.14 *Average Monthly Flows at Kaiha 2 Hydropower Plant Site*

Source: Multiconsult (2016).

7.3.6 Water Quality

The measured water quality parameters (temperature, turbidity, pH, dissolved oxygen and total dissolved solids) provide an indication of the health of the water body.

Based on the recorded values, the Kaiha River confirmed as a likely favourable habitat for aquatic life due to the high quality of the water. The river water has pH and TDS (total dissolved solids) values within the WHO drinking water guidelines (*Table 7.2, Table 7.3*) and DO (dissolved oxygen) values in line with the Canadian Water Quality Guidelines for the Protection of Aquatic Life.

The comparison between the recorded values at the hydropower plant site between April 2015 and April 2016 shows a noticeable increase in turbidity and dissolved oxygen values. This increase might be due to the rainfall events occurring in April 2016 on the nights prior to measurements.

Table 7.2 *Water Quality Data at the Hydropower Plant Site*

Location	Date	Temperature (°C)	Turbidity (NTU)	pH	Dissolved Oxygen (mg/l)	TDS (mg/l)
Upstream	27/04/2015	28.23	4.8	7.02	6.35	37.50
	26/04/2016	27.95	12.4	7.38	16.48	43.05
Waterfall	27/04/2015	28.01	5.3	7.04	6.85	41.17
	26/04/2016	27.92	11.8	7.37	18.01	42.76
Downstream	27/04/2015	28.35	4.3	7.09	6.64	37.13
	26/04/2016	28.12	11.8	7.22	10.02	42.19
WHO Drinking Water Standard			5	6.5 - 8		1000

Source: Multiconsult (2016)

Table 7.3 *Water Quality Data Upstream (U/S) and Downstream (D/S) of the 2 Hydropower Plant Site*

Location		Date	Temp (°C)	Turbidity (NTU)	pH	Dissolved Oxygen (mg/l)	TDS (mg/l)
U/S of Kaiha2 (Agriculture Dam)	U/S of Dam	30/04/2016	28.46	10.0	7.51	25.86	40.20
	D/S of Dam	30/04/2016	26.83	11.1	7.3	15.87	40.63
D/S of Kaiha 2 Hydropower Plant (Madina)	U/S of Confluence	28/04/2016	28.55	8.0	7.54	38.79	44.37
	D/S of Confluence	28/04/2016	28.39	8.1	7.85	35.92	45.16
WHO Drinking Water Standard				5	6.5 - 8		1000

Source: Multiconsult (2016)

Table 7.4 *Canadian Water Quality Guidelines for Dissolved Oxygen for the Protection of Aquatic Life*

	Early Life Stages	Other life stages
Warm Water	6	5.5
Cold Water	9.5	6.5

In conclusion, the water quality in the Kaiha River is generally favourable in ecological terms although it does not fully meet drinking water quality standards due to elevated turbidity levels.

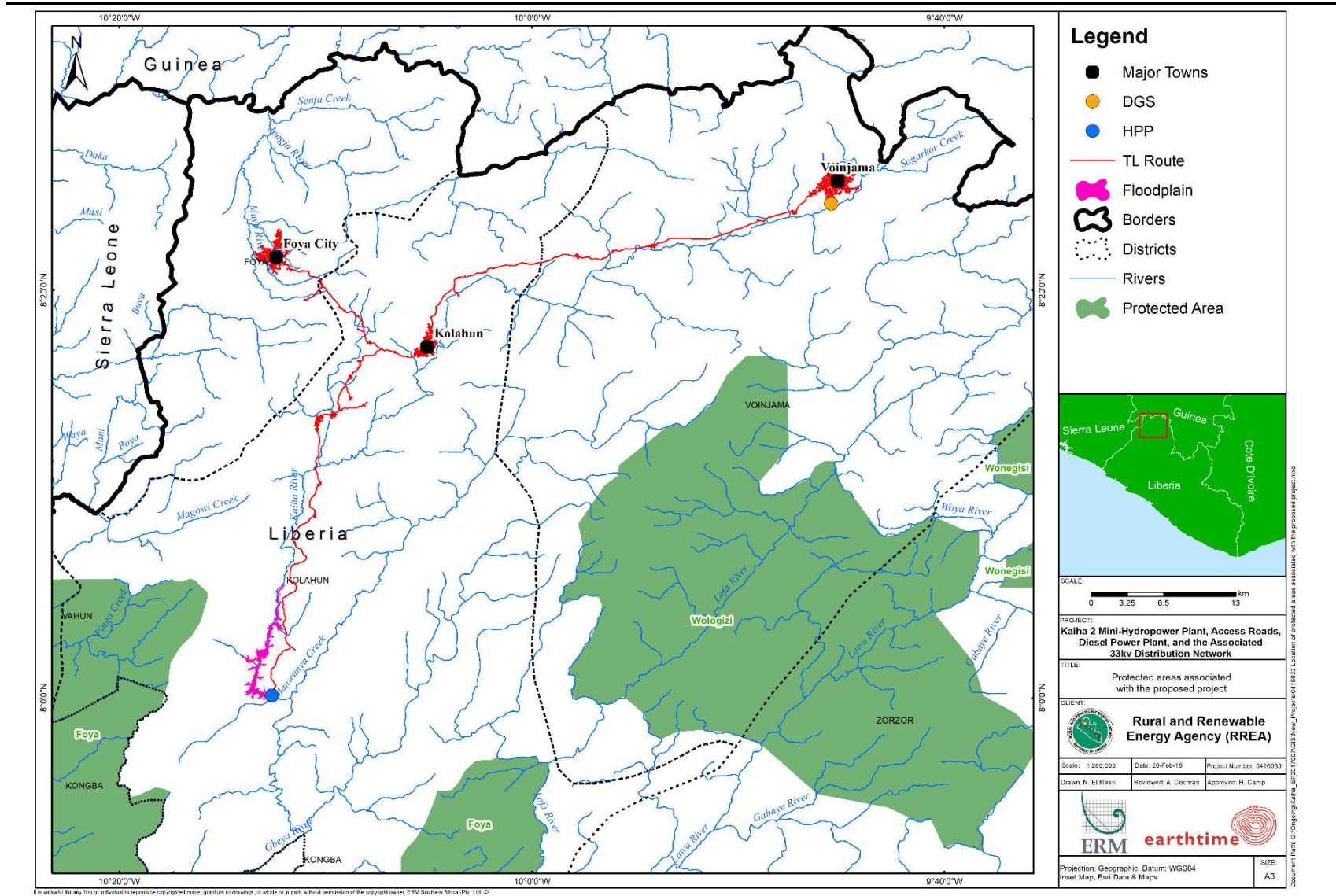
7.3.7***Sediments***

Based on a combination of site observations, reference to the published literature, and application of an Africa-specific sediment yield equation, indicate a very low sediment loads. Most of the sediment load will be in the form of quartz sand, with a mean diameter of approximately 0.5 mm based on sediment samples from Kaiha River (GLM Engineering 2017).

7.4***BIOLOGICAL ENVIRONMENT*****7.4.1*****Protected Areas******Nationally Protected Areas***

The proposed site for the hydropower plant is situated about 10 km from the boundary of the nearest protected area, namely Foya National Park, and slightly further away from Wologizi National Park (*Table 7.14*). These national parks qualify as IUCN Management Category II (National Park). Other protected areas in north-western Liberia include North Lorma National Forest and Gola National Forest, yet they are located further to the south of the Project.

Figure 7.15 Location of Protected Areas Relative to Project Location



Internationally Recognised Areas

Internationally recognised protected areas include Ramsar sites, Important Bird Areas (IBA) and Key Biodiversity Areas (KBAs) as Internationally Recognised Areas.

There are no Ramsar sites in north-western Liberia.

The IUCN documents the occurrence of KBAs around the world, which incorporate important bird areas. Two KBAs occur in the vicinity of the project, as illustrated in *Figure 7.15*. The Kaiha 2 hydropower plant is located adjacent to the Lofa-Gola-Mano IBA, which qualifies as a KBA.

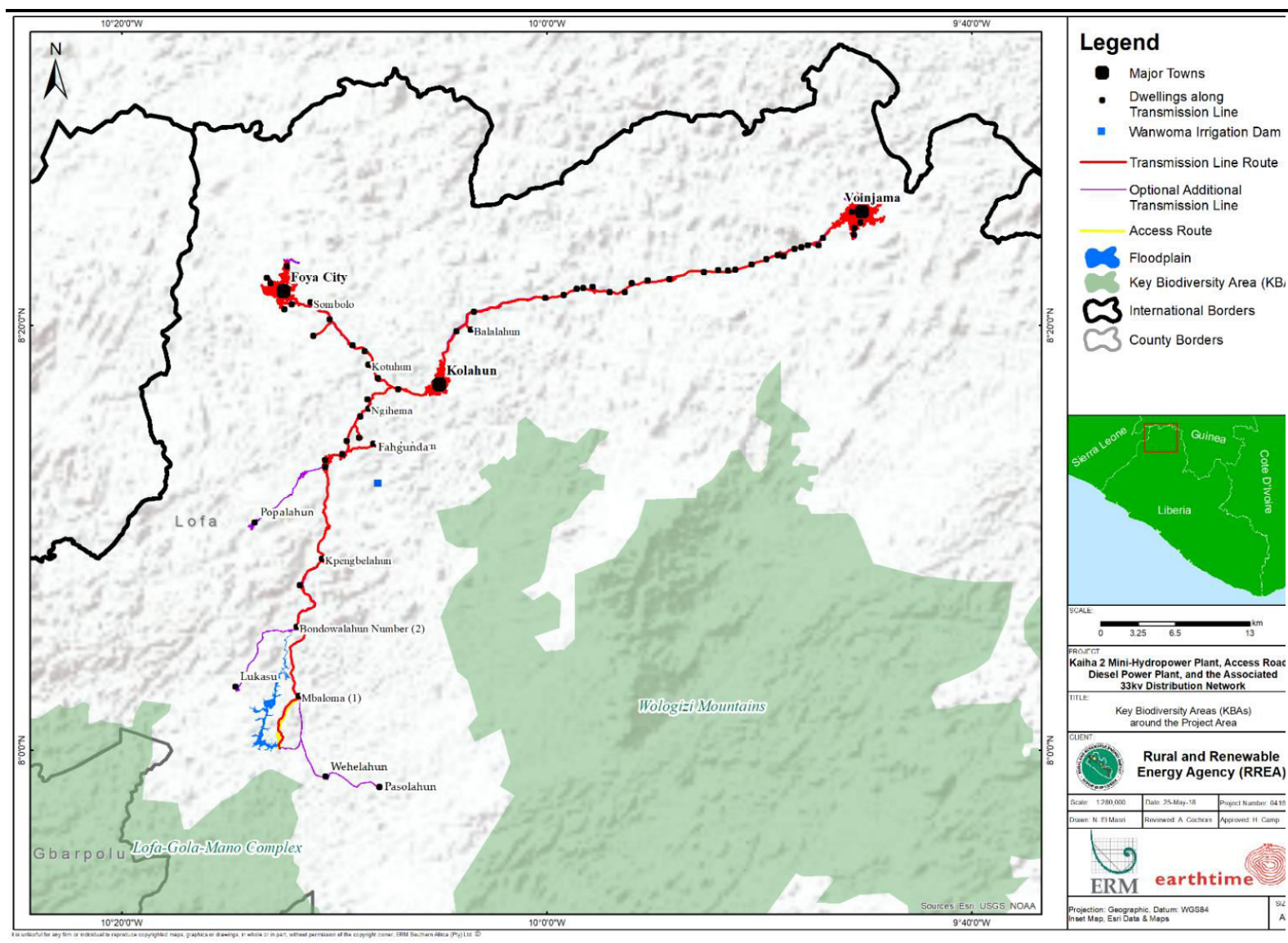
Lofa-Gola-Mano IBA

This IBA and proposed park includes part of Gola National Forest, situated between the Lofa and Mano Rivers that drain the park. The international frontier with Sierra Leone forms the western boundary of the site, where it is contiguous with the Gola Forest Reserve IBA in Sierra Leone.

The IBA and proposed park covers a large area of rainforest, evergreen in the south, becoming progressively more semi-deciduous to the north. The IBA and proposed park also includes large patches of low bush, marshes and some savannah on lateritic soil. The region consists of a series of ridges of rounded hillocks with, in places, steep, bare, rocky slopes and river valleys. The rivers are characterized by spectacular rapids and waterfalls and are usually unfordable. The human population within the IBA is very low and the vegetation remains largely unmodified. One hundred bird species trigger the IBA classification, while important mammal populations include forest elephant *Loxodonta africana* (EN), pygmy hippopotamus *Choeropsis liberiensis* (EN), western chimpanzee *Pan troglodytes* (EN) and diana monkey *Cercopithecus diana* (VU).

The hydropower plant is located adjacent to the IBA and proposed park, with the river downstream of the hydropower site forming the eastern boundary of the proposed IBA for approximately 22 km before running through the IBA.

Figure 7.16 *Location of Key Biodiversity Areas relative to the Project Location*



7.4.2

Vegetation

Liberia belongs to the Upper Guinea Forest (White 1983), which according to historic sources was originally covered by tall, closed-canopy forest. Over the past century or so, the original continuous forest cover has been fragmented into a mosaic of forest, bush fallows, cleared land and human settlements. Currently, the larger forest tracts are now isolated from each other into 'islands,' mainly concentrated in the north-northwest and central- southwest of the country.

Reduction in the forest cover has been accelerated by land development, road construction, timber exploitation and the introduction of rubber plantation within the forest zone, thus opening the country to agriculture and mining activities. Though large in some cases, the forests have become isolated from each other and there is a gradual edging of savannah into areas, including the sandy coastal belt, and some inland zones. However, Liberia still contains some of the largest portions of the Upper Guinea Forest cover in West Africa and remains the most important reservoir for all forest plant species that occur in the Upper Guinea Forest zone (Gatter 1997).

Vegetation Types

The classification of vegetation in the area to be affected by the project is presented in *Table 7.5*. Most of the closed-canopy forest occurs as gallery forest along the rivers including at the proposed hydropower plant site. The rest of the forest is patchily distributed and occurs in close association with communities, which in some cases use the forest for exploitation, traditional practices, and sacred groves.

These community forests are also characterised by extensive agroforestry practices, which involves the cultivation of cacao and/or coffee plantation in forest areas, and in some cases, monocultures of cacao, coffee and oil palm. The secondary forests bush fallows are inundated by stands of oil palm *Elaeis guineensis*. Some monoculture/ plantations of oil palm, cocoa and coffee occur in places across areas to be affected by the transmission line. The following paragraphs summarises the vegetation characteristic of the main project sites.

Table 7.5 *Land cover in the Project Area (within 1km of Hydropower Plant, Reservoir, Transmission Line and Diesel Power Plant)*

Land Cover Unit	Area (ha)	Percentage
Natural Habitats		
Closed Forest	14 206	41.2%
Open/Secondary Forest	7 766	22.5%
Grassland	3 405	9.9%
Water (Rivers)	78	0.2%
Modified Habitats		
Bare Land	6 493	18.8%

Land Cover Unit	Area (ha)	Percentage
Built-up (settlements)	1 235	3.6%
Undetermined		
Cloud Cover and Unclassified	1 291	3.7%
Total Area	34 474	100%

Hydropower Plant and Dam Site

The hydropower plant site comprises mainly close canopy gallery forest (Figure 7.17) with high tree density, tree heights ranging between 40 and 50 meters and a significant proportion of trees with diameter at breast height (dbh) of over 100 cm. The forest canopy is healthy.

No form of recent agricultural activities was observed, but there are signs of old timber and wood extraction.

The common tree species are *Albizia zygia* West African walnut, *Albizia adianthifolia* Flat crown, *Cathormion altissimum*, *Cathomium rhombifolium*, *Pterocarpus santalinoides*, *Pentaclethra macrophylla* African oil bean, *Pycnanthus angolensis* African/False nutmeg, *Uapaca heudelotii* and *Amphimas pterocarpoides*.

Figure 7.17 *Example of Closed Canopy Gallery Forest at Hydropower Plant Site*



Access Road

Vegetation along the access road is predominantly secondary forest, with the forest structure becoming more mature as one move towards the dam site. The area is interrupted by farm bush and a few farmlands. There are a couple of locations with inland valley swamps, which were not under cultivation at the time of the survey.

The main tree species include *Pentdesma butyracea* Buttertreet, *Albizia zygia*, *Albizia adiantifolia* Flat Crown, *Samanea dinklagei*, *Funtumia africana*, *Eremospatha macrocapa* Silk-rubber, *Musanga cecropioides* African corkwood, Umbrella tree *Myrianthus serratus*, *Myrianthus libericus*, *Myrianthus arborea* Giant Mulberry, Bush Pineapple or Corkwood, *Phyllanthus discoideus* and *Smeathmannia pubescens*.

Downstream (Madina Town area)

In this site, the gallery forest is mature with some trees over 50 meters high and dbh over 1 m (Figure 7.18). Much of the upland vegetation was young secondary forest, farmbrush, farmlands and open land. Many of threatened species occurred here (see below).

Presumably, the large extent of gallery forest and secondary forest is as a result of the low population density and remoteness of the area. Tree species typical of the area are *Cryptosepallum tetraphyllum*, *Chrysophyllum perpulchrum*, *Cathormion altissimum*, *Cathormion rhombifolius*, *Pterocarpus santalinoides*, *Amanoa bracteosa*, *Amphimas pterocarpoides*, *Carapa procera*, *Xylopia aethiopica*, *Calpocalyx aubrevillei* and *Nauclea diderrichii*.

Figure 7.18 *Example of Gallery Forest with Large Mature Trees Downstream of the Hydropower Plant Site*



Upstream (Wanwoma Irrigation Dam)

The vegetation in the areas upstreams appears to have undergone extreme levels of degradation or regeneration over the years. Whilst some areas, especially along the main road, have been cleared and are being used for commercial agriculture, the surrounding forest is secondary but less

disturbed. Some portions of the gallery forest at the Wanwoma irrigation dam site (Figure 7.18) have been degraded because of the presence of people engaged in the rehabilitation of the dam, which is expected to supply water to the agricultural project being developed (see Section 7.3.5).

Common tree species include *Nauclea diderrichii*, *Cathormion altissimum*, *Cathormion rhombifolius*, *Sterculia oblonga*, *Funtumia africana*, *Pentaclethra macrophylla* and *Pycnanthus angolensis*.

Transmission Line (from hydropower plant site to Kolahun) (Section 1)

The areas to be directly affected by the transmission line comprises a mosaic of vegetation types derived mainly from closed forest, including mature and young secondary patches, coffee and cacao plantations, farmbush and farmland.

A number of community sacred forest were encountered; it is worth mentioning that the ecology specialist was prevented from going near to the one at Facunda village (also called Fahgunda, see Figure 2.2) because of the female cultural activity that was taking place in the forest.

Tree species that characterise the vegetation include *Antiaris africana*, *Sterculia tragacantha*, *Terminalia glaucescens*, *Coffea sp.*, *Theobroma cacao*, *Pseudospondias microcarpa*, *Trichilia ornithothesa* and *Ceiba pentandra*.

Transmission Line (from Kolahun to Foya) (Section 2)

This area appears to show serious forest degradation with a few remnants of forest vegetation in places. Much of the remnant forest vegetation is characterised by a mixed forest and coffee/cacao plantations. At some locations, the vegetation has been transformed into one dominated by grass species (particularly *Panicum maximum* and *Andropogon sp.*) and invasive shrub (*Chromolaena odorata*).

The limited forest cover is dominated by species such as *Cassia seiberiana*, *Ceiba pentandra*, *Theobroma cacao*, *Coffea sp.*, *Terminalia ivorensis*, *Antiaris africana* and *Anthocleista nobilis*.

Transmission Line (from Kolahun to Voinjama including the diesel power plant site) (Section 3)

The vegetation of this area is comparatively the most degraded portion of the area to be traversed by the transmission line. It is characterised by a mosaic of different plant communities and topographic features. There are small patches of forest, but the landscape is dominated by extensive farmbush, cultivations, oil palm plantations in places, old/disused rubber plantations and large expanses of rocky pans covered in thin grass.

Some of the young farmbrush are dominated by the invasive shrub *Chromolaena odorata* and the grass *Panicum maximum*. The main tree species are *Microdesmis puberula*, *Maniophyton fulvum*, *Mareya micantha*, *Macaranga barteri*, *Tetrorchidium didymostemon*, *Smeathmannia pubescens*, *Phyllanthus discoideus* and *Piptadeniastrum africanum*.

Plant Diversity and Status

One hundred and ninety-three (193) species of vascular plants species belonging to 54 plant families were recorded during the survey, across the various ecosystems encountered. These include 19 species of global conservation concern (IUCN 2015) as given in Table 7.6. Seventeen (17) species are vulnerable (VU) and two (2) are near threatened (NT).

The forests in the downstream area (Madina) accounts for the highest number of species listed in IUCN as vulnerable and near threatened, followed by the dam site and access road respectively. However, all of the threatened species are widely distributed in the forest habitats where they occur.

Table 7.6 *Distribution of Vulnerable (VU) and Near Threatened (NT) Plant Species*

Botanical name	IUCN Status	Dam site	Access Road	Down-stream	Up-stream	TL Section 1	TL Section 2	TL Section 3
<i>Afzelia africana</i>	VU	x		x				
<i>Cryptosepalum tetraphyllum</i>	VU	x	x	x		x		
<i>Gilbertiodendron limba</i>	NT	x		x				
<i>Terminalia ivorensis</i>	VU		x					
<i>Amanoa bracteosa</i>	VU	x						
<i>Garcinia afzelii</i>	VU	x	x	x	x			
<i>Irvingia gabonensis</i>	NT	x	x	x				
<i>Trichilia ornithocheira</i>	VU	x	x	x		x		
<i>Turraenthus africanum</i>	VU	x	x	x				
<i>Entandrophragma candollei</i>	VU		x	x				
<i>Albizia ferruginea</i>	VU			x				
<i>Milicia regia</i>	VU	x	x	x	x			
<i>Lophira alata</i>	VU	x	x	x				
<i>Hallea stipulosa</i>	VU		x		x	x	x	x
<i>Nauclea diderrichii</i>	VU	x		x	x			
<i>Zanthoxylum atchoum</i>	VU	x	x	x	x			
<i>Placodiscus oblongifolius</i>	VU	x	x	x	x		x	
<i>Heritiera utilis</i>	VU	x		x	x			
<i>Sterculia oblonga</i>	VU	x		x	x			

Key: DD=Data Deficient, LC=Least Concern, VU=Vulnerable, EN=Endangered, CR=Critically Endangered TL=Transmission Line.

7.4.3

Terrestrial Fauna*Mammals*

Liberia is home to 150 species of mammals, including nine endangered (EN), 12 vulnerable (VU) and nine near threatened (NT), according to IUCN (2015). The distribution of mammalian species, especially primates and large mammals is strongly correlated with the distribution of forest ecosystems. Areas that have relatively pristine forest cover support higher numbers of mammal species and accounts for greater proportions of threatened and rare species.

A total of 38 species of mammals were recorded through interviews, signs and visual evidences. These include nine primate species among which three are endangered (red colobus monkey *Procolobus badius*, western chimpanzee *Pan troglodytes verus* and diana monkey *Cercopithecus diana*) and two are vulnerable (pied colobus monkey *Colobus polykomus* and sooty mangabey *Cercocebus atys*). Four other large mammals occur, notably the endangered pygmy hippopotamus *Choeropsis liberiensis* and the vulnerable leopard *Panthera pardus*. There were also ten species of antelopes, one of which is vulnerable (zebra duiker *Cephalophus zebra*), two are near threatened and one is data deficient. In addition, small mammals of interest were identified; of particular interest are the giant, long-tailed and tree pangolins, all of which are considered threatened by the IUCN (2015).

Table 7.7 gives a full list of the mammals recorded in the area, their IUCN conservation status and their local relative abundance status. With the exception of spot-nosed monkey *Cercopithecus petaurista*, royal antelope *Neotragus pygmaeus*, tree pangolin *Phataginus tricuspidis* and the squirrel species, all other species were recorded through interviews with local hunters (ie, not directly observed). The faecal matter of maxwell duiker *Cephalophus maxwelli*, bushbuck *Tragelaphus scriptus* and a number of small mammals were encountered during the course of the survey, particularly in areas encompassing the proposed access road and dam site.

Table 7.7 *Mammal Species in the Project Area*

Common Name	Scientific Name	IUCN Status	Dam / Road	D/S	U/S	TL 1	TL 2	TL 3
Primates								
Western Chimpanzee	<i>Pan troglodytes verus</i>	EN	NC			Rare		NC
Red Colobus Monkey	<i>Piliocolobus badius</i>	EN	NC		Rare	Rare		
Diana Monkey	<i>Cercopithecus diana</i>	VU	NC			Rare		
Pied Colobus Monkey	<i>Colobus polykomus</i>	VU	C	NC		C	C	C
Sooty Mangabey	<i>Cercocebus atys</i>	NT	C	C	NC	NC	NC	NC
Olive Colobus	<i>Poliocolobus versu</i>	LC	Rare	NC		Rare		
Mona Monkey	<i>Cercopithecus mona</i>	LC	C	NC	NC	NC		

Common Name	Scientific Name	IUC N Stat us	Dam / Roa d	D/S	U/S	TL 1	TL 2	TL 3
Spot-nosed Monkey (S)	<i>Cercopithecus petaurista</i>	LC	C	C	C	C	C	NC
Senegal Galago	<i>Galago senegalensis</i>	LC	C	C	NC	C	Rare	NC
Carnivores								
Leopard	<i>Panthera pardus</i>	VU	Rare	Rare	Rare			
Long-snorted Mongoose	<i>Herpestes naso</i>	LC	C	NC	NC	C	Rare	
Slender Mongoose	<i>Herpestes sanguinea</i>	LC	Rare	Rare	Rare	Rare	Rare	
Common Cusimanse	<i>Crossarchus obscurus</i>	LC	C	C	C	C	R	
Common Genet	<i>Genetta</i>	LC	C	C	NC	C	NC	
Blotched Genet	<i>Genetta tigrina</i>	LC	C	NC	NC	C	NC	
Pangolins								
Long-tailed Pangolin	<i>Uromanis tetradactyla</i>	LC	NC	NC	NC	Rare		
Tree Pangolin (S)	<i>Phataginus tricuspid</i>	NT	Rare	C	C	Rare	NC	NC
Giant Pangolin	<i>Smutsia gigantea</i>	NT	Rare	Rare	Rare	Rare		
Hogs and Hippos								
Pygmy Hippopotamus	<i>Choeropsis liberiensis</i>	EN	NC	NC	Rare	Rare		
Bush Pig	<i>Potamochoerus larvatus</i>	LC	C	C	C	C	NC	NC
Red River Hog	<i>Potamochoerus porcus</i>	LC	Rare	NC	NC	Rare	NC	
Antelope								
Water Chevrotain	<i>Hyemoschus aquaticus</i>	LC	NC	NC	Rare	Rare	NC	
Bushbuck (F)	<i>Tragelaphus scriptus</i>	LC	C	C	C	C	C	NC
Bongo	<i>Tragelaphus euryceros</i>	NT	Rare	Rare	NC	Rare	NC	
Maxwell's Duiker (F)	<i>Cephalophus maxwelli</i>	LC	C	C	C	C	C	NC
Bush Duiker	<i>Sylvicapra grimmia</i>	LC	C	NC	NC	C		
Red-flanked Duiker	<i>Cephalophus rufilatus</i>	LC	C	C	NC	Rare		
Zebra Duiker	<i>Cephalophus zebra</i>	VU	Rare			Rare		
Black Duiker	<i>Cephalophus niger</i>	LC	NC	NC	NC	NC	NC	
Yellow-backed Duiker	<i>Cephalophus silvicultor</i>	LC	NC			Rare		
Bay Duiker	<i>Cephalophus dorsalis</i>	NT	C	NC	NC	C	NC	
Royal Antelope (S)	<i>Neotragus pygmaeus</i>	LC	NC	C	NC	NC		
Rodents								
Marsh Cane-rat (F)	<i>Thryonomys swinderianus</i>	LC	Rare	C	C	C	NC	C
Barbary Ground Squirrel (S)	<i>Atlantoxerus getulus</i>	LC	C	C	C	C	C	C
Fire-footed Rope Squirrel (S)	<i>Funisciurus pyrropus</i>	LC	C	C	C	C	C	C
Gambian Sun Squirrel (S)	<i>Heliosciurus gambianus</i>	LC	C	C	C	C	C	C
Crested Porcupine	<i>Hystrix cristata</i>	LC	NC	NC	NC	NC	Rare	
Brush-tail. Porcupine (F)	<i>Atherurus africanus</i>	LC	C	C	C	C	NC	NC

Key: LC – Least concern; EN – Endangered; VU – Vulnerable; NT – Near threatened;
 NC – Not common; C – Common; Empty cells – Not occurring in the area;
 (S) – Mammals sighted during the survey; (F) – Presence confirmed from faecal matter; Other species confirmed through interviews with local hunters.

For most of the mammal species identified as present, there was a general decline in their occurrence with increasing distance from the dam site, along the route to be traversed by the transmission line. In fact, all mammalian

species recorded from interviews with local hunters were reported to occur in and around the areas closest to the hydropower plant and dam site, which by observation had more forest cover. This is consistent with the general concept that greater forest cover provides better habitat for wildlife in tropical ecosystems, because of abundant and diverse habitats therein.

In some locations (with special reference to the access road, dam site and Madina forest downstream of the site), some of the mammals considered threatened by IUCN (eg, black-and-white colobus monkey, red colobus monkey and pygmy hippopotamus) are said to be common by local hunters in these remote communities. For instance, based on information from respondents in Mbaloma and Madina, the pygmy hippo (which is generally very difficult to see) is fairly regularly encountered within their respective riverine forests.

Data from the interviews with hunters in areas closest to the large human settlements show a notable absence of most of the species of global conservation interest (*Table 7.7*), where invariably the forest covers are thin and patchy. These areas, particularly settlements along the transmission line and diesel power plant site, such as the Foya, Kolahun and Voinjama axis, are characterised by intensive and extensive agricultural activities, open bush fallows, rocky outcrops and housing development, and so only small and degradation-tolerant mammals could survive in such degraded habitats.

However, respondents indicated that there are occasional encounters of some of the relatively common primates (eg, spot-nosed monkey and sooty mangabey) and duikers (eg, maxwell duiker and bush buck) in the forest patches that occur around these large human settlements.

Birds

Most of the avifauna that occurs in the area of the Project are forest-dependent and so their presence and abundance follows the distribution of forests. Although site-based avifauna studies are rare in Liberia, studies done by Gatter (1997), Robertson (2001) and Demey (2007) have shown that Liberia is a stronghold for many endemic, rare and threatened birds in the Upper Guinea Forest and the Guinea-Congo Forest biome. The Upper Guinea Forest is considered an Endemic Bird Area, with the highest priority ranking for conservation based on the combination of its biodiversity importance and threat status (Stratton *et al.* 1998).

Liberia supports 695 species of birds, including Liberian greenbul *Phyllastrephus leucolepis*, which is endemic only to the country. There are 21 species of global conservation concern according to IUCN (2015) and Birdlife International (2015), 18 species of which are entirely forest dependent; these include two endangered, seven vulnerable, six near threatened and three data deficient species. A significantly large proportion of the species are resident, with 184 restricted to the Guinea-Congo biome and 15 (100%) of the species

endemic to the Upper Guinea Forest block. The few known savanna species are thought to be seasonal breeding visitors, but so far no Sudan-Guinea biome dependent species has been recorded.

A total of 176 species of birds belonging to 42 avian families was recorded over six days of surveys (see Annex 9). These include six species with IUCN conservation status: hooded vulture *Necrosyrtes monochas* (EN), yellow-casqued hornbill *Ceratogymna elata* (VU), green-tailed bristlebill *Bleda eximius* (VU), brown-cheeked hornbill *Bycanistes cylindricus* (NT), yellow-footed honeyguide *Campaphega lobata* (NT) and black-headed rufous warbler *Bathmocercus cerviniventris* (NT).

Table 7.8 shows the distribution of birds of global conservation interest in the various sites surveyed.

The access road, downstream (Madina area) and transmission line (Section 1) are most important locations in terms of the number of threatened species they support. Among the species of conservation interest, the black-headed rufous warbler was the most widespread encountered, followed by yellow-casqued hornbill. Although brown-cheeked hornbill was recorded in only two locations, they accounted for the largest number of individuals recorded among IUCN Red List of Threatened Species; about 10 individuals were seen in one location along the transmission line (Section 1).

Table 7.8 *Threatened and Near Threatened Bird Species Recorded in the Project Area*

Threatened Species	IUCN Status	Dam Site	Access Road	Downstream	Upstream	TL Section 1	TL Section 2	TL Section 3
Hooded Vulture	EN			x		x		
Yellow-casqued Hornbill	VU		xx			x	x	
Green-tailed Bristlebill	VU		x					
Brown-cheeked Hornbill	NT			x		x	x	
Yellow-footed Honeyguide	NT	x						
Black-headed Rufous Warbler	NT		x	x	x	xx		x
Total	6	2	3	3	1	4	2	1

Note: DD=Data Deficient, LC=Least Concern, VU=Vulnerable, EN=Endangered, CR=Critically Endangered

The project area occurs at a considerable distance from the biogeographic location of the North Lorma and the Gola National Forests, yet its avifauna is probably influenced by the diversity that occurs in these forests. However, these two national forests mentioned empirically have greater forest cover than areas covered in the survey for the ESIA (Gatter 1997) and so have greater avifauna diversity (Demey 2007). Such large forest areas do serve as reservoirs for forest species that may suffer from the degradation

accompanying the proposed project. This is particularly true for species of conservation interest, which by comparison are more abundant in North Lorma and the Gola National Forests than the area to be affected by the proposed project.

The following are notes on important birds observed in the Project area

- Hooded Vulture, *Necrosyrtes monochas*: Two birds were seen during the survey. One was seen flying over a farm in the Madina area (downstream). A second one was recorded whilst perching on a big tree in the gallery forest overhanging a bridge along transmission line (Section 1). A local hunter at Madina purported that the bird numbers have dropped over the previous couple of decades, but even at present their numbers in that location fluctuates with the seasons.
- Yellow-casqued hornbill, *Ceratogymna elata*: Four pairs of birds were encountered in three locations during the surveys: two pairs were recorded at two locations above a forest along the access road, whilst the rest were encountered in two other forest locations along the transmission line.
- Green-tailed bristlebill, *Bleda eximius*: This bird, listed as Vulnerable by the IUCN (2015), is generally cryptic and very difficult to see. Only one individual was heard in a forest along the proposed access road. The call of the bird was recorded and cross-checked with published recording (African Bird Sounds).
- Brown-cheeked hornbill, *Bycanistes cylindricus*: This species is listed as near threatened by the IUCN (2015). It was the most abundant bird encountered among species of conservation interest listed by IUCN that occur across the project area. About 10 birds were seen perching on the branches of a large tree at a location along transmission line – section 1 and another 4 birds were seen in the canopy of a forest patch along transmission line – section 2.
- Yellow-footed honey guide, *Campaphega lobata*: This is a species that is listed as near threatened by IUCN (2015). A single bird was seen within 100 meters upstream of the proposed dam site.
- Black-headed Rufous Warbler, *Bathmocercus cerviniventris*: This species was the most widespread of all the species of conservation interest; it is listed as Near Threatened by IUCN (2015). The species was recorded in all but two sites visited (see Table 7.8). A single bird was seen in one of the locations along the access road, while the remaining recordings of the species came from the calls of the bird. The bird is usually difficult to see but its vocal ability makes it easy to identify.

Reptiles and Amphibians

In Liberia, despite the substantial efforts of some pioneering fieldworkers, current understanding of the number of reptile and amphibian species, and their distributions is limited. Current understanding is based on results from a number of disparate sources including Taylor et al. (1958), stating that there are 58 amphibian and 77 reptilian species known to occur in Liberia, Hoke et al. (2007) in a rapid survey of amphibians and reptiles of three National Parks including Lorma, Gola and Grebo, recorded 40 amphibian and 17 reptile species and Hiller et al. (2007) in a rapid survey of three national parks of Liberia recorded 40 amphibian species. There is no single comprehensive and updated list of reptiles and amphibians of Liberia.

During the survey for the ESIA, a total of 37 amphibians species including seven species that are of IUCN conservation concern were recorded. The seven species are all Near Threatened and include *Hyperolius chlorosteus* Sierra Leone reed frog (NT), *Hyperolius zonatus* Nimba reed frog (NT), *Kassina cochranæ* Cochran's running frog (NT), *Leptopelis macrotis* big-eyed forest tree frog (NT), *Phrynobatrachus alleni* Allen's river frog (NT), *Phrynobatrachus liberiensis* Liberia river frog (NT) and *Phrynobatrachus phyllophilus* puddle frog sp. (LC). Three of the seven IUCN conservation concerned species (*Phrynobatrachus alleni* Allen's river frog (NT), *Phrynobatrachus liberiensis* Liberia river frog (NT) and *Phrynobatrachus phyllophilus* (LC)) were recorded around the dam site whereas six, with the exception of *Leptopelis macrotis* big-eyed forest tree frog (NT), were recorded in the upstream area and one (*Phrynobatrachus alleni* Allen's river frog (NT)) was recorded in the downstream area.

Of the seven species of conservation concern recorded, none are known to be dependent upon fast flowing water or waterfalls for survival. *H. chlorosteus* Sierra Leone reed frog (NT) is arboreal and in normal situations occurs in primary rainforest, mostly by streams. However, it breeds exclusively in flowing water, laying its eggs on leaves above water into which the larvae fall and develop (Rödel et al. 2004).

The *H. zonatus* Nimba reed frog (NT) lives in primary forests (though due to habitat alteration, they can be found in unusual places), close to small temporary ponds and swamps. Its eggs are laid on vegetation above small stagnant pools.

Kassina cochranæ Cochran's running frog (NT) is an arboreal, forest dwelling species that can also exist in secondary forests. It has also been recorded in secondary forest, moist and montane savannah area as well as montane grassland. It seems to survive in fragmented habitats but is unlikely to tolerate completely open habitats.

According to Rödel et al. (2004), it presumably breeds in both temporary and permanent waterbodies, favouring large well-vegetated pools.

Leptopelis macrotis big-eyed forest tree frog (NT) depends on areas of undisturbed forest which are becoming gradually uncommon in Liberia. It is arboreal and lives along streams in rainforests. Its breeding biology is unknown but tadpoles are aquatic. It relies on good rainforest and does not occur in disturbed forest (M.O. Rödel, pers. comm. June 2012).

The *Phrynobatrachus alleni* Allen's river frog (NT), *Phrynobatrachus liberiensis* Liberia river frog (NT) and *Phrynobatrachus phyllophilus* puddle frog sp. (LC) depend on areas of undisturbed forest. Though the *P. alleni* and *P. phyllophilus* are widely distributed but their habitats are declining thus making them close to qualifying for vulnerable. The *P. liberiensis* is confined to the upper Guinea forest zone of West Africa (Sierra Leone, southern Guinea, Liberia, Cote d'Ivoire and south-west Ghana). It is usually associated with swampy areas, breeding in small forest streams (Rödel et al. 2004). The *P. alleni* can survive in small forest fragments but at lower population density. It breeds in very small temporary puddles (Rödel et al. 2004), whereas *P. phyllophilus* lives in swampy parts of primary forest, and doesn't survive in secondary habitat. It deposits its eggs terrestrially close to water and the larvae develop in extremely small puddles (Rödel et al. 2004).

Among the amphibian species associated with fast flowing water are *Odontobatrachus natator* (formerly known as *Petropedetes natator*) Sierra Leone water frog and *Conraua alleni* Allen's slippery frog. Both are known to occur in Liberia but the present survey did not record them. Hoke et al. (2007) recorded the *C. alleni* in the Grebo and Gola National Park during a rapid assessment program that covered Loma, Gola and Grebo National Forests.

Hillers and Rödel et al. (2007) also recorded *C. alleni* and *O. natator* in a survey of three national forests including North Lorma, Gola and Grebo in Liberia. The species are found in forested hilly areas and lives in or near fast flowing streams.

O. natator breeds in fast flowing streams with its eggs laid on land and the larvae attached themselves by means of suckers to rocks in waterfalls and rapids (Rödel 2004), while the *C. alleni* breeds in streams and the tadpoles are usually found in slow-flowing or nearly stagnant sections of streams (Rödel et al. 2004).

Table 7.9 shows the list of species recorded within the surveyed areas.

Table 7.9 Amphibian Species in the Project Area

	Common Name	Scientific Name	IUCN Status	Up-stream	Dam Site	Down-stream
1	Banded Banana Frog	<i>Afrivalus fulvovittatus</i>	LC	•		
2	Savanna Banana Frog	<i>Afrivalus vittiger</i>	LC	•		

	Common Name	Scientific Name	IUCN Status	Up-stream	Dam Site	Down-stream
3	Striped Spiny Reed Frog	<i>Afraxalus dorsalis</i>	LC	•		
4	Flat-backed Toad	<i>Amietophrynus maculatus</i>	LC	•	•	•
5	African Common Toad	<i>Amietophrynus regularis</i>	LC	•	•	
6	Western Night Frog	<i>Astylosternus occidentalis</i>	LC		•	
7		<i>Arthroleptis sp</i>		•	•	
8	Silver Long-fingered Frog	<i>Cardioglossa leucomystax</i>	LC		•	
9	African Foam-nest Tree Frog	<i>Chiromantis rufescens</i>	LC		•	
10	African Grove-crowned Frog	<i>Hoplobatrachus occipitalis</i>	LC	•	•	•
11	Variable Reed Frog	<i>Hyperolius concolor</i>	LC	•		
12	Sierra Leone Reed Frog	<i>Hyperolius chlorosteus</i>	NT	•		
13	Lime Reed Frog	<i>Hyperolius fusciventris</i>	LC	•	•	
14	[Reed Frog]	<i>Hyperolius picturatus</i>	LC	•		
16	Plain Reed Frog	<i>Hyperolius nitidulus</i>	LC	•		
17	Nimba Reed Frog	<i>Hyperolius zonatus</i>	NT	•		
18	Cochran's Running Frog	<i>Kassina cochranae</i>	NT	•		
19	Big-eyed Forest Tree Frog	<i>Leptopelis macrotis</i>	NT	•		
20	Forest Tree Frog	<i>Leptopelis spiritusnoctis</i>	LC	•	•	•
21	Brown-backed Tree Frog	<i>Leptopelis viridis</i>	LC	•	•	•
22		<i>Phlychmantis boulengeri</i>	LC	•		
23	Allen's River Frog	<i>Phrynobatrachus alleni</i>	NT	•	•	•
24	[Puddle Frog]	<i>Phrynobatrachus francisci</i>	LC	•		
25	[Puddle Frog]	<i>Phrynobatrachus fraterculus</i>	LC	•		
26	Ahl's River Frog	<i>Phrynobatrachus latifrons</i>	LC	•	•	•
28	Liberia River Frog	<i>Phrynobatrachus liberiensis</i>	NT		•	
29	Natal Dwarf Puddle Frog	<i>Phrynobatrachus natalensis</i>	LC	•	•	
32	[Puddle Frog]	<i>Phrynobatrachus phyllophilus</i>	NT	•	•	
33	[Puddle Frog]	<i>Phrynobatrachus tokba</i>	LC	•	•	•
34	Broad-banded Grass Frog	<i>Ptychadena bibroni</i>	LC	•	•	•
35	Mascarene Grass Frog	<i>Ptychadena mascareniensis</i>	LC	•	•	•
36	Medine Grass Frog	<i>Ptychadena pumilio</i>	LC	•	•	•
37	Sharp-nosed Grass Frog	<i>Ptychadena oxyrhynchus</i>	LC	•	•	•

Key: DD=Data Deficient, LC=Least Concern, VU=Vulnerable, EN=Endangered, CR=Critically Endangered

A total of 17 reptile species were recorded during the six days survey (Table 7.10) while the one-on-one interviews with locals resulted in documenting 16 additional species.

Among the 17 species recorded in the survey, one tortoise species (*Kinixys homeana* Home's hinge-back tortoise) is vulnerable according to IUCN (2015). This is due to habitat loss and hunting for various reasons including subsistence, traditional medicine and pet trade. It is likely that these threats

will continue over the coming years due to human population growth, deforestation and industrial development in its range of occurrence.

K. homeana Home's hinge-back tortoise is a forest tortoise occurring within the range of the Guinea-Congo rainforest region, though its habitat use varies depending on the type of treatment by the indigenous people. The treatments largely include hunting and veneration. If it finds itself in veneration areas, the tortoises will be frequently found in habitats including dense dry bush, sparse dry bush, riparian vegetation, swamps, and plantations; whereas if in the hunting areas, the tortoises will be found almost exclusively inside dense bush, and always avoid plantations. It seems likely that the different habitat usage reflects extirpation from easier hunting areas (Luiselli et al. 2006).

According to Luiselli et al. (2006), this species is found throughout Liberia, though there are no recent surveys on the distribution of the species. However, during the current survey, *K. homeana* Home's hinge-back tortoise and also *K. erosa* serrated hinge-back tortoise were recorded from two communities including Madina and Mbaloma. Both communities are within 5 km distance from the proposed Kaiha 2 dam. Four *K. homeana* were found in Mbaloma (2) and Madina (2), and one *K. erosa* from Mbaloma. The four *K. homeana* included two males and two females while the one *H. erosa* was a juvenile. Though the *H. erosa* is Data Deficient (IUCN, 2015), it is included in CITES Appendix II.

Additional data on reptiles were also collected through interviews with local key informants (Table 7.11). Though the interview results are useful, the survey team did not confirm the occurrence of the species, as no sign of the species were noted. Of the 16 reptile species confirmed by locals three, including slender-snouted crocodile (CR), dwarf crocodile (VU) and Gray's monitor (VU), are Threatened (Table 7.10).

Slender-snouted crocodile *M. cataphractus* (CR) occurs through West Africa though recent publications state that the distribution has changed due to local extirpations. *M. cataphractus* prefers forested rivers and other densely vegetated water bodies (e.g. reservoirs and freshwater lagoons) but they can also occur in sparsely vegetated gallery habitats (Shirley 2014). The females lay eggs in mound nests composed of organic matter at the edge of aquatic habitats. The nests are constructed at the base of trees at the edge of undisturbed forested wetland habitats.

The nesting season of *M. cataphractus* overlaps with that of dwarf crocodile *Osteolaemus tetraspis* (VU). *M. cataphractus* eggs are larger when compared to the female's size and the hatchlings are also larger than those of other crocodile species. The young crocodiles feed primarily on small fish and a variety of invertebrates (Shirley 2014). Notably, Nile crocodile *Crocodylus niloticus* (now known as *Crocodylus suchus*), which was not reported in this study, is larger than the two other species known to occur in the region.

Though common and considered as least concerned species by IUCN (2015), it is classified under CITES Appendix I.

Table 7.10 Reptile Species in the Project Area

Common Name	Scientific name	IUCN Status	Up-stream	Dam Site	Down-stream
Tortoises and Turtles					
Serrated Hinge-back Tortoise	<i>Kinixys erosa</i>	DD	•	•	•
Home's Hinge-back Tortoise	<i>Kinixys homeana</i>	VU		•	
West African black turtle	<i>Pelusios niger</i>	NA	•	•	
Lizards and Geckos					
Common Agama	<i>Agama africana</i>	LC	•	•	•
Common Agama	<i>Agama agama</i>	LC	•	•	•
Boulenger's Agama	<i>Agama boulengeri</i>	LC	•		
Fire skink	<i>Lepidothyris fernandi</i>	NA		•	
Senegal Mabuya Skink	<i>Trachylepis affinis</i>	NA	•	•	•
[Skink]	<i>Trachylepis paucisquamis</i>	LC			•
[Skink sp.]	<i>Cophoscincopus simulans</i>	LC	•	•	
Guinea Leaf-toed Gecko	<i>Hemidactylus cf. muriceus</i>	NA	•		
Tropical House Gecko	<i>Hemidactylus mabouia</i>	NA	•		
Large Snakes					
Forest Cobra	<i>Naja melanoleuca</i>	NA	•	•	•
Black-neck. spitting cobra	<i>Naja nigricolis</i>	NA	•	•	•
Mole Viper	<i>Atractaspis aterrima</i>	NA	•		
Lesser Snakes					
Keeled Water Skink	<i>Cophoscincopus durus</i>	LC	•	•	•
[Tree snake]	<i>Dipsadoboa sp.</i>	-	•		

Key: DD=Data Deficient, LC=Least Concern, VU=Vulnerable, EN=Endangered, CR=Critically Endangered

Table 7.11 Reptile Species Identified through Interviews

Common Name	Scientific Name	IUCN Status
Crocodiles		
Slender-snouted Crocodile	<i>Mecistops cataphractus</i>	CR
Nile Crocodile	<i>Crocodylus niloticus (suchus)</i>	LC
Dwarf Crocodile	<i>Osteolaemus tetraspis</i>	VU
Chameleons and Lizards		
Slender Chamaeleon	<i>Chamaeleo gracilis</i>	LC
Gray's Monitor	<i>Varanus olivaceus</i>	VU
Large Snakes		
Western Green Mamba	<i>Dendroaspis viridis</i>	LC
African Rock Python	<i>Python sebae</i>	NA
Royal Python	<i>Python regius</i>	LC
Lesser Snakes		
African Brown Water Snake	<i>Afronatrix anoscopus</i>	LC
African Water Snake	<i>Grayia smythii</i>	NA

Common Name	Scientific Name	IUCN Status
Variable Marsh Snake	<i>Natriciteres variegata</i>	NA
Spotted Bush Snake	<i>Philothamnus semivariatus</i>	NA
Northern Green Bush Snake	<i>Philothamnus irregularis</i>	LC
[Grass snake sp.]	<i>Psammophis elegans</i>	NA
[Grass snake sp.]	<i>Psammophis sibilans</i>	NA
Twig Snake	<i>Thelotornis kirtlandii</i>	NA

Note: DD=Data Deficient, LC=Least Concern, VU=Vulnerable, EN=Endangered, CR=Critically Endangered

Varanus spp monitor lizards are arboreal and can be found in both primary and secondary forests often with rocky outcrops. They lay eggs close to water bodies and juveniles have a diet of snails and crabs.

Summary

The habitat of the Project's AoI has the ability to support a high diversity of mammals, birds, amphibians and reptiles, including four Endangered species (western chimpanzee, red colobus monkey, pygmy hippopotamus, hooded vulture) and one Critically Endangered (CR) species (slender-snouted crocodile). Of these, only one species (hooded vulture) was sighted during the survey for the ESIA, while all the others were reported by local informants as rarely occurring.

7.4.4

Aquatic Ecology

Fish Species Diversity

Twelve species were caught during the fish survey. Of the total catch, two of the fish species are classified by IUCN as Near Threatened (NT) or Vulnerable (VU). These are *Sarotherodon occidentalis* (NT) and *Doumea chappuisi* (VU) Loach catfish sp. (Figure 7.19), which were recorded only at the hydropower plant site immediately downstream of the waterfall.

The abundance of fish species recorded per sampling area and the IUCN red list status of all of the freshwater species identified by this survey is indicated in Table 7.12.

Figure 7.19 *Sarotherodon Occidentalis* (NT) (left) and *Doumea Chappuisi* (VU) (Loach Catfish Sp.) (Right)



Table 7.12 *Fish Species in the Kaiha River in the Project Area*

Family	Common name	Species	Dam site	Downstream	Upstream	IUCN Status
Cichlidae		<i>Tilapia louka</i>	1		2	LC
		<i>Sarotherodon occidentalis</i>	1			NT
	Banded jewelfish	<i>Hemichromis fasciatus</i>	4	2	8	LC
	Jewelfish	<i>Hemichromis bimaculatus</i>	2			LC
Cyprinidae	African carp	<i>Labeo parvus</i>			5	LC
	Golden-coloured Barbel	<i>Barbus sacratius</i>	2	4	10	LC
Alestidae	African Longfin, African Long-finned Tetra, African Tetra, Characin, Long-finned Characin, Long Finned Characin, Longfin Tetra, Silverside	<i>Brycinus longipinnis</i>	5	8	16	LC
	Large Scaled Robber, Characin, Imberi, Silverside, True Big-scale Tetra	<i>Brycinus macrolepidotus</i>	2	2		LC
Mormyridae	Elephant Fish	<i>Petrocephalus pellegrini</i>	5	2	7	LC
Bagridae		<i>Chrysichthys johnelsi</i>	6	5	20	LC
		<i>Chrysichthys maurus</i>	2			LC
Amphilidae	[Loach catfish sp.]	<i>Doumea chappuisi</i>	3			VU

Key: DD=Data Deficient, LC=Least Concern, VU=Vulnerable, EN=Endangered, CR=Critically Endangered

In the deeper pools with overhanging forest trees, typical calmer water species such as the predatory cichlid *Hemichromis fasciatus* banded jewelfish, *H. bimaculatus* jewelfish as well as the Characids *Brycinus macrolepidotus* true big-scale tetra and *B. longipinnis* Longfin Tetra were recorded upstream and to a lesser extent downstream of the river as far as Madina. However, *H. fasciatus* and *B. longipinnis* occurred almost ubiquitously along the river.

Hemichromis fasciatus banded jewelfish is considered as least concern in IUCN (2015) and inhabits inland waters of permanent rivers and streams/creeks (including waterfalls). It is one of the most common and widely distributed species in West Africa and has been recorded across Sub-Saharan Africa from Angola to Zimbabwe (www.iucn.org, Paugy et al. 2004). It is a benthopelagic species (living and feeding near the bottom as well as in mid waters or near the surface) that can thrive in both fresh as well as brackish water. It occurs in mud-bottom and sand-bottom canals some distance inland from the coast associated with areas of intact or recently disturbed forest cover. The migration behavior of *H. fasciatus* is mainly potamodromous (migratory fish that migrates within fresh water only), thus migrating within streams, migratory in rivers, like the *Labeo spp.* Migrations should be cyclical and predictable and cover more than 100 km. In Liberia, this species is known from Farmington Lake, Mano, Loffa, St Paul, St John, Du, Nipoure and Cavally Rivers (Fermon and Gsegner, 2006).

Brycinus longipinnis longfin tetra, like *H. fasciatus* banded jewelfish, is also considered least concern by IUCN (2015). It is a very common species with a wide range of distribution across West Africa from Benin to Togo (Paugy et al. 2004). This species inhabits both seasonal and permanent rivers and streams/creeks (including waterfalls). It could also inhabit intermittent saline or brackish waters. It is the only *Brycinus* sp. that can penetrate small rivers and stream and feeds on plants and invertebrates (Fermon and Gsegner 2006). In Liberia, it occurs in Farmington Lake, Mano, Loffa, St Paul, Du and St John Rivers.

A further consistent feature of the species assemblage of fish in the Kaiha River was the presence of the golden-coloured barbel *Barbus sacratus*, typical of fast-flowing rocky rivers (Payne, 2006) such as the Kaiha River and was recorded in low quantity at the hydropower plant site and also further upstream (Wanwoma irrigation dam) and downstream of Madina. *B. sacratus* is listed as least concern in IUCN (2015). This species is distributed across Sub-Saharan Africa including Liberia, Sierra Leone, Guinea, Cote d'Ivoire and Guinea Bissau and mostly inhabits inland waters of permanent rivers and streams/creeks (including waterfalls) (www.iucn.org, Paugy et al. 2004). The species is benthopelagic (living and feeding near the bottom as well as in midwaters or near the surface) in terms of habitat and, in Liberia, it is known from the Loffa, St Paul and St John Rivers including Vai River.

Of the total catch, two of the fish species are classified by IUCN (2015) as near threatened (NT) or vulnerable (V).

These are *Sarotherodon occidentalis* (NT) and *Doumea chappuisi* (VU) (loach catfish sp.), which were recorded only at the hydropower plant site immediately downstream of the waterfall. *S. occidentalis* (NT) is distributed in some countries across West Africa including Guinea, Guinea Bissau, Liberia, Senegal and Sierra Leone (www.iucnredlist.org, Paugy et al. 2004). Record of this species has been made in the River Casamance in Senegal to the St John in Liberia (Paugy et al. 2004). It inhabits inland waters of permanent rivers and streams/creaks (including waterfalls). It is a demersal (bottom dwelling) species and recent studies in Liberia reveals that the species also occurs in the Loffa and St. Paul Rivers (Fermon and Gsegner 2006). It has widespread threats, particularly from drought, deforestation, overfishing and dams. The species is near threatened (NT) (www.iucnredlist.org).

Doumea chappuisi (VU) (loach catfish sp.), belonging to the family Amphiliidae, is a small catfish and a characteristic species of small fast-flowing streams. This species is comprised of suctorial mouthparts which enable it to cling onto the underside of rock surfaces. Judging by the body shape, these fishes are adapted to life in quick waters (Paugy et al. 2004). It is a purely demersal (bottom dwelling) species (Fermon and Gsegner 2006).

In fact, it was collected with a scoop net placed underneath the flow of water over small rocks while being washed away by the fast flowing water at the waterfall. *D. chappuisi* is distributed in the Sub-Saharan Africa and particularly Liberia, Guinea Bissau, Cote d'Ivoire and Guinea (www.iucn.org) and has been recorded in rivers Cavally and Gbin (St. John basin, Liberia) and Corubai (Guinea Bissau) (Paugy et al. 2004). *D. chappuisi* is threatened by deforestation, and agricultural development.

The number of catfish species in the samples was limited. The most distinctive catfish groups were species belonging to the family Bagridae and of the genus *Chrysichthys* including *Chrysichthys maurus* (recorded only at the waterfall below the dam site) and *Chrysichthys johnelsi*, recorded at all three sites. The *Chrysichthys* spp. are potamodromous (migratory within freshwater only) in terms of migration and are demersal (bottom-dwelling) species that inhabit freshwater systems. In terms of distribution, the species are known from the St John and St Paul Rivers in Liberia (Fermon and Gsegner 2006).

Further fish species composition downstream and upstream of the Kaiha 2 waterfall included the mormyrid *Petrocephalus Pellegrini* elephant fish. This species inhabits inland water/wetlands-permanent or seasonal rivers/streams/creeks (including waterfalls) as well as coastal waters and has been recorded in Cote d'Ivoire, Guinea, Liberia, Sierra Leone (www.iucnredlist.org, Paugy et al. 2004). It is a demersal (bottom dwelling)

species and its migration behaviour is poorly known (Fermon and Gsegner 2006).

Public Knowledge and Perception of Fish Species

Out of 37 fish species identified by the local communities to exist in the Kaiha River, seven (7) of these are of conservation concern, two of which were also recorded during fish sampling (*Doumea chappuisi* and *Sarotherodon occidentalis*), while two species with a conservation status of CR were recorded from local interviews. These included: *B. carcharhinoides* (a barbel sp.) and *Labeo curriei* (a carp sp.).

Barbus carcharhinoides (a barbel sp.) is listed by the IUCN (2015) as CR. This species is believed to be restricted to one location, the type locality, River Via, St Paul's river drainage, in Liberia. And it is thus unlikely to occur within the Mano River catchment or the Kaiha River sub-catchment. The conservation status of this fish has been assessed by Paugy et al., 2004, Fermon and Gsegner, 2006.

Labeo curriei (a carp sp.) is also regarded as CR and is native to Liberia and the current population trend is decreasing. There are indications of continuing habitat degradation by deforestation, farming and mining with possible decline in population in Liberia. The species is reliably known from River Via, St Paul drainage, Loffa and Mano (Paugy et al. 2004, Fermon and Gsegner 2006).

Table 7.13 *Fish Species of Conservation Concern Identified Through Interviews*

Common Name	Species	Habitats	Location	IUCN Status
[Barbel sp.]	<i>Barbus carcharhinoides</i>	Inland water/wetlands-permanent or seasonal rivers/streams/creeks (including waterfalls)	Liberia	CR
Carp	<i>Barbus eburneensis</i>	Inland water/wetlands-permanent or seasonal rivers/streams/creeks (including waterfalls)	Cote d'Ivoire, Guinea, Liberia	VU
[Loach catfish sp.]	<i>Doumea chappuisi</i>	Seasonal/intermittent/irregular rivers/ streams/creeks	Cote d'Ivoire, Guinea, Guinea Bissau, Liberia	VU
	<i>Rhexipanchax nimbaensis</i>	Inland water/wetlands-permanent or seasonal rivers/streams/creeks (including waterfalls)	Guinea, Liberia	VU
[Carp sp.]	<i>Labeo curriei</i>	Rivers/streams/creeks (including waterfalls)	Liberia	CR
	<i>Sarotherodon occidentalis</i>	Permanent rivers/streams/creeks (including waterfalls)/ marine	Sub-Saharan Africa (Guinea, Guinea Bissau, Liberia, Senegal, Sierra Leone)	NT
	<i>Tilapia walteri</i>	Freshwater lakes/pools	Cote d'Ivoire, Liberia	NT

Note: DD=Data Deficient, LC=Least Concern, VU=Vulnerable, EN=Endangered, CR=Critically Endangered

7.4.5

Sensitive Areas

The following is a discussion of sensitive areas in the context of the criteria for Critical Habitat as defined by the IFC Performance Standards. Noting that the Project is guided by the World Bank Safeguard Policies and the IFC Performance Standards, the following is intended to provide characterisation and context to the baseline condition.

The IFC Performance Standards defines the following criteria for designation as Critical Habitat:

- (i) Habitat of significant importance to Critically Endangered and/or Endangered species;
- (ii) Habitat of significant importance to endemic and/or restricted-range species;
- (iii) Habitat supporting globally significant concentrations of migratory species and/or congregatory species;
- (iv) Highly threatened and/or unique ecosystems; and/or
- (v) Areas associated with key evolutionary processes.

Criterion (i) - Occurrence of Endangered and Critically Endangered Species

The evaluation of the existing environmental setting indicates the possible presence of five Endangered and Critically Endangered species. These species are presented in *Table 7.14* with an assessment of their status as critical habitat triggers.

Other Criteria

There is no evidence of highly range restricted (endemic) species, congregatory species, unique threatened habitats or key evolutionary processes within the Project area of influence that would trigger critical habitat under criteria (ii), (iii), (iv) or (v).

Presence of Protected Areas

There are two national parks (IUCN management category II) in the vicinity of the Project, but these are not considered to be directly or indirectly impacted by the project. The Project is however adjacent to the boundaries of the Lofa-Gola-Mano Important Bird Area.

Table 7.14 *Endangered and Critically Endangered Species in the Project Area and Status*

Common Name Scientific Name	IUCN Status	Confirmation of Occurrence	Comment on Critical Habitat Status
Mammal Species			
Western Chimpanzee <i>Pan troglodytes verus</i>	EN	Reported to be not common downstream of the dam site and some locations along the transmission line routes.	There is no confirmed presence.
Red Colobus Monkey <i>Piliocolobus badius</i>	EN	Reported above and below the dam site and rare along the lower transmission line route (TL1).	There is no confirmed presence.
Pygmy Hippopotamus <i>Choeropsis liberiensis</i>	EN	Reported to be not common above and below the dam site and rare along the lower transmission line route (TL1).	There is no confirmed presence.
Bird Species			
Hooded Vulture <i>Necrosyrtes monochas</i>	EN	Observed below the dam site and along the lower transmission line route (TL1).	Vultures are wide-ranging species, and observations do not trigger Critical Habitat, based on item (d) for criterion (i) in
Reptile Species			
Slender-snouted Crocodile <i>Mecistops cataphractus</i>	CR	Reported during interviews, but no specific locations were identified.	Reporting on occurrence is vague and not confirmed.
Fish Species			
[Barbel sp.] <i>Barbus carcharhinoides</i>	CR	Reported during the interviews with local fisherman. Its occurrence within the Kaiha sub-catchment is doubtful. This species was not observed during the baseline assessment.	The species is only known from its type locality in the Via River.
[Carp sp.] <i>Labeo curriei</i>	CR	Reported during the interviews with local fisherman. The species is known from a few locations including the Mano catchment. The presence of <i>L. curriei</i> was not confirmed during the baseline assessment.	This species is known from other locations, but not confirmed within the Project AoI.

7.5 HUMAN ENVIRONMENT

7.5.1 Local Government and Administration

The proposed hydropower plant is located in the newly established Lukambeh District in Lofa County. This district has been sub-divided from Kolahun District with the new district centre being Pasolahun town.

The transmission grid extends from the hydropower plant site in Lukambeh District into Wanhasse District (also sub- divided from Kolahun District, but not yet officially announced) and further to Kolahun District, Foya District and Voinjama District.

Administratively, Lofa County is headed by the Superintendent, while the districts are headed by a district commissioner. Each district is sub-divided into chiefdoms headed by a paramount chief, and each chiefdom is divided into clans headed by clan chiefs and sub-clan chiefs. Urban clans are headed by town chiefs. Voinjama, Foya and Kolahun/Kolba are defined as cities, headed by city mayors. The clan areas were originally related to tribal sub-groupings and whilst this still largely applies, increasing urbanization and civil war has disrupted this pattern and clans are now defined as administrative units.

7.5.2 Population

Population Size and Distribution

Lofa County has the fourth highest population among counties of Liberia after Montserado, Nimba and Bong counties. However, population density is moderate, at 71 persons per square mile (LISGRIS 2009). Average household size is 5.5, while the country-wide population growth rate is 2.1% per annum.

The largest city in the country and the county capital is Voinjama with a population of 4,945. Foya is the second largest city with a population 1,760.

Prior to its recent sub-division, Kolahun District was the largest administrative district of Lofa County. According to the 2008 National Population and Housing Census, the total population in Kolahun District (including Lukambeh and Wanhasse) is 60,557 with a ratio of 47% men and 53% women (LISGRIS 2009). The gender distribution of the population in Lofa County and the four affected districts is presented in *Table 7.15*, while the number of households in the directly affected towns (ie, those that could connect to the new electricity grid) is given in *Table 7.16*. Assuming a population growth of 2.1% per year, the total population and households in the targeted towns in the year 2019 are presented in *Table 7.17*.

Table 7.15 Population in the Project Area by County and District (2008)

County or District	Male	Female	Total
--------------------	------	--------	-------

Lofa County	133,611	143,252	276,863
• Kolahun District	28,586	31,971	60,557
• Voinjama District	20,623	22,167	42,790
• Foya District	36,152	37,160	73,312

Source: LISGRIS (2009)

Table 7.16 *Household Head Population in the Project Area by Town, Clan, Chiefdom and District (2008)*

District	Chiefdom	Clan	City/Town	Household Heads
Lukambeh	Bandi	Lukasu	Mbaloma	109
Lukambeh	Bandi	Lukasu	Bondowalahun	132
Wanhasse	Bandi	Hasala	Kimbalahun	135
Wanhasse	Bandi	Hasala	Kpengbelahun	102
Wanhasse	Bandi	Wanwoma	Lehuma	234
Wanhasse	Bandi	Wanwoma	Fangonda	131
Wanhasse	Bandi	Wanwoma	Masambolahun	732
Wanhasse	Bandi	Wanwoma	Polowu	182
Wanhasse	Bandi	Wanwoma	Bolahun	139
Wanhasse	Bandi	Wanwoma	Bolahun (B)	104
Wanhasse	Bandi	Wanwoma	Tewulahun	a
Wanhasse	Bandi	Wanwoma	Sosomolahun	173
Kolahun	Bandi	Tahamba	Mawulohun	b
Kolahun	Bandi	Tahamba	Twingihewa	b
Kolahun	Bandi	Tahamba	Babahun	74
Kolahun	Bandi	Tahamba	Korworhun	71c
Foya	Kissi	Luankollie	Bolay Town	54
Foya	Kissi	Luankollie	Sombolo	66
Foya	Kissi	Luankollie	Shelloe	78
Foya	Kissi	Luankollie	Kpeloe	55
Foya	Kissi	Luankollie	Foya city	3,252
Foya	Kissi	Luankollie	Kornduma	95
Kolahun	Bandi	Tahamba	Morgrohun	d
Kolahun	Bandi	Tahamba	Kolahun	/ 1,476
			Kolba city	
Kolahun	Bandi	Tahamba	Kambolahun	69e
Kolahun	Bandi	Tahamba	Sovasu	
Kolahun	Bandi	Tahamba	Honeyahun	14f
Voinjama	Loma	Lower Workor	Johnny's Town	78
Voinjama	Loma	Lower Workor	Kpakuta	g
Voinjama	Loma	Lower Workor	Velezala	155
Voinjama	Loma	Lower Workor	Yandisu	/ 113
			LPMC Camp	
Voinjama	Loma	Lower Workor	Voinjama city	3,301

Notes: a Probably included in Bolahun (B) census.

b Probably included in Sosomolahun census.

c Probably included in Savalahun census (141 households). Assuming population in Korwohun to be 50%.

d Probably included in Kolahun census.

e Probably included in Balahun census (103 households). Assuming 2/3 of the households in Kambolahun and Sovasu.

f Probably other towns and included in Honeyahun census, thus assuming only 14 households in the settlement along the road.

g Probably included in neighbouring town census. Source: Adapted from LISGRIS (2009)

Table 7.17 **Estimated Population in the Project Area (2018)**

Town	Households	Population
Voinjama	4 149	19 191
Kolahun	1 855	9 013
Foya	4 087	25 852
Bolahun	358	1 987
Masambolahun	920	8 978
Smaller settlements along the transmission line	1 587	9 075
Total	12 956	74 097

Source: Multiconsult (2016)

Ethnic and Religious Composition

The dominant ethnic groups (sometimes referred to as tribes) in the Project area are Bandi (Gbandi), Loma and Kissi (*Table 7.16*). However, all the sixteen major ethnic groups of Liberia are represented in Lofa County, including other major groups such as Mende, Mandingo and Kpelleh. The two largest groups in the project area are the Loma and Bandi, which are predominantly Christian and Muslim, respectively.

Marital Status

Over 50% of the adult population in the project area are in some form of recognised marital union (LISGRIS et al. 2014). Consultations with key stakeholders revealed that marriage among the female population is commonly earlier than boys with age at first marriage estimated at 19 for girls, compared to 25 for boys. Polygyny is also a common practice in the project area.

Health

In terms of disease prevalence, in addition to the recently managed Ebola outbreak that spread throughout the entire country, other common diseases in the project area include:

- Diarrhoea among infants attributed to factors such as unhygienic sources of water, unhygienic food preparation processes and lack of proper sanitation facilities;
- Malaria, mostly described as fever for both infants and adults; and
- Upper respiratory tract infections.

HIV prevalence is generally low with the national prevalence rated at 1.7% among the male population and 2.0% among the female population. It is even lower (0.8%) in rural communities.

Consultations with the health workers in Kolahun revealed that myalgia (muscle pain) is increasingly being reported as a common health complaint within the communities.

Education

LISGRIS (2009) reported that the fraction of Lofa population between 5 and 29 years old that is attending schools is less than 50% while the literacy rate in the county is at 40%. The low level of education and literacy was also confirmed in the latest demographic and health survey (2013) (LISGRIS et al. 2014).

Only 25.5% of the female population were considered literate, while 74.5% did not have the ability to read and write simple sentences. The corresponding figures for the male population were 54.5% and 45.5%, respectively.

An assessment of the educational attainment by gender indicates that 56% of the female population in Lofa County did not attend school at all, compared to 24.8% of the male population. In terms of school completion, only 4.2% and 1.2% of the female population completed primary and secondary school, respectively, while 4.3% and 18.4% of the male population completed primary and secondary education.

Notably, the low literacy rate in the project area was evidenced by the fact that several stakeholders that turned up for the consultation meetings did not have the ability to write their own names.

Gender Indicators

In the absence of site and region indicators national Liberian indicators was assessed and presented below. Gender inequalities and the marginalization of women has been on the forefront of many discussions over the last 10 years, and the general consensus is that although there is progress being made the gap is still substantial and needs to be proactively addressed. Liberia is no exception and *Table 7.18* shows the current situation.

Table 7.18 ***Comparison of Social Indicators for Females and Males in Liberia***

Indicator	Females	Males
Estimated gross national income per capita (2011, PPP\$)	575	788
Expected ¹ years of schooling	9.3 years	10.6 years
Human Development Index (HDI)	0.387	0.466
Labour force participation rate (% ages 15 and older)	58	63.9
Life expectancy at birth	62.2years	60.2 years
Mean years of schooling	3.0	6.0
Population with at some secondary education (% ages 25 and older)	17.3	39.7

¹ Number of years of schooling that a child of school entrance age can expect to receive if prevailing patterns of age-specific enrolment rates persist throughout the child's life. Source: UNESCO Institute for Statistics (2016), ICF Macro Demographic and Health Surveys and UNICEF's Multiple Indicator Cluster Surveys, Accessed on 15 July 2016

Adult mortality rate (per 1,000 people)	231	269
Suicide rate (per 1,000,000 people)	2	6.8

Source: Multiconsult (2016)

Note also the following other indicators related to gender:

- Sex ratio at birth (males to female births) = 1.05;
- Adolescent birth rate (birth per 1000 women ages 15 – 19) = 108.8;
- Gender Development Index (GDI) = 0.830;
- Gender Inequality Index (GII) = 0.649;
- Maternal mortality ratio (deaths per 100 000 live births) = 725;
- Shares of seats in parliament (percentage held by women) = 10.7;
- Unemployment rate (total), female to male ratio = 1.0;
- Youth unemployment rate, female to male ratio = 1.2;
- Mandatory paid maternity leave (days) = 90;
- Violence against women ever experienced (intimate partner) = 38.6 %; and
- Violence against women ever experienced (non-intimate partner) = 2.6 %.

Upon review of online media sources the following issues were identified:

- Consistent physical and mental abuse from mostly male intimate partners;
- Female genital mutilation;
- Rape and a very worrying wide reports of incest;
- Early arranged/forced marriage;
- High rate of teenage pregnancy; and
- Poverty induced prostitution.

Given the information presented above Liberia has a high gender sensitivity that should be considered during impact assessment.

7.5.3 *Land Tenure, Ownership and Use*

Land Tenure

Customary land ownership is the most dominant land tenure system in the project area, whereby access and rights to land and natural resources are governed by customary rules administered by the chiefs at the various levels. According to Namubiru-Mwaura et al. (2011), claims to land in Liberia are highly nested, typically ranging from claims held by the lineage-based chieftaincy or clan to claims held by towns, extended families, and households and individuals. At the household level, claims can be temporary, as with seasonal upland rice and vegetable crops, or they can be permanent as with tree crops and house plots.

Land Use

The main land use is agriculture practiced as shifting cultivation and slash and burn farming which involves the cutting and burning of forest plots to create

temporary farms for seasonal crops (*Figure 7.20*). The fields are usually cultivated for two years until the soil nutrients have become depleted and the forest is left to regenerate. The main crop is upland rice intercropped with vegetables and tubers, including cassava, okra, cucumber, pepper, eddoes, potatoes, eggplant, pumpkin, peanuts, yams and beans.

Cash crops such as coffee, cacao and oil palm are also grown, mainly in the vicinity of settlements and along the roads, yet plantations can also be found scattered within the forest (*Figure 7.20*). Coffee and cacao require shade and are therefore planted under the canopy of larger trees. Other perennial crops include banana, pineapple, sugarcane and fruit trees (eg, mango, avocado, papaya).

The other main land uses are for settlements and road infrastructure. The towns that will be served by the Project are those situated along the main road from Mbaloma to Kolahun and further to Foya and Voinjama. All the settlements are organised into well-defined clusters (towns). The road is partly gravel but for the most part earth road (*Figure 7.20*). The road reserve is defined as 75 feet (23 m) from the centre line, but the actual width is much narrower (< 10 m) with coffee, cacao, oil palms and banana plantations typically grown along the roadsides.

Figure 7.20 *Slash and Burn Agriculture (left) and Coffee Plantation along the Main Road (right)*



The land cover at the proposed hydropower plant site is rainforest, and it is devoid of any settlements. There is an existing footpath from the nearest town Mbaloma. This footpath will be upgraded to a permanent access road. The forest surrounding the planned road alignment is in various stages of succession (ie, secondary forest), an evidence that shifting cultivation has been practised for a long time. There are also a few openings in the forest where the farmers have planted crops, mainly rice. Temporary farm shelters are erected during the planting and harvesting season (*Figure 7.22*).

The reservoir when fully flooded will cover an area of approximately 405 ha. *Table 7.19* provides a summary of the areas in the Project that will be permanently changed (calculations by Earthtime Consultants).

Table 7.19 *Current Land Cover that will be Permanently Altered by Flooding*

Land cover	Expected flooded area (ha)
Closed forest	193
Open Forest	131
Bareland	24
Water bodies	10
Grassland	47

Figure 7.21 *Bolahun Town (left) and Kolahun Town (Kolba City) (right).*



Figure 7.22 *Temporary Farm Shelter along the Planned Access Road*



River Use

The only major water user on the Kaiha River is the Wanwoma irrigation scheme, about 25 km north north-east (upstream) from the proposed

hydropower plant site. As described previously the scheme was constructed in the 1970s and is currently being rehabilitated with funding from the Swiss Agency for Development and Cooperation.

The rehabilitation works involve installation of a new weir across the river, which will rise the water level by approximately 1 m allowing sufficient water to enter the intake to the irrigation canals (*Figure 7.11*). The abstraction is estimated at 300 l/s, and although the intake is equipped with a gate it is likely that the abstraction will be constant throughout the year. The scheme is intended for swamp rice (paddy cultivation).

Fishing is practiced mostly on a subsistence basis. No data are available for inland fisheries in Liberia, but fishing methods along the Kaiha River include gill nets, casting nets, hooked lines and fish traps. On top of the rapids at the hydropower plant site, a temporary weir with fish traps was observed across part of the river channel (*Figure 7.22*).

Interviews with fishers and some nearby communities to the Kaiha River indicated that fishing practices and the fishery are similar throughout the river and have not changed significantly in the past times. Fishing methods are essentially the same at all locations, and largely include the use of crude methods such as hook and line in the communities of Mbaloma and Madina. The fish obtained in these areas are purely for subsistence purposes.

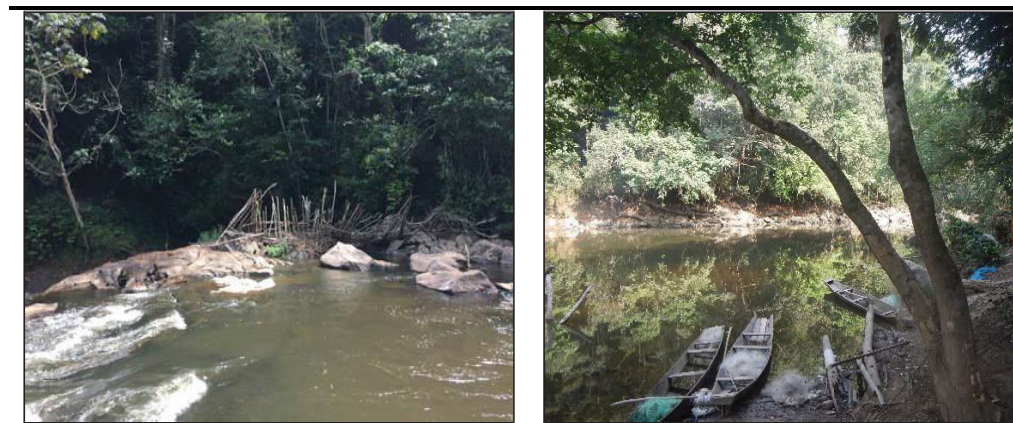
At Madina, migrant part-time fishers from neighbouring Guinea, using more efficient fishing gears, are highly engaged in large scale commercial fishing in the Kaiha River using gill nets and long lines as fishing methods. The presence of the migrant fishers in this part of the river is mostly felt during the dry season, whereas they tend to move out of their temporary base camp at Madina in the early rains.

Madina is located downstream of the dam site. Fish respond to the natural reductions in river flow in the dry season by moving into the centre of the channel as the margins dry, and many also migrate downstream in the late rains and early dry season, to areas where the changes in the water body are less extreme. This increases the chance of fishers catching more fish during the dry season in the downstream reaches of a river than during the rainy season when there is increased river flow and reduction in migration of species from other sources coupled with the high effects of current on fish movements and fishing gears.

At the Wanwoma irrigation dam around Mbolatahun, community people use kru-canoes as fishing craft and largely employ gill nets for fishing. Fishers interviewed at the irrigation dam stated that catch is mostly dependent on the efficiency of their fishing gears (gill nets). Most of the catch at good times is marketed and some being used for consumption. The fishers were however not certain about the differences in catch per season.

Due to the relatively long distance to settlements, there is only insignificant use of the river for domestic water. The towns are served by boreholes and hand pumps, and some people also collect water from the nearby streams.

Figure 7.23 *Fish Traps at the Waterfall at the Hydropower Plant Site (left) and Kru-Canoes used for Fishing at Mbaloma (right)*



7.5.4 *Livelihoods and Economic Activities*

The main source of livelihood in the project area is agriculture mainly practiced for subsistence purposes characterised by low levels of mechanisation, low productivity, limited access to improved farm inputs and poor post-harvest handling techniques. According to LISGRIS et al. (2014), agriculture is the main source of employment for 84% of the female population and 71% of the male population in Lofa County, while the sales and marketing industry (restaurants, bars, shops, and video clubs) employ 12.9% of the female population and 3.6% of the male population. The public sector/government institutions employ 0.9% and 12.6% of the educated female and male population, respectively. Finally, casual labour was reported as the main form of employment for 1.2% of the females and 9.4% of the males.

Employment opportunities in the Project area are limited. According to IED (2016a), there are no major industries, agro-processing plants, or any other large enterprise in the area except for small mills which are typically owner-operated. The main formal employers in the project area are the government institutions like schools, local administration, health centres, and private firms like banks, fuel dealers and NGOs.

In regard to income, *Table 7.20* shows the average income per income level category of the households in the project area as estimated by IED (2016a). From the results, it is clear that the majority (74%) of the households are in the low-income category. The low levels of income are probably attributed to the fact that a significant proportion of the population is engaged in the

agricultural sector which is usually non-paid work as one tend to be self-employed working on own farm.

Table 7.20 *Three Categories of Households Based on Declared Income*

Category	Average monthly income (LRD)	No of surveyed HH in category	% total
1 - low	7300	478	74%
2 - medium	19900	156	24%
3 - high	52400	14	2%
Total	11300	648	100%

Source: IED (2016a)

The low income levels can also be due to the low productivity in the agricultural sector. A case in point is the low coffee productivity estimated at only 500 kg per hectare per year, which is much lower compared to typical yield of 650 kg per acre (1,606 kg per hectare) in other parts of the world. However, it should be noted that Lofa County has set among its priorities the need to transform its agricultural sector from traditional to mid-scale mechanised agriculture, with a key focus on rejuvenating rice production to the pre-civil war levels.

Concerning food security, 41% or about 1.2 million people in Liberia have an unacceptable food consumption, that is, they consume limited or insufficient nutritious foods to maintain an active and healthy life (Owadi et al. 2010). Food insecurity is more prevalent in rural areas than urban areas with rural residents at least three times more likely to be food insecure (57% of rural households have unacceptable food consumption compared with 18% of urban households). In Lofa County, 36.5% of the households were reported as food insecure in 2010 while 39.4% were chronically malnourished (Owadi et al. 2010).

The majority of households do not produce more than five months of food for their own consumption. For several months of the year, they are net buyers of food and dependent on markets characterised by frequent price escalation, which are not affordable for the local populace. According to Owadi et al. (2010), households in Lofa County spend 44% of the household budget on food related expenditures. This is considered to be among the lowest in the country. For all households, urban and rural, rice is the number one food purchase, accounting for the greatest share of expenditure regardless of whether they have acceptable or poor food consumption scores. Other priority non-food items include transport, clothing, communication, health and cooking fuel.

Regarding markets, consultations with the town chiefs indicated that communities in the project area had access to weekly markets while those close to Voinjama had access to a daily market. However, it was reported that

during the rainy season farmers have trouble accessing the weekly markets due to the poor road infrastructure.

The issue of access is also made worse by the long distances. According to RoL (2007), the average walking time to reach the nearest market is 2.5 hours. Major markets utilised by the population in the project area include Kolahun with a market day on Monday, Vonjama with a market day on Thursday and Masambolahun.

7.5.5 *Infrastructure and Social Services*

Health Services

Institutions for health service delivery are well distributed within the project area. These range from hospitals to health posts/dispensaries and training/research centres. There are three hospitals serving the population within the Project's general area: Kolahun Hospital, Foya Boma Hospital and Tellowoyan Memorial Hospital. There also several health centres. For non-complicated cases, the population relies on health centres or health posts at town level. Health posts mainly serve as outpatient departments and are normally manned by one health worker.

Health service delivery is constrained by the long distances to the referral units and limited access to reliable power supply. Lack of electricity is a major risk during night time operations and it also restricts the ability to store blood reserves which is vital in case of emergencies. Furthermore, consultations with Kolahun Hospital revealed that inadequate staffing is a major challenge at all levels. For example, Kolahun Hospital has a staffing gap of 22 personnel, coupled with other challenges like inadequate medicine supplies.

The main hindrance to accessing medical services in Lofa County is the long distances, as reported by 66.5% of the population (LISGRIS et al. 2014), coupled with the high costs for treatment. *Table 7.21* illustrates the long distance problem within the Kolahun Hospital catchment area. The situation is expected to be similar in the catchments of Foya Boma Hospital and Tellowoyan Memorial Hospital.

Table 7.21 *Distance from Clinics to Kolahun Hospital*

Name of Clinic	Distance to Kolahun Hospital (km)
Nyandemoilahun	27
Faith Clinic	4.2
Fassavolu	13.5
Korworhun	11.1
Bolahun Health Centre	14.4
Fangoda	16.9
Kiantahun	28
Popalahun	28
Kamatahun	34
Lukasu	38

Gondorlahun	44
-------------	----

Source: Field data (Kolahun hospital)

Educational Facilities

According to LISGIS (2009), Lofa County has 334 schools in total. The number of schools in each of Kolahun, Foya and Voinjama Districts is given in *Table 7.22*.

There are two colleges in the county, namely Lofa County Community College and Free Pentecostal College, both located in Voinjama City.

Table 7.22 ***Number of Schools per Districts***

District	Number of Schools
Kolahun	92
Foya	71
Voinjama	83

Source: LISGRIS (2009)

The large majority of schools are primary schools, while secondary schools are very few. This probably contributes to the low levels of school completion beyond secondary school and the low level of skills within the population. Currently all schools operate with several challenges ranging from inadequate scholastic materials to lack of access to energy for lighting and operating necessary equipment.

Water Supply

According to GoL (2014), 65% of the rural population have access to an improved water source, which is usually in form of a protected source like a borehole or a hand dug well. It is also worth noting that 23% still rely on surface sources of water. The functionality rate of the improved water sources in Lofa County was estimated at 63%. Furthermore, 67% of the population in Lofa County live within 1.5 miles from a safe water point. *Table 7.23* shows the percentage of the population with access to safe water within the project area.

Consultations with the town chiefs revealed that the communities in the Project area rely on boreholes and hand pumps for their domestic water needs, while surface water sources such as creeks and rivers are used to supplement the water needs particularly during the dry season or when their main water source breaks down.

In regard to sanitation, only 19% of the rural households have access to improved sanitation, with the overwhelming majority (74%) of households defecating in the open (GoL 2014).

Table 7.23 *Percentage of Population with Access to Safe Water in Lofa County*

County	District	Population per Functional Water Point**	Access
Lofa	Foya	1243	23%
	Kolahun	459	47%
	Quardu Boundi	553	41%
	Salayea	393	56%
	Vahum	1428	18%
	Voinjama	303	70%
	Zorzor	490	45%
Total		531	43%

Source: GoL (2014)

Transport and Communication

The project area is served by the main gravel roads connecting Voinjama, Foya and Kolahun. The road from Kolahun (Kolba City) running southwards to Mbaloma ends approximately 5 km east of the hydropower plant site. The access to the river and proposed dam site is via an existing footpath. There are also a number of other feeder roads which are generally in poor condition especially during the rainy season. The road distance from the capital Monrovia to Kolahun is 436 km.

In terms of access to information, the communities rely on radio and information through the community leadership. There are three community radio stations in the Project area: Radio Kintoma (Voinjama), Radio Tamba Taikor (Foya) and Radio Harleyngee (Kolahun).

In addition to radios, some households own cell phones, which serves for information sharing and even radio listening. Several companies offer mobile network services in the area although the coverage is intermittent.

Energy

The main sources of energy for all households in the project area, as reported by the IED (2016a), are as shown in *Table 7.24*

According to the IED (2016a), the main energy use in the Project area is for lighting. The sources of energy for lighting among the low, medium and high-income households are as shown *Table 7.25*. The findings indicate that irrespective of the income levels, households mainly rely on dry cell powered light facilities for their lighting needs followed by solar lanterns for the high earning households.

It should be noted though that access to electricity is possible in some towns in the project area through diesel-fueled generators either as own gen-sets or through informal electricity suppliers. IED (2016a) reported that 3% of the

households included in the study owned a generator while 10% relied on electricity from a local supplier.

Table 7.24 *Main Energy Sources for Households in Each Income Category (excluding cooking)*

% of hh using, as main source of energy	Low	Medium	High	Average
Dry cell battery	90%	75%	37%	86%
Electricity from local provider	8%	16%	16%	10%
Generator (own)	1%	8%	47%	3%
Solar Home System	1%	0%	0%	1%
Storage battery	0%	1%	0%	0%
Total	100%	100%	100%	100%

Source: IED (2016a)

Table 7.25 *Main Source of Lighting for Households in Each Income Category*

% of hh using, as main source of lightning	Low	Medium	High	Average
Electricity from local provider	8%	16%	16%	10%
Solar lantern	6%	13%	32%	8%
Kerosene/ gas lamp	0%	0%	0%	0%
Dry cell powered LED lamp	55%	59%	42%	55%
Dry cell powered Torch light	27%	10%	11%	23%
Candle	3%	1%	0%	2%
Battery current	1%	0%	0%	0%
Solar Torchlight	1%	0%	0%	0%
Chargeable Torchlight	1%	0%	0%	1%
Total	100%	100%	100%	100%

Source: IED (2016a)

Institutions like health centres rely on solar power for their energy needs (e.g. lighting, water supply, refrigeration), while hotels, video clubs and shops mainly use diesel generators for both lighting and refrigeration.

In regard to energy for cooking, the entire population (institutional and residential), irrespective of the income level, rely on fuelwood for cooking (23% firewood and 77% charcoal). IED (2016a) found that none of the households owned an electric stove.

7.5.6 *Safety and Security*

According to the Lofa County development agenda 2008-2012, the security situation has stabilised but remains fragile, and seeds of past discord remain largely in place and new security challenges have arisen triggered by both internal and external factors including cross border issues.

Key security concerns reported in Lofa County include porous borders, sexual violence, drug abuse, and theft (of cattle, livestock, rubber).

In terms of security service provision, the system was reported as having challenges mainly related to shortage of qualified security personnel, corruption by security personnel, and lack of adequate logistical support for security personnel including vehicles, accommodation, and communication. Within the project's impact zone, there are a number of police stations serving the communities while traditional conflict resolution mechanisms continue to play an important role at the community level.

7.5.7 *Tourism*

There is no significant tourism activity in the Project area and the potential for tourism is also considered as low.

7.5.8 *Cultural Heritage*

Archaeological Resources

The cultural heritage baseline study did not identify any known archaeological resources within the proposed Project area. The study did, however, identify a number of known archaeological resources in western Lofa County which suggest there is a potential for undiscovered archaeological resources.

An archaeological survey of Liberia conducted in 1973 (Creighton et al 1974) identified a number of different archaeological sites types in Lofa County:

- 'Old town' sites, two near Masambolahum and three near Kpademai, identified as historic village locations in local oral traditions. "Old town" sites were found throughout the Liberian countryside during the survey and typically consisted of stands of particular types of trees, remains of iron smelting furnaces, house depressions, and medicine rock piles. They were believed to be approximately 150 to 200 years old;
- Historic Bandi burial ground located beneath the ca. 1920 Holy Cross monastery at Bolahun; and
- Iron Age (ca. AD 450) rockshelter site located between Kolahun and Bolahun, known locally as Kokasu, found in an area of dense forest overlooking the steep valley near the Kaiha River. Excavations recovered plain, cordmarked, and linear incised potsherds, microlithic stone tools, charcoal, and oil-palm nut shells (Creighton et al. 1974).

Regional surveys have identified similar archaeological sites dated to the Middle Stone Age (MSA [100,000-30,000 BC]), Late Stone Age (LSA [30,000-500 BC]), and Iron Age (500 BC-AD 1000) across the interior forested portions of Liberia and neighbouring Sierra Leone, Guinea, and Cote d'Ivoire. The known sites are interpreted as stone tool quarry and workshop sites,

settlements, cemeteries, rock shelters, iron smelting sites, and agricultural or hunting camps (Orr 1972; Creighton 1976, Scerri 2017).

The presence of these types of archaeological resources across Lofa County and across the northern, forested portions of Liberia suggest there is the potential for similar resources within the footprint of the proposed Project. Undiscovered archaeological resources could be present within the footprint of the various Project components.

The significance of archaeological resources is typically assessed in terms of research potential and the type and uniqueness of the data that could be collected at a site. Larger, more complex archaeological sites such as settlements and large cemeteries have greater research value due to the multiple types of activities and/or time periods represented at these sites. Older sites, such as MSA sites, are less common than more recent sites, such as Iron Age or Historic Period sites, because they are less often preserved. As a result, the possible information available is more significant as it is rarer and more unique compared to later, more common sites.

Built Heritage Resources

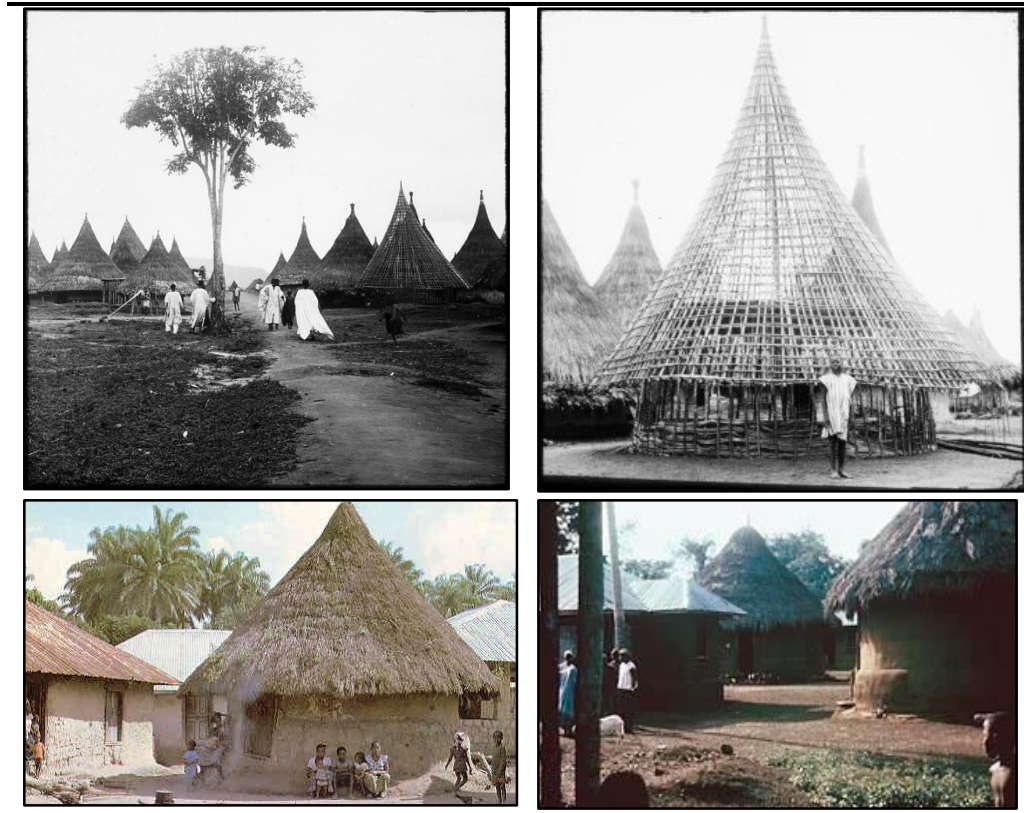
The desktop study suggests there are two principal types of built heritage resources in the study area. The first are traditional structures built in the area prior to extended contact with Euro-American populations. The second are Euro-American influenced structures built in towns and villages in the late 19th through early 20th century.

A common type of traditional structures in Lofa County, and northwestern Liberia, is the 'western Sudan style' or 'traditional village houses' (HPSOL 2018). The structures consist of circular structures with walls made of a woven lattice of wooden poles covered by mud plaster and conical thatched roofs (*Table 7.23*). Examples of rectangular structures with rounded corners are also common.

These types of structures are multi-purpose and often used as residential, commercial, or administrative, or religious structures (HPSOL 2018).

A review of publicly available satellite imagery of Lofa County identified numerous possible examples of the western Sudan style traditional structures in villages near the Project Area (*Figure 7.25*).

Figure 7.24 *Traditional Structures in Northwestern Liberia. Historic Photos (top) and Modern Photos (bottom) of Traditional Western Sudan Style Houses.*



Source: HPSOL 2018

The historical and cultural significance of these types of structures depends on the characteristics of individual structures. Older structures have historic significance as standing examples of historical building techniques and styles. More recent or modern structures are significant as examples of the continuation of long standing building techniques and traditions in the area.

The second category of built heritage likely to be found in the Project area are historic structures built in the late 19th through 20th centuries with Euro-American stylistic design elements and materials. The historic maps reviewed as part of the desktop study do not show settlements or infrastructure in the study area until the late 19th and early 20th century.

This is not interpreted as indicating settlements and villages were not present but, rather, that these areas had yet to have sustained, direct contact with Euro-American populations until the late 19th and early 20th century. One outcome of this sustained contract was the introduction of new building designs and materials.

An example of a building from this period is the Holy Cross Episcopal Mission in Bolahun (Figure 7.26).

Episcopal missionaries began arriving in Liberia in the late 1830s and the missionary church in Bolahun was built ca. 1920 (HPSOL 2018). In 1938, a missionary at Bolah published a book entitled *A Brother At Bolahun: Letters from the Holy Cross Mission in Liberia, West Africa* describing his experiences as a missionary in Lofa County. In addition to new buildings, older traditional buildings (houses, mosques, administrative buildings, markets, etc.) were likely rebuilt or replaced by new buildings made of modern materials such as concrete (Figure 7.26).

Figure 7.25 *Possible Example of a Western Sudan style structure in Bondowalahun No. 2 Village*



Figure 7.26 *Examples of Late 19th and 20th Century buildings in Liberia: ca. 1920 Holy Cross Episcopal Mission, Bolahun, Lofa County; 20th century Salayea Mosque, Salayea, Lofa County; and Late 19th/early 20th century street in Liberia.*



Source: HPSOL 2018

Built heritage resources are typically found within or near existing or former towns, villages, and cities. The relatively remote location of the proposed power generating infrastructure (dam, powerhouse, reservoir) means it is highly unlikely there are any undiscovered built heritage resources within the footprint of these components. Built heritage resource, however, could be present near or within portions of the 33 KV transmission line and access road right-of-ways near villages and towns. Depending on the final transmission line route, the line may pass near the Holy Cross Episcopal Mission in Bolahun.

The cultural significance of these structures is due to their historical association with broad themes in the history of Liberia and Lofa County, their historical design elements and construction methods, aesthetic elements, and association with historic events or persons in local and regional history. These structures may also have cultural and religious significance to local and regional populations, particularly early Christian missions or mosques.

Living Heritage Resources

The majority of Liberians self-identify as Christian or Muslim (Olukoju 2006). Living heritage resources associated with rituals and beliefs of these two

major religions include churches, mosques, and cemeteries (*Figure 7.26*). Christian churches, Muslim mosques, and cemeteries associated with either religion are easily identified and are most often found within established towns and villages. Individual family cemeteries, however, are often more difficult to identify and can be found across the landscape near current or former house locations. Religious living heritage resources are culturally significant due to their use for religious practices and rituals as well as, through participation in group rituals and services, providing a sense of group/community identity. Cemeteries in particular, establish a sense of belonging to a place or location by reminding individuals of ancestral connections to an area.

In addition to being members of Christian or Muslim communities, numerous ethnic groups in northern Liberia participate in traditional secret societies associated with the supernatural world of ancestral and bush spirits. The two most prominent societies are the Poro for men and the Sande for women. Mande immigrants who began arriving in the region as early as A.D. 1000 introduced the Poro society to northern Liberia. The earliest reference to the Sande society in Liberia is from a Dutch geographer in A.D. 1628 (Little 1949; Olukoju 2006).

The primary roles of both the Sande and Poro societies in local communities is initiate young girls and boys as full adult members of the local community (Little 1949; Olukoju 2006). These initiation rites are performed at secret locations or compounds sometimes referred to as 'bush schools.' The Poro initiation rituals take place in the dry season, between October and May, at secret compounds (*Figure 7.27*). Sande initiations also take place in the post-harvest dry season at secret, specially cleared areas in the forest surrounding the village or town (*Figure 7.27*). Through these rites of initiation, the Poro and Sande societies instil a sense of social cohesion and comradery in initiates and deter antisocial behaviours or beliefs (Little 1949; Olukoju 2006).

Figure 7.27 *Poro Enclosure (left) and Sande Ritual Graduation Dance (right)*



Source: HPSOL 2018

The exact location of the religious sites are secret and cannot be revealed to outsiders/non-members. This makes it difficult to determine whether any Poro, Sande, or other secret society sites are located within Project's direct or indirect impact zone. During earlier Project sponsored baseline studies, the secrecy surrounding these religious practices and cultural sites prevented further investigations, but stakeholders assured that cultural heritage, graveyards, etc. should not be considered as a major obstacle to the proposed project (Multiconsult 2016). The ecology specialist was prevented from going near to a religious site near at Facunda village (also called Fahgunda, see Figure 2.2) because of the female cultural activity that was taking place in the forest.

Living heritage resources are likely present across the Project area. Large, structural resources such as churches or mosques are typically found in permanent villages, towns, or cities although remote locations such as monasteries and shrines are not uncommon. Depending on the final route the 33KV transmission and access road may pass near the larger living heritage resources such as churches, mosques, or cemeteries.

If present, more remote living heritage resources such as Sande and Poro enclosures/clearings and small, abandoned cemeteries could be present within the footprint of Project component.

Cultural Heritage Resource Sensitivities

The sensitivities of the various types of cultural heritage resources identified during the baseline study were evaluated using definitions for replicable, non-replicable, and critical cultural heritage as defined by World Bank Group (IFC Performance Standards).

- **Low Sensitivity:** Built heritage or living heritage resources that can be relocated another location or replaced by a similar structure or natural features to which the cultural values can be transferred by appropriate measures.

Archaeological or historical sites where the particular eras and cultural values they represent are well represented by other sites and/or structures in the region.

- **Medium Sensitivity:** Cultural heritage resources that are unique or relatively unique for the period or cultural values they represent or cultural heritage that is unique or relatively unique in linking several periods in the same site. Resources with significant cultural value to local indigenous communities.
- **High Sensitivity:** Internationally recognized heritage of communities who use, or have used within living memory the cultural heritage for long-standing cultural purposes or legally protected cultural heritage.

These criteria were applied to the types of cultural heritage resources identified during the baseline study that may be present within the Project area. The results of this analysis are summarized in Table 7.26.

Table 7.26 *Sensitivity of Cultural Heritage Resources*

Resource Type	Site Types	Classification	Sensitivity
Archaeological Sites	Late Stone Age and Iron Age small artefact scatters, isolated artefact finds, temporary camp or resource procurement or iron smelting sites.	Replicable	Low
	Middle Stone Age open air or rock shelter sites, Late Stone Age and Iron Age settlement sites, "Old Town" historic village sites.	Non-Replicable	Medium
Built Heritage	Modern Western Sudan style structures; middle to late 20 th century Euro-American style buildings.	Replicable	Low
	Late 19 th -early 20 th century Euro-American style buildings and Western Sudan style structures. Historic Mosques and cemeteries.	Non-replicable	Medium
Living Heritage	Small shrines and monuments. Individual family cemeteries.	Replicable	Low
	Modern and historic churches, mosques, community cemeteries. Poro, Sande, and other secret society ritual locations (enclosures, compounds, forest clearings, etc.)	Non-replicable	Medium

This Chapter identifies and assesses environmental and social impacts and risks of the Project and Project-related activities during construction and operations. Measures to mitigate negative impacts are described. Impacts have been assessed based on the methodology provided in Chapter 4.

A summary of the impacts discussed in this chapter is provided in Table 8.1.

Table 8.1 *Summary of Project Impacts and Risks*

Resource or Receptor	Impact or Risk	Pre-mitigation	Post-mitigation
Biophysical			
Surface Water	Degradation of Surface Water Quality from Construction of Hydropower Plant, Associated Infrastructure, Transmission Line and Diesel Power Plant	Moderate (-)	Minor (-)
Surface Water	Degradation of Surface Water Quality from Operation of Hydropower Plant, Associated Infrastructure, Transmission Line and Diesel Power Plant	Moderate (-)	Minor (-)
Surface Water	Degradation of Water Quality and Indirect Negative Effects on Ecology due to Sedimentation of the Reservoir During Operations	Minor (-)	Negligible (-)
Surface Water	Changes on Downstream River Flow Volumes and Indirect Effects from Hydropower Plant, Associated Infrastructure, Transmission Lines and Diesel Power Plant during Construction and Operations	Minor (-)	Minor (-)
Public Safety	Risk of Major Flooding and Related Catastrophic Impacts Due to Dam Failure during Operations	Moderate (-)	Minor (-)
Aquatic Ecology	Alteration of Downstream Aquatic Habitat Due to Peaking during Operations	Moderate (-)	Minor (-)
Aquatic Ecology	Loss of Downstream Aquatic Habitat due to Reduced Water Quality because of Hydropower Plant Construction Activities	Moderate (-)	Minor (-)
Aquatic Ecology	Alteration of Upstream Aquatic Habitat Due to Inundation Caused by Construction and Operation of the Dam	Moderate (-)	Moderate (-)
Aquatic Ecology	Loss of Waterfall and Water Rapids Features and Fish Spawning Habitat Due to Construction and Operation of the Hydropower Plant	Moderate (-)	Minor (-)
Aquatic Ecology	Risk of Alteration of Fish Migration and Breeding Patterns Due to Construction and Operation of the Hydropower Plant	Moderate (-)	Minor (-)

Resource or Receptor	Impact or Risk	Pre-mitigation	Post-mitigation
Aquatic Ecology	Injury to Fish Caused by Interaction with Physical Structures including Turbines or Spillway during Operations	Moderate (-)	Minor (-)
Terrestrial Ecology	Loss of Forest Habitat due to Reservoir Inundation, Hydropower Plant Footprint, Access Road, Construction Camp and Laydown Areas during Construction and Operations	Major (-)	Major (-)
Terrestrial Ecology	Loss of Forest Habitat due to Construction of the Transmission Line	Moderate (-)	Moderate to Minor (-)
Terrestrial Ecology	Displacement and Loss of Fauna Due to Disturbance from Hydropower Plant and Access Road Construction Activities	Major (-)	Moderate (-)
Biodiversity	Increased Pressure on Natural Resources due to Increased Ease of Access as a Result of Construction and Operation of a New Access Road	Moderate (-)	Moderate to Minor (-)
Biodiversity	Risk of Increased Incidence of Invasive and Alien Plant Species due to Hydropower Plant, Associated Infrastructure, Access Road, Transmission Lines and Diesel Power Plant Construction	Moderate (-)	Minor (-)
Fauna	Risk of Physical Injury to Birds and Bats due to Operations of Transmission Line	Moderate (-)	Moderate to Minor (-)
Fauna	Disturbance of Fauna (excluding birds) due to Transmission Line Construction	Major (-)	Moderate (-)
Soils	Loss of Fertile Soil for the Construction of the Hydropower Plant Footprint, Access Road, Transmission Line, Construction Camp and Laydown Area	Moderate (-)	Moderate (-)
Soils	Impact of Change in Land Use and Capability for Construction and Operation of the Hydropower Plant Footprint, Access Road, Transmission Line, Construction Camp and Laydown Area	Moderate (-)	Moderate (-)
Air Quality	Reduced Air Quality due to Operation of the Diesel Power Plant	Minor (-)	Minor (-)
GHG	Increase in GHG Emissions due to the Construction of the Hydropower Plant and Access Road and Operation of Diesel Generators	Minor (-)	Minor (-)
GHG	Risk of Climate Change Related External Factors on Operation of the Hydropower Plant	See report	See report
Socio-Economic			
Macroeconomy	Increased Employment, Skills Enhancement and Local Business Due to the Construction of the Hydropower Plant, Associated Infrastructure, Transmission Lines and Diesel Power Plant	Moderate (+)	Moderate (+)
Macroeconomy	Increased Employment, Skills Enhancement and Local Business due to the Operation of	Major (+)	Major (+)

Resource or Receptor	Impact or Risk	Pre-mitigation	Post-mitigation
	the Hydropower Plant and Diesel Power Plant		
Land	Land Tenure, Ownership and Use (Economic Displacement)	Major (-)	Minor (-)
Public Infrastructure	Increased Pressure on Local Infrastructure and Services	Moderate (-)	Moderate (-)
Community Health and Safety	Increased Health and Safety Risk for Community Associated with Influx of People during Construction of the Hydropower Plant and Diesel Power Plant	Moderate (-) to High (-)	Minor - Moderate (-)
Sense of Place	Increased Nuisance Factors and Changes in Sense of Place due to Hydropower Plant and Access Roads	Moderate (-)	Minor (-)
Visual Amenity	Loss of Visual Amenity and Sense of Place of the Waterfall due to Construction of the Hydropower Plant, Dam and Access Road	Negligible (-)	Negligible (-)
Noise	Disturbance of Local Communities due to Noise from Operation of the Diesel Generators	Minor (-)	Minor (-)
Cultural Heritage	Risk of Loss of Cultural Heritage due to Construction of Hydropower Plant Infrastructure, Access Roads and Transmission Lines	Minor (-) to Major (-)	Negligible to Moderate (-)

8.1 BIOPHYSICAL ENVIRONMENT

8.1.1 *Degradation of Surface Water Quality from Construction of Hydropower Plant, Associated Infrastructure, Transmission Line and Diesel Power Plant*

Potential Impacts

Surface water could be contaminated by excess runoff of soil from cleared areas or from stockpiles. The result could be siltation of watercourses and smothering of aquatic plants and vegetation. Surface water could also be contaminated from accidental spills of hazardous materials.

Baseline Conditions

The water quality in the Kaiha River is of generally high quality in ecological terms although it does not fully meet drinking water quality standards due to elevated turbidity levels. Furthermore, according to GLM Engineering (2017), a combination of site observations, reference to the professional literature, and application of an Africa-specific sediment yield equation, point to very low sediment loads.

The water quality in smaller waterbodies nearby access roads and power lines and Sagarkor Creek 230 m from the Diesel Power Plant is unknown but is likely to be of reasonably good given the generally rural setting.

Impact Assessment

Vegetation clearance, road upgrades and earthworks, soil erosion and run-off of crushed and ground rock material from drilling, blasting and stone crushing during construction, if not properly managed, could cause increased sediment load, and hence increased turbidity and reduced dissolved oxygen in the river. In addition, there is the potential for siltation in slow-flowing river stretches.

The development of the transmission lines and the access road may require construction of corridors crossing aquatic habitats that may disrupt watercourses and wetlands, and require the removal of riparian vegetation.

The existing 40 km road between Mbaloma town and Kolahun town will need upgrade and maintenance during and after rainy seasons, leading to an increase sediment runoff.

There is also the potential for pesticides to be used in vegetation clearance. Further, there is a potential for accidental fuel and oil spills from construction machinery, releases of insulating oils used for the transformers as well as leaching of creosote near the treated transmission poles or lead from batteries.

The concrete batching and mixing plant has the potential to contaminate receiving watercourses with concrete during construction, resulting in a higher pH. Other potential sources of watercourse contamination during construction:

- Accidental fuel and oil spills from machinery;
- Leaching of ammonia and nitrogen from the blasting;
- Releases/spills of hazardous materials;
- Hydrocarbon release (fuel, lubricating oil, grease, hydraulic fluid) from the workshop;
- Contamination from any solid and liquid wastes generated; and
- Sanitary effluents from the workers' camp (offices and housing) which will generate potential sources for microbiological and organic pollution.

The impact significance of the construction of the project on surface water quality is considered to be moderate negative without mitigation.

Table 8.2 *Pre-Mitigation Impact Assessment*

Type of Impact		
Direct, indirect		
Rating of Impacts		
Characteristic	Designation	Summary of Reasoning
Extent	Local	Contamination is likely to be limited to areas immediately surrounding site.
Duration	Short term	Impacts will peak during a spill or rainfall event.
Scale	<1km	Contamination is likely to be limited to areas immediately surrounding site.
Frequency	Often	Without mitigation rainfall would frequently transport spills to watercourses.
Magnitude		
Medium		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
Medium		
Water quality within Kaiha River is very good and watercourses in other areas of the project are likely to be good.		
Significance Rating Before Mitigation		
Moderate negative		

Mitigation Measures

The following mitigation measures will be incorporated into the site management:

- Route access roads to avoid areas with gradients in excess of 8%. Where this is unavoidable, stabilise the road surface.
- Provide runoff-control measures such as sloping roads to allow for unrestricted runoff of water and the incorporation of permanent slope diversions which intercept the down-slope flow of runoff and divert this via natural contours and gradual slopes into vegetated areas.
- Provide adequate road drainage based on road width, surface material, compaction, and maintenance.
- Install erosion control measures as each road section is completed.
- Route roads to avoid drainage lines, wetlands and riparian areas. Where access roads through drainage lines and riparian zones is unavoidable, only one road is permitted, constructed perpendicular to the drainage line. Avoid roads that follow drainage lines within the floodplain.
- The smallest footprint necessary for construction/decommissioning must be cleared, with clearance done in a phased approach as and when necessary.

- For transmission lines vegetation may not need to be completely removed but could be cut back to allow for at least the substrate plant matter to prevail on site where possible.
- Construction vehicles and personnel to stay within the designated footprint area.
- Use temporary bridges or mats and wide-track vehicles to distribute weight at crossing watercourses if there is no bridge present.
- For transmission lines no pylons must be placed within the riparian zone of the watercourse. Rather have lines avoid or span watercourse/wetland/riparian areas.
- During blasting, measures should be employed where practical to limit the spread of fly-rock.
- Remove any stockpiled soils, waste and equipment from below the reservoir high-water mark prior to filling.
- Geo-textiles shall be used to stabilize soil stockpiles and uncovered soil surfaces during the construction phase and to serve as a sediment trap to contain as much soil as possible that might erode away.
- Soil stockpiles shall be covered or dampened with dust suppressant or equivalent, as required, to prevent wind erosion.
- Compile a stormwater management plan for the site to separate and manage clean and dirty water.
- In general all equipment, machinery, trucks and camp installations have to be located a distance of more than 250 m to water used for human consumption and at least 150 m to any surface water.
- Waste water from the camp site must be collected in portable latrines or septic tanks and has to be treated before releasing into a river. Pit latrines may not be used.
- For access road construction/upgrading and transmission lines portable latrines are to be in place along the route where construction is taking place.
- Compile a **Waste Management Plan (WMP)**, in accordance with the World Bank Group General EHS Guidelines (April 2007) section 1.6. See Box 1 below.

Box 1 : Key principles of World Bank Group General EHS Guidelines (April 2007) Section 1.6

Facilities that generate and store wastes should practice the following:

- Establishing waste management priorities at the outset of activities based on an understanding of potential EHS risks and impacts and considering waste generation and its consequences.
- Establishing a waste management hierarchy that considers prevention, reduction, reuse, recovery, recycling, removal and finally disposal of wastes.
- Avoiding or minimizing the generation of waste materials, as far as practicable.
- recovering and reusing waste, where waste generation cannot be avoided but has been minimized.
- Treating, destroying and disposing of waste in an environmentally sound manner, where waste cannot be recovered or reused.

The following guidance applies to the management of non-hazardous and hazardous waste:

- **Waste management planning:** Facilities that generate waste should characterise waste according to composition, source, types of wastes produced, generation rates, or according to local regulatory requirements.
- **Waste prevention:** Processes should be designed and operated to prevent, or minimise, the quantities of and hazards associated with wastes generated.
- **Recycling and reuse:** The total amount of waste should be reduced through the implementation of recycling plans.
- **Treatment and disposal:** If waste materials are still generated after the implementation of feasible waste prevention, reduction, reuse, recovery and recycling measures, waste materials should be treated and disposed of and all measures should be taken to avoid potential impacts to human health and the environment. Selected management approaches should be consistent with the characteristics of the waste and local regulations.
- **Hazardous waste management:** Hazardous wastes should always be segregated from non-hazardous wastes. If generation of hazardous waste cannot be prevented through the above general waste management practices, its management should focus on the prevention of harm to health, safety and the environment.
- **Waste storage:** Hazardous waste should be stored so as to prevent or control accidental releases to air, soil, and water resources.
- **Transportation:** On-site and off-site transportation of waste should be conducted so as to prevent or minimise spills, releases and exposures to employees and the public. All waste containers designated for off-site shipment should be secured and labelled with the contents and associated hazards, be properly loaded on the transport vehicles before leaving the site, and be accompanied by a shipping paper (i.e. manifest) that describes the load and its associated hazards, consistent with Section 3.4 of World Bank Group General EHS Guidelines section on the transport of hazardous materials.
- **Treatment and disposal:** In the absence of qualified commercial or government-owned waste disposal operations, project sponsors should consider installing on-site waste treatment or recycling processes or as a final option on-site waste disposal.
- **Monitoring:** Monitoring of the management of hazardous and non-hazardous waste should be undertaken, including monitoring of groundwater quality.

- Develop an Erosion Control Plan.
- Develop a Hazardous Material (HAZMAT) Register.
- Undertake a Hazard Assessment which includes spill scenarios, potential for uncontrolled reactions, consequence analysis, occupational health and safety.
- Compile a Hazardous Materials Management Plan for handling, storage, use and disposal.
- Develop and implement a Pesticides Management Plan.

- Undertake soil and vegetation rehabilitation measures through a formalised Rehabilitation Plan.
- Develop and implement a Water Quality Monitoring Plan.
- Accidental spills or any contaminated water will be isolated and treated as soon as possible. An emergency spill procedure will be drafted and the construction team will be versed in identifying and responding to accidental spill events.
- Monitor roads during the construction phase to ensure adequate maintenance is undertaken.
- Removal and disposal of the aboveground fuel tanks at the Diesel Power Plant site shall include:
 - Remove and containerise any residual liquids and sludges from the above-ground storage tanks at the Diesel Power Plant site, such that no recoverable product and less than one inch of material remains in the tank. Transport and dispose off-site at a landfill licensed to accept hazardous waste and in compliance with local law. A spillkit shall be on hand during removal of the storage tanks.
 - Before commencing tank removal activities the tanks should be inerted so as to remove the risk of explosion. Proven inerting methods include hydrophobic foam fill, nitrogen foam fill, nitrogen gas purging, water fill, dry ice, combustion of gas and cleaning-degassing. The presence of vapours shall be checked with a combustible gas meter.
 - Disconnect, cut, remove and dispose of the tanks in accordance with local regulations. Any tank cutting shall be performed in accordance with a risk assessment and management plan for hot works specific to the tank removal to ensure risks to workers are mitigated. Piping from tanks to storage or burning equipment shall be removed and disposed off-site at a landfill licensed to accept hazardous waste and in compliance with local law.

Table 8.3 *Residual Impact Significance*

Impact	Project Phase	Significance (Pre Mitigation)	Residual Impact Significance (Post Mitigation)
Reduced water quality from Hydropower Plant	Construction	Moderate negative	Minor negative

8.1.2 *Degradation of Surface Water Quality from Operation of Hydropower Plant, Associated Infrastructure, Transmission Line and Diesel Power Plant*

Potential Impacts

The Kaiha River upstream of the dam will be converted into a slow flowing reservoir and as such water quality characteristics will change. Depending on the stratification patterns and the depth of the euphotic zone in the new impoundment, temperature, dissolved oxygen, turbidity and nutrient concentrations may change compared to the previous flowing river environment. The increase in surface water area also has the potential to increase the water temperature. The dam will reduce flow velocities and increase sediment trapping. These changes could determine which species could adapt, which could die out and which may take on pest proportions in the impoundment.

There is also the potential for the accidental release of fuel and oil spills from the diesel power plant site, particularly from the fuels tanks and associated pumps, piping system, filters and meters. Accidental release of hydrocarbons has the potential to impact to the Sagarkor Creek located about 230 m from proposed plant location. Similarly fuel spills could occur from the storage tanks of the emergency generator within the Hydropower Plant power house.

Baseline Conditions

The water quality in the Kaiha River is high in ecological terms although it does not fully meet drinking water quality standards due to elevated turbidity levels. Furthermore, according to GLM Engineering (2017) a combination of site observations, reference to the professional literature, and application of an Africa-specific sediment yield equation, point to very low sediment loads.

The water quality in smaller waterbodies nearby access roads and power lines and Sagarkor Creek 230 m from the Diesel Power Plant is likely to be of reasonably good water quality given the generally rural setting.

In the operation phase, the impact significance of the project on water quality is moderate negative without mitigation.

Impact Assessment

The impacts on Kaiha River water quality generally depends on the retention (turnover) time of the reservoir (ie, storage capacity in relation to the amount of water flowing into it) and the pre-impoundment conditions, especially the amount of submerged biomass.

Water in small reservoirs behind a run-of-river dam will undergo very little deterioration, while that stored for many months or years behind a major dam

where vegetation is left decomposing in anoxic conditions may produce methane, lethal to most life in the reservoir and in the river downstream.

Due to the combined effect of the following, it is unlikely that the Kaiha 2 reservoir will be subject to significant water quality deterioration:

- The Kaiha 2 hydropower plant will be operated as a run-of-river scheme, except in the transition period between the dry and wet season when the reservoir will be used for daily peaking. The average retention (turnover) time of the reservoir is approximately 2 hours in the wet season and 2 days in the dry season, assuming a reservoir volume of 700,000 m³.
- The maximum depth of the reservoir is 5 m at the dam and significantly less towards the tail of the reservoir.
- The amount of organic matter and nutrients entering the reservoir is assumed to be low and is not expected to create eutrophic conditions.

During the operation phase, the risk of water pollution at the Hydropower Plant will be reduced as compared to the construction phase. However, accidental spills could still occur with inadequate handling of waste and wastewater combined with failure of spill prevention systems.

Potential sources of water quality impact during the operational phases include:

- Accidental fuel and oil spills from machinery or turbines;
- Hydrocarbon impact (fuel, lubricating oil, grease, hydraulic fluid) from the workshop;
- Releases of stored hazardous materials;
- Contamination from any solid and liquid wastes generated; and
- Unmanaged sanitary effluents from the workers' camp (offices and housing) which will generate potential sources for microbiological and organic pollution.

The same potential for the above listed accidental spills exists for the Diesel Power Plant, however the Sagarkor Creek is located 230 m from the building hence there are unlikely to be any direct spills to the creek, which offers greater protection and opportunity for remediation.

The proposed transmission line is likely to result in a low impact towards the formation of erosion and sedimentation due to the relatively low maintenance requirements of the line and limited human interference. However, there may

be use of pesticides to ensure vegetation growth does not affect the transmission line and this could enter watercourses.

Table 8.4 Pre-Mitigation Impact Assessment

Type of Impact		
Direct, indirect		
Rating of Impacts		
Characteristic	Designation	Summary of Reasoning
Extent	Local	Contamination is likely to be limited to areas immediately surrounding site. The reservoir water quality is unlikely to degrade.
Duration	Short term	Impacts will peak during a spill or rainfall event.
Scale	<1km	Contamination is likely to be limited to areas immediately surrounding site.
Frequency	Infrequent	Although the water quality in the reservoir will be a more-or-less frequent change this change is likely to be very minor, whilst infrequent accidental spills are likely to have larger effects.
Magnitude		
Medium		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
Medium		
Water quality within Kaiha River is very good and watercourses in other areas of the project are likely to be good.		
Significance Rating Before Mitigation		
Moderate negative		

Mitigation Measures

The following mitigation measures are recommended:

- Sanitary water treatment facilities shall be installed.
- Update and continue using the Water Quality Monitoring Plan.
- Update and continue using the Waste Management Plan.
- Update and continue using the HAZMAT Register and Hazardous Materials Management Plan.
- Continue use of the Pesticide Management Plan drawn up for construction.
- Restrict vehicle access to the transmission line servitude for maintenance work.
- Continued monitoring to ensure that there are no water quality impacts due to releases of insulating oils / gases used for the transformers.

- Undertake regular road maintenance to limit erosion.
- Regularly remove topsoil (and other material) accumulated in side drains of roadways to keep these open and functional.
- For Diesel Power Plant and Hydropower Plant permanent fuel storage area, permanent fuel storage should be done within designated areas only, which are roofed and properly bunded to 110% capacity to contain any potential fuel leaks. Firefighting equipment to be present. Bunds should be equipped with sumps. Any liquid pumped from the bunds must be adequately treated before proper disposal in accordance with the Waste Management Plan. All storage areas shall have spill kits, sand, dust, and other appropriate absorbent materials. The contaminated absorbent and any contaminated soils to be disposed of properly.

Table 8.5 *Residual Impact Significance*

Impact	Project Phase	Significance (Pre Mitigation)	Residual Impact Significance (Post Mitigation)
Reduced water quality from operation of Hydropower Plant, associated infrastructure, transmission line and Diesel Power Plant	Operation	Moderate negative	Minor negative

8.1.3***Degradation of Water Quality and Indirect Negative Effects on Ecology due to Sedimentation of the Reservoir During Operations****Potential Impacts*

The dam will create a physical barrier in the river continuum and hence obstruct the flow of sediments from the upstream to the downstream. The sediments will be transported into the reservoir by the inflow, mainly during the rainy season, or from shoreline erosion caused by water level fluctuations in the reservoir during peaking operation.

Summary of Relevant Baseline Conditions

Very low sediment loads are anticipated in the Kaiha River. Most of the sediment load will be in the form of quartz sand, with a mean diameter of approximately 0.5 mm based on sediment samples from Kaiha River (GLM Engineering 2017).

Impact Assessment

Coarse sediments will be deposited in the head and tail reach of the reservoir before progressively filling up the pool closer to the dam. This will reduce the life of the reservoir and eventually increase the amount of coarse sediments entering the intakes, while fine sediments (clay, silt and fine sand) and associated nutrients will mostly pass over the spillway or through the turbines. According to GLM Engineering (2017), it is estimated that the sand delta will not reach the dam within the first 20 years of operation.

The significance of sedimentation of the reservoir is considered to be minor negative without mitigation.

Table 8.6 *Pre-Mitigation Impact Assessment*

Type of Impact		
Direct		
Rating of Impacts		
Characteristic	Designation	Summary of Reasoning
Extent	Local	Sedimentation will be limited to the reservoir.
Duration	Long term	The impact will only be felt after a long time but will be permanent.
Scale	<1km	Sedimentation will be limited to the reservoir.
Frequency	Continuous	The affect will start with operation and continue for the life of the reservoir
Magnitude		
Medium		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
Low		
Very low sediment loads are anticipated in the Kaiha River.		
Significance Rating Before Mitigation		
Minor negative		

Mitigation Measures

The following mitigation measures are recommended:

- Reservoir sedimentation to be reduced using the flushing gate and/or by drawing down the water level and using excavators.
- Apply erosion control measures to all new roads constructed and implement an Erosion Management Plan.
- Implement the recommendations of the sedimentology report (GLM Engineering. 2017), including:
 - Promote development and dissemination of improved agricultural practices (both cultural and post-harvest) which enable farmers to obtain more economic benefit from the more intensive utilisation of the best agricultural soils, thereby reducing the pressure to cut and burn erosion-prone forest lands with steeper soils.
- Monitor sediment annually during operation from the dam upstream as far as possible, with the reservoir full, measuring water depth along the original (now flooded) river channel at intervals of approximately 100 m. Make measurements in the straight portion of the channel and not in river bends. The location of each measurement point can be recorded using a hand-held GPS unit (horizontal accuracy about 5m). It is recommended that the measurement points be pre-selected and recorded by GPS prior to filling the reservoir to avoid sites with rocks which will give an irregular bottom depth, and to revisit these same sites at each subsequent sediment

survey. These survey sites should be areas with relatively flat bottoms and devoid of large stones, in straight reaches of the river between meander bends.

- Provide access to the upstream portion of the reservoir to permit sand and rock extraction from the reservoir for construction purposes.
- In the design and construction of the turbines, provide a port for extracting water samples from an area of high turbulence exiting the turbine for the purpose of monitoring sand concentration. When the sandy delta approaches to within 500 m of the intake, sampling of the concentration of sand exiting the turbines should increase to once daily. This sampling will help identify operational procedures which are useful to minimise the sediment load and resultant abrasion of turbines.

Table 8.7 *Residual Impact Significance*

Impact	Project Phase	Significance (Pre Mitigation)	Residual Impact Significance (Post Mitigation)
Sedimentation of the reservoir	Operation	Minor negative	Negligible

8.1.4***Changes on Downstream River Flow Volumes and Indirect Effects from Hydropower Plant, Associated Infrastructure, Transmission Lines and Diesel Power Plant during Construction and Operations****Potential Impact*

During construction coffer dams will be used to divert the river to allow for construction, the reservoir will be filled and impervious areas will be constructed (roads, buildings, construction camps). All these have the potential to change flows on nearby watercourses.

During operation the use of the reservoir for peaking power will change the downstream flow regime.

Baseline Conditions

The river flows currently experienced at the Hydropower Plant site are natural. The smaller watercourses along the access road, transmission line and near the Diesel Power Plant site probably experience moderate flow changes from human activities such as footpaths, roads and slash and burn agriculture.

Impact Assessment

During the main construction phase, coffer dams will be constructed to separate the construction pit from the river flow, thus providing a bypass for the water. In later stages of the dam construction, the river flow will pass through the flushing gate. As a result, the water flow in the Kaiha River during construction will be as it was before and there will be little of no impact to water quantity.

The construction of the hydropower plant will require a batching/crushing plant, stores (material, cement, fuel, etc.), workshop, offices and housing. The transmission line and access road will create exposed surfaces from vegetation clearing and harden surfaces such as the access roads themselves. The hardened surfaces and drainage are expected to slightly increase the runoff to the watercourse.

At the end of construction the reservoir will be filled, causing a reduction in downstream flow for a short period. However, as the impoundment is likely to occur during the rainy season, the filling period will only last for a few hours even if the flushing gate is kept open.

The impoundment will create a narrow reservoir extending approximately 13 km upstream of the dam to a point approximately 10 km north of the dam. The Project is not considered a significant consumer of water once the reservoir is full.

During operation, flow will be diverted through a penstock to the powerhouse and back to the river through the tailrace. Thus, the river flow will be significantly reduced along the bypassed section (approximately 60 m) to the extent that the riverbed (ie, rapids/waterfall) will be totally desiccated during the dry season, apart from the required environmental flow of 0.35 m³/s. In the rainy season, however, there will be spilling of water from the dam when the inflow exceeds the turbine discharge.

The Hydropower Plant is proposed to be operated as a peaking plant in periods when the daily average demand matches the river inflow (8 to 13 m³/s) to the maximum turbine discharge. These periods are typically in June and December ie, the transitions period between wet and dry seasons. There will be a 1 m draw-down of the reservoir during the hours with peak demand (afternoon and evening) when the turbines are run at maximum discharge (approximately 15 m³/s in the initial years). The reservoir will then be re-filled until the next afternoon with the turbines running in constrained mode to meet the off-peak demand. The typical turbine discharge during the re-filling hours will be approximately 5 m³/s in the initial years.

The inflows and outflows considered in this impact assessment are summarized in the following text and figures:

- During the dry season, all flow will be diverted to the turbines and the reservoir inflow will match the turbines flow. During this stage, there will be no flow over the spillway.
- In the wet season, there will be times when the inflow slightly exceeds the outflow provided by the turbines and spillway, and there will be times when the outflow slightly exceeds the inflow. The fluctuation will range from a 4% decrease to a 2% increase.
- During the transition period flow regime where river flow will be slightly higher than demand flow there will be times when the outflow exceeds the inflow (maximum increase in river flow of 38%) and times where the inflow exceeds outflow (maximum decrease in river flow of 43%).
- During the transition period flow regime where river flow is near the demand flow there will be times when the outflow exceeds the inflow (maximum increase in river flow of 99%) and times where the inflow exceeds outflow (maximum decrease in river flow of 35%).

Although there is a maximum decrease in downstream flow of 43% and a maximum increase in downstream flow of 99% during the transition period between wet and dry seasons, the flow does not decrease to below that of the average dry season flow, nor does it increase to above the average wet season flow. This peaking effect will be greatest in the immediate downstream reaches, and it will be buffered by the flow coming from the tributary at Munwunya Creek about 2 km downstream of the proposed dam site.

The only expected cessation of flow to the stream downstream of the tailrace during the operational phase would be if the turbine flow comes to a full stop as a result of planned or unplanned outages of the hydropower plant during periods when there is no spilling over the dam. However, this is unlikely for the hydropower plant due to (i) the short distance between the dam and the powerhouse tailrace, (ii) the short time period (a few minutes) until water will start spilling over the dam, and (iii) the opportunity to open the flushing gate for immediate release of a compensation flow.

Figure 8.1 *Dry Season Flow Regime: All the Inflow is diverted to the Turbines.*

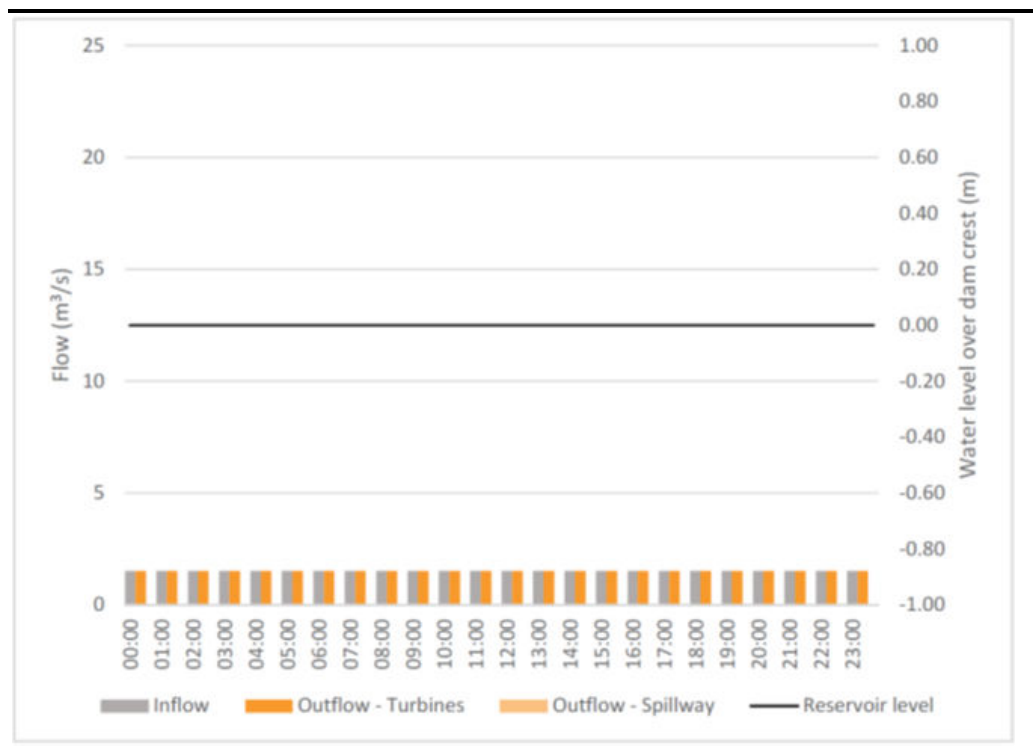


Figure 8.2 *Wet Season Flow Regime: The Turbine Flow Meets the Demand, while the Excess Water is Spilled Over the Dam.*

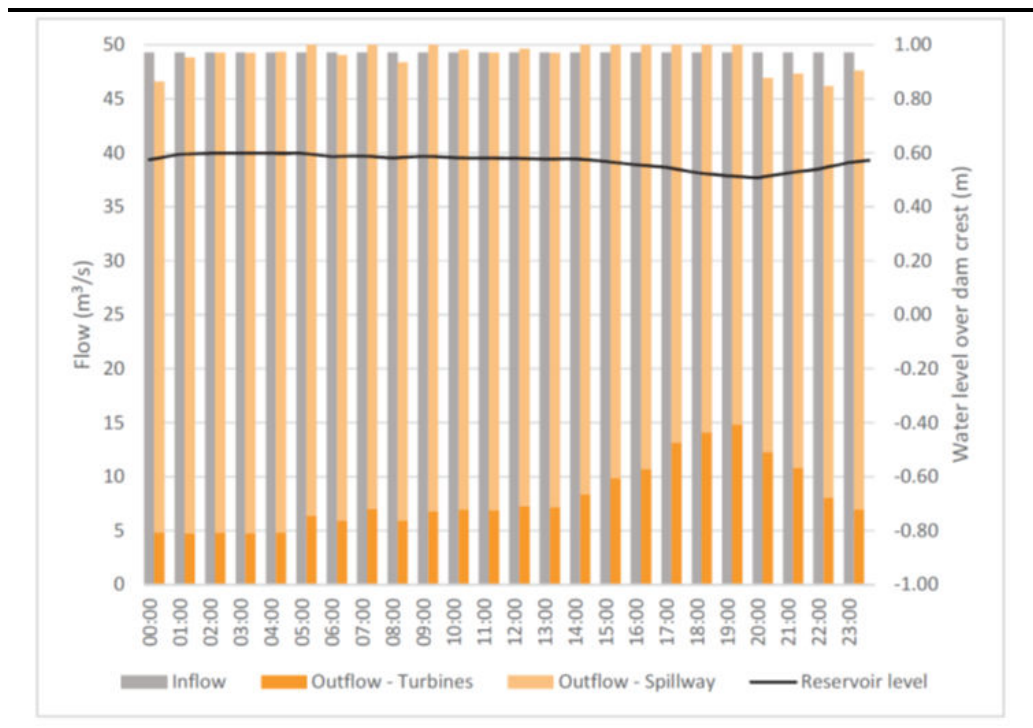


Figure 8.3

Transition period flow regime (river flow slightly higher than demand flow): Modest peaking operation with variable downstream flow combined with spilling over the dam for most of the day.

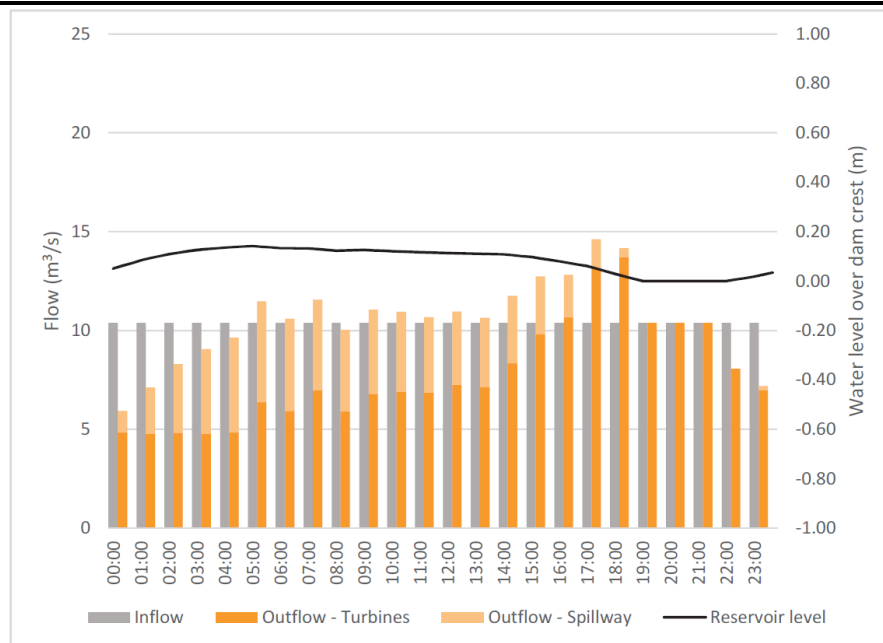
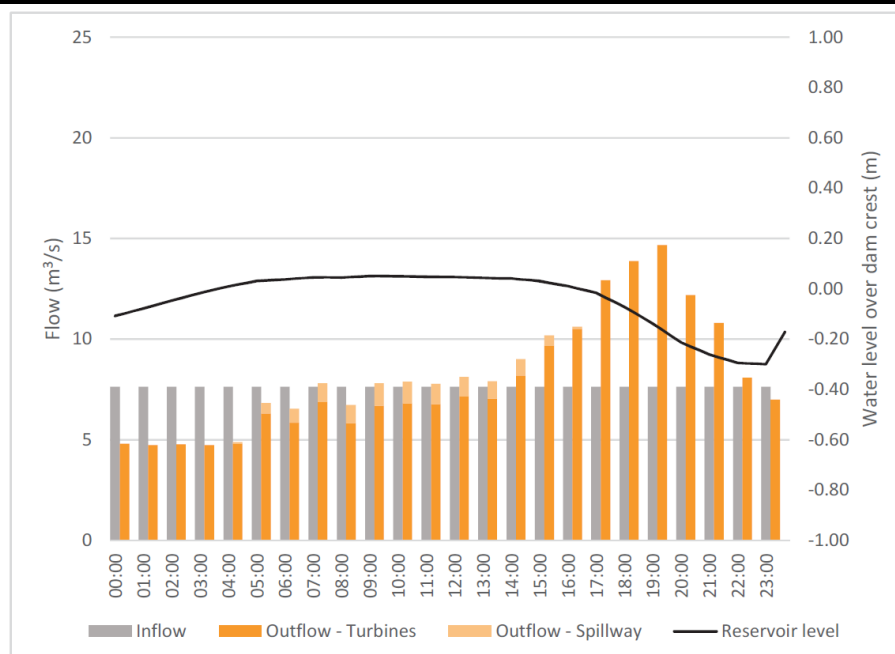


Figure 8.4

Transition Period Flow Regime (river flow near the demand flow): Peaking Operation with Variable Downstream Flow Combined with no (Or Minimal) Spilling over the Dam



Although dams have a positive impact on flood attenuation; given the small size of the dam (370,000m³ available for peaking regulation) this is expected to be insignificant.

The impact significance of the changes to water flow (water quantity) during construction and operation are considered to be minor negative with and without mitigation.

Table 8.8 *Pre-mitigation Impact Assessment*

Type of Impact		
Direct, indirect		
Rating of Impacts		
Characteristic	Designation	Summary of Reasoning
Extent	Local	The biggest impact, that of stoppages of outflow from the Hydropower Plant turbines, would be limited to within 2 km of the site.
Duration	Temporary	The change would be felt during rainfall events and during peaking periods (transition between wet and dry season).
Scale	<2km	The biggest impact, that of stoppages of outflow from the Hydropower Plant turbines, would be limited to within 2 km of the site.
Frequency	Occasional	The change would be felt during rainfall events and continuously during peaking periods (transition between wet and dry season, a few weeks of the year).
Magnitude		
Medium		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
Low		
The Kaiha River and smaller watercourses of the area are naturally subject to changes in flow during the wet and dry season.		
Significance Rating Before Mitigation		
Minor negative		

Mitigation Measures

The following mitigation measures will be incorporated into the site management:

- Should any water be required to be abstracted from the watercourse for construction purposes, this should be done in a way not to impact the flow. This abstraction may require regulatory permissions.
- Where possible, allow runoff from hard/exposed surfaces to infiltrate the soils rather than discharge direct to the watercourse.
- Ensure reservoir filling occurs during the rainy season (May to November, ideally June to September).

- During the initial filling of the reservoir, a minimum flow shall be released through the flushing gate equal to at least 50% of the inflow at the time of impoundment.
- An environmental flow of at least 0.35 m³/s (10% of the dry season flow) shall be released into the bypassed reach at all times. Once biomonitoring has been undertaken the environmental flow shall be amended to the flow volumes and regimes as required by an aquatic ecology specialist.
- The daily peaking to be operated to ensure smooth transitions between maximum and minimum discharge, thus avoiding rapid changes in downstream river flow and water levels.
- In case of hydropower plant outage during periods when there is no spilling over the dam, provide a compensation flow by immediately opening the flushing gate.
- Do not locate infrastructure not designed to be inundated within the 1:100 year floodline or within a horizontal distance of 100 m (whichever is greater) of the watercourse.
- Define an **Emergency Preparedness and Response System** as per *Section 8.2.5*.

Table 8.9 *Residual Impact Significance*

Impact	Project Phase	Significance (Pre Mitigation)	Residual Impact Significance (Post Mitigation)
Changes on downstream flow volumes from Hydropower Plant, Associated infrastructure, transmission lines and Diesel Power Plant	Construction, operation	Minor negative	Minor negative

8.1.5

Alteration of Downstream Aquatic Habitat Due to Peaking during Operations*Potential Impacts*

The water flows from the reservoir will alter compared to normal during the transition periods between the wet and dry season when peaking power will be generated. The downstream impacts of the changes in flow due to peaking operation of the Hydropower Plant will be minimal for most of the time due to the predominantly run-of-river operation mode of the hydropower plant. However, during the transition periods the water levels in the reservoir as well as in the downstream reaches will fluctuate daily.

Summary of Relevant Baseline Conditions

The Kaiha River and its project impact zone contains at least 12 fish species, including *Sarotherodon occidentalis* (NT) and *Doumea chappuisi* (VU) (a loach catfish sp.). In addition, five other species of conservation concern were reported by local fishermen, including the critically endangered (CR) *Barbus carcharhinoides* (a barbel sp.) and *Labeo curriei* (a carp sp.). Of these, the presence of *B. carcharhinoides* is questionable while *L. curriei* is also known from Mano River and other rivers in Liberia. In fact, all the fish species that were confirmed by sampling are also known from other rivers in the sub-region. Nevertheless, due to the presence of these species of global conservation concern, the value with respect to aquatic ecology is rated as high. Endangered and critically endangered species are present that can potentially trigger critical habitats.

Of the observed fish, three species, *L. parvus* (LC), *B. sacratius* (LC) and *D. chappuisi* (V) are considered sensitive to habitat transformation. Transformation of instream habitat structure of hydrology typically impacts negatively on these species, which will alter the fish assemblages as a whole.

Impact Assessment

Specific impacts associated with daily fluctuation (peaking) may include:

- Flushing of aquatic organisms;
- Isolation or stranding of aquatic organisms as peaking recedes;
- Increase erosion on banks as riparian vegetation may struggle to establish due to rapid fluxes in water depth; and
- Rapid in temperature and dissolved oxygen, which can affect aquatic organisms

The ramping rate (the rate of change of water flow) in the downstream reaches cannot be determined for the project due to the lack of site-specific hydrological measurements. However, the ratio between the maximum and minimum flow during peaking operation (known as the peaking flow ratio) will be approximately 3 (15 m³/s divided by 5 m³/s), which is generally considered to have no or very small impacts on ecosystem properties (Bain 2007). This low peaking flow ratio is mainly due to the constant operation and turbine flow in non-peak hours, hence there will be no sudden shutdown of the power plant to re-fill the reservoir.

The only exception would be if the turbine flow comes to a full stop because of planned or unplanned outages of the hydropower plant during periods when there is no spilling over the dam. In such a case, the critical factor would be the time lag from the outage event until a compensation flow can be released over the dam or from the flushing gate.

The pre-mitigation significance of peaking on downstream aquatic habitat is assessed as moderate negative without mitigation.

Table 8.10 Pre-Mitigation Impact Assessment

Type of Impact		
Direct: Hydro-peaking is a direct result of the Hydropower Plant operations.		
Rating of Impacts		
Characteristic	Designation	Summary of Reasoning
Extent	Regional	The daily flow variations due to peaking may influence the entire downstream of the Kaiha River. However, the intensity of the variation will decrease further downstream due to the hydrological contribution of tributaries.
Duration	Permanent	Peaking will continue for the lifetime of operations.
Scale	~30 km	The bottom 30 km of the Kaiha River, prior to its confluence with the Mano River will most notably be influenced by peaking.
Frequency	Daily during June to December	Peaking may occur during periods when the daily average demand matches the river inflow (8-13 m ³ /s), typically during June to December.
Likelihood	Possible	Impact on instream biota due to peaking is likely to occur at some time during normal operating conditions.
Magnitude		
Medium		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
Medium		
A number of species with international conservation status may occur within the affected reach. Three of the 12 observed species (<i>B. sacratu</i> s, <i>L. parous</i> , <i>D. chappuisi</i>) are sensitive to flow and water quality changes and are likely to be affected by peaking.		
Significance Rating Before Mitigation		
Moderate Negative		

Mitigation Measures

The following mitigation measures will be incorporated into the site management:

- Operate daily peaking in such a way as to ensure smooth transitions between maximum and minimum discharge, thus avoiding rapid changes in downstream river flow and water levels. Typically this rate should not be more than 4 or 5 cm/hour as some drift is likely to occur if this rate increases but this rate should be confirmed by an aquatic ecologist performing monitoring at the site.
- Provide a compensation flow by immediately opening the flushing gate in the event of hydropower plant outage when there is no spilling over the dam. The volume of compensation flow should be confirmed by an aquatic ecology specialist.
- Biomonitoring of fish assemblage in the downstream reach of Kaiha River prior to and during operations. The results from the monitoring regime will: (i) inform any assumptions made regarding fish sensitivity in relation to peaking and (ii) monitor the impact of peaking on the receiving fish assemblages (iii) make recommendations where necessary to reduce any negative impacts.
- Implementation of recommendations from biomonitoring must be followed where technically feasible.

Table 8.11 *Residual Impact Significance*

Impact	Project Phase	Significance (Pre Mitigation)	Residual Impact Significance (Post Mitigation)
Altered downstream aquatic habitat due to peaking	Operation	Moderate Negative	Minor Negative

8.1.6 *Loss of Downstream Aquatic Habitat due to Reduced Water Quality because of Hydropower Plant Construction Activities*

Potential Impacts

Site preparation including removal of vegetation, earthworks, blasting etc., will release sediment material into the water, increasing water turbidity, a known threat to most of the biota (eg, clogging of fish gills), and affect the dissolved oxygen of the water in the immediate downstream reaches from the construction works.

Summary of Relevant Baseline Conditions

Based on the recorded water quality, the Kaiha River was confirmed as a favourable habitat for aquatic life with pH and Total Dissolved Solids values within the WHO drinking water guidelines and dissolved oxygen values in line with the Canadian Water Quality Guidelines for the Protection of Aquatic Life. Three of the 12 sampled fish are sensitive to low dissolved oxygen levels and include *B. sacratus*, *L. parvus*, *D. chappuisi*.

Impact Assessment

Aquatic toxicity may occur from accidental fuel and oil spills, leaching of ammonia and nitrogen from the blasting and rock spoil, etc. Any pollution event would cause negative impact on the aquatic biota in the immediate downstream and even at further distance depending on the type and amount of spill.

The pre-mitigation significance of loss of downstream aquatic habitat due to reduced water quality during Hydropower Plant construction is assessed as moderate negative.

Table 8.12 *Pre-Mitigation Impact Assessment*

Type of Impact		
Direct: Changes in water quality may directly result from Project activities during the construction phase.		
Rating of Impacts		
Characteristic	Designation	Summary of Reasoning
Extent	Regional	Spills may vary in intensity which will influence the extent well beyond the direct footprint of the Project.
Duration	Short term	The impact is limited to the construction period which will last approximately three years.
Scale	30 km	The length of the Kaiha River to the confluence of the Mano River at which point any impact should be diluted to a level that reduces the significance of the impact.
Frequency	Intermittently	Spills may occur on intermittent basis during instream construction activity.
Likelihood	Likely	Some form of water pollution is likely to occur during construction.
Magnitude		
Small		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
High		
The instream ecology is considered sensitive to water pollution.		
Significance Rating Before Mitigation		
Moderate Negative		

Mitigation Measures

The following mitigation measures will be incorporated into the site management:

- Implement mitigation measures to reduce impacts on water quality as included in Section 8.1.1.

Table 8.13 *Residual Impact Significance*

Impact	Project Phase	Significance (Pre Mitigation)	Residual Impact Significance (Post Mitigation)
Aquatic habitat impact due to reduced water quality from sediment and spills due to the Hydropower Plant construction activities	Construction	Moderate Negative	Minor Negative

8.1.7

Alteration of Upstream Aquatic Habitat Due to Inundation Caused by Construction and Operation of the Dam*Potential Impacts*

The impoundment will have two potential impacts on the Kaiha River ecosystem; (i) it will change the aquatic habitat and (ii) it may change the water quality of the system.

Baseline Conditions

The observed fish assemblages mainly consist of lotic species, with at least three species intolerant to reduced flow velocities. The species of conservation significance potentially occurring within the study area also has a habitat preference for fast flowing water (> 0.3 m/s) associated with relatively shallow depths (< 0.5 m) and rocky substrate. The change in habitat from lotic to lentic will result in a change in fish assemblages, with a potential decrease in aquatic diversity.

The baseline water quality of the Kaiha River is considered good, with nearly neutral pH values, low salt loads and high oxygen levels. The baseline water quality is not expected to be a major driver of the baseline fish assemblages and aquatic ecology.

Impact Assessment

The impoundment of the Kaiha River will create a narrow reservoir extending approximately 13.5 km upstream to a point about 10 km north of the dam site. The affected river section will thus be converted into an artificial lake, or more precisely a slow-flowing river. The consequence of river impoundment is the transformation of a lotic (fast flowing) environment to lentic (slow flowing/still) habitats. While some species can adapt easily to this type of habitat, others cannot and will therefore diminish in numbers or disappear altogether from the reservoir.

In the reservoir, it is expected that the fish biomass will increase in the initial phase of operation due to decomposition of the remaining organic materials after reservoir clearing (phytoplankton and zooplankton populations will be growing rapidly after dam closure). This 'trophic upsurge' will cause a temporary boom in fish production, mainly consisting of plankton-feeders and predators. Afterwards, as has been observed in many man-made lakes with small surfaces, the water will become poorer in its natural nutrients, reaching a productivity level equal to, or lower than, before the construction of the dam.

The impacts on water quality generally depend on the retention (turnover) time of the reservoir (its storage capacity in relation to the amount of water flowing into it) and the pre-impoundment conditions, especially the amount of submerged biomass. Water in small reservoirs behind a run-of-river dam

will undergo very little deterioration, while that stored for many months or years behind a major dam where vegetation is left decomposing may be lethal to most life in the reservoir and in the river downstream. As noted in *Section 8.1.2* the risk of water quality deterioration in the Kaiha 2 reservoir is considered to be low.

The pre-mitigation impact significance for the loss of upstream aquatic habitat due to inundation is assessed as moderate negative.

Table 8.14 *Pre-Mitigation Impact Assessment*

Type of Impact		
Direct		
Rating of Impacts		
Characteristic	Designation	Summary of Reasoning
Extent	Local	Approximate extent of 10 km.
Duration	Permanent	The change in habitat will be permanent.
Scale	10 km upstream	The habitat change will occur for the extent of the inundation zone.
Frequency	Continuously	The habitat alteration will be continuous.
Likelihood	Likely	Habitat alteration is intrinsic to weir and dam construction.
Magnitude		
Moderate		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
Moderate		
The change in lotic to lentic habitat, will result in a change in fish assemblages. The inundation is not expected to notably alter water quality.		
Significance Rating Before Mitigation		
Moderate Negative		

Mitigation Measures

The following mitigation measures will be incorporated into the site management:

- Pre-impoundment biomass clearing in the reservoir area.

Table 8.15 *Residual Impact Significance*

Impact	Project Phase	Significance (Pre Mitigation)	Residual Impact Significance (Post Mitigation)
Altered upstream aquatic habitat due to inundation	Operation	Moderate Negative	Moderate Negative

8.1.8***Loss of Waterfall and Water Rapids Features and Fish Spawning Habitat Due to Construction and Operation of the Hydropower Plant****Potential Impacts*

During the construction phase, water flow in the Kaiha River will be as it was before. Cofferdams will be constructed to intercept the construction pit from the river flow, thus providing a bypass for the water. In later stages of the dam construction, the river flow will pass through the flushing gate, it follows that the hydrology of the rapids/fall area will remain largely intact during construction.

During operations, the diversion of the river for hydropower production will result in periodic dry periods of the waterfall/rapids in the bypassed river section (between the intake and outlet). This will happen mainly in the dry season when all the inflow will be diverted to the turbines, and in the transition period between the wet and dry season, when the reservoir will be subject to daily peaking. The periodic dry waterfall/rapids will most probably result in degradation of these aquatic habitats over a relatively short river section (approximately 60 m).

Baseline Conditions

The hydraulic nature of rapids makes it a hostile environment for fish and other aquatic organisms. Typically, the more sensitive aquatic receptors associated with rapids and water falls include mist dependent flora and amphibians. The baseline studies do not indicate presence of mist dependant species hence this impact assessment focusses on the sensitivity of the recorded fish assemblages.

Impact Assessment

The stretch of river immediately downstream of rapids are often important spawning grounds, particularly for migrating species such as the cyprinids (*L. parvus* and *B. sacratu*). Migrating species often congregate below barriers during their spawning runs. If these spawning grounds are deprived of sufficient flow during critical times of the wet season, or the cobbles and gravel beds are covered with sediment spawning success may be affected. Even marginal decrease in spawning success will compound over time and can have a large impact on the fish population in the long run.

Pre-Mitigation Assessment of Impacts

The impact on waterfall habitat due to construction and operation of the reservoir is assessed as moderate negative prior to mitigation.

Table 8.16 *Pre-Mitigation Impact Assessment*

Type of Impact		
Rating of Impacts		
Characteristic	Designation	Summary of Reasoning
Type	Direct	Operations will directly influence the flow over the rapids.
Extent	Local	The dry reaches extent will be of local significance.
Duration	Permanent	The duration will be permanent.
Scale	60 m	The extent of the impact pertains to the dry reach which consists of the rapids/falls.
Frequency	Permanent	Although permanent the impact will be more pronounced during the dry season and during the transition periods (June to December).
Likelihood	Likely	This impact is likely to occur during normal operating conditions
Magnitude		
Small		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
High		
Migrating species typically spawn below migration barriers such as rapids and falls and are sensitive to changes in habitat that might influence spawning success.		
Significance Rating Before Mitigation		
Moderate Negative		

Mitigation Measures

The following mitigation measures will be incorporated into the site management:

- An environmental flow of at least 0.35 m³/s shall be released into the bypassed reach at all times. Once biomonitoring has been undertaken the environmental flow shall be amended to the flow volumes and regimes as required by an aquatic ecology specialist.
- Conduct fish monitoring prior to dam construction and after impoundment. Fish monitoring will define flow requirements associated with spawning and the habitat maintenance over the dry reach. The results of the monitoring will be applied to inform adaptive management in terms of the environmental flow releases.
- Controlled energy dissipation of the water downstream of the dam needs to be taken into account eg, through baffle blocks after the dam toe.

Table 8.17 ***Residual Impact Significance***

Impact	Project Phase	Significance (Pre Mitigation)	Residual Impact Significance (Post Mitigation)
Loss or impairment of waterfall habitat and possible spawning grounds due to the construction and operation of the weir.	Construction and operation	Moderate Negative	Minor Negative

8.1.9

Risk of Alteration of Fish Migration and Breeding Patterns Due to Construction and Operation of the Hydropower Plant*Potential Impacts*

It is uncertain to what extent upstream migration may be impeded by the rapid/falls associated with the Kaiha River at the Project site during the wet season flows. Some of the observed and expected species (Cyprinids) are strong swimmers and can move up turbulent water during the wet season. The same species also reflect a requirement for downstream movement. If the rapids are completely impassable it is likely that the area immediately downstream of rapids/falls may be important spawning grounds for migrating species. If this is the case, these species will congregate below the falls during their seasonal spawning migration and will be forced to spawn near the rapids/falls.

The additional restriction in movement that may be imposed by the Project or the alteration in possible nearby spawning grounds may prevent access to such spawning or feeding grounds and threaten the life-cycle completion of these species.

Summary of Relevant Baseline Conditions

Two of the observed fish species (*L. parvus* and *B. sacatus*) are strong migrating species and can manage short bursts through highly turbulent waters. Both species have very specific spawning requirements associated with substrate and flow. They typically spawn during a single breeding season following an upstream migration. Both species are vulnerable to damming that prevents migration and are also adversely affected by changes in the timing of high flow events that are inappropriate to their breeding seasonality, as well as to changes in the quality of breeding habitat, which may become obstructed with silt or have inadequate flow to air the eggs.

Impact Assessment

Migrating fish species have very specific spawning requirements associated with substrate and flow. They may typically spawn during a single breeding season following an upstream migration. This can make them vulnerable to damming that prevents migration, although they may respond favourably to appropriately designed fish passes. They can also be adversely affected by changes in the timing of high flow events that are inappropriate to their breeding seasonality, as well as to changes in the quality of breeding habitat, which may become obstructed with silt or have inadequate flow to air the eggs.

The occurrence of these species may be improved by reinstating longitudinal connectivity and mimicking the natural hydrological regime. The points

below summarise likely risks to these Cyprinids due to alteration in flow and instream habitat:

- Tend to disappear when rivers are fragmented through weir and dam construction that prevent migration or when timing of flow release is inappropriate to their breeding seasonality.
- Sensitive to habitat flows if breeding substrates are destroyed or degraded.
- Sensitive to structure of habitat particularly presence of suitable substrate such as pebbles, cobbles and gravel beds.

The pre-mitigation impact of changes in fish migration and breeding patterns due to construction of the Hydropower Plant is assessed as moderate negative.

Table 8.18 *Pre-Mitigation Impact Assessment*

Type of Impact		
Unplanned, Direct		
Rating of Impacts		
Characteristic	Designation	Summary of Reasoning
Extent	Regional	The extent of the Kaia River from the Project area to the confluence of the Mano River.
Duration	Permanent	Impact may occur permanently for the duration of Project operations.
Scale	Not defined	The proportion of the fish population that may be affected have not been defined. However, a small but chronic decrease in breeding success will compound over time.
Frequency	Seasonally	Migrating species will require access to spawning grounds on a seasonal basis in a response to spawning cues (increased discharge, water temperature and day light length).
Likelihood	Unlikely	The rapids/falls may naturally impede access to spawning grounds resulting in a lower likelihood assigned to this impact.
Magnitude		
Small		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
High		
Some of the observed and possibly occurring fish reflects a migration requirement and access to suitable spawning grounds.		
Significance Rating Before Mitigation		
Moderate Negative		

Mitigation Measures

The following mitigation measures will be incorporated into the site management:

- An environmental flow of at least 0.35 m³/s shall be released into the bypassed reach at all times. Once biomonitoring has been undertaken the environmental flow shall be amended to the flow volumes and regimes as required by an aquatic ecologist.
- Conduct fish monitoring prior to dam construction and after impoundment. Fish monitoring will define flow requirements associated with spawning and the habitat maintenance. The results of the monitoring will be applied to inform adaptive management in terms of the environmental flow releases. This may include the addition of a fish ladder.

Table 8.19 *Residual Impact Significance*

Impact	Project Phase	Significance (Pre Mitigation)	Residual Impact Significance (Post Mitigation)
Alteration of fish migration and breeding patterns due to construction and operation of the Hydropower Plant	Construction and Operation	Moderate Negative	Minor Negative

8.1.10 *Injury to Fish Caused by Interaction with Physical Structures including Turbines or Spillway during Operations*

Potential Impacts

Migrating species follow the major flow when moving downstream and diversion of this into the Kaiha 2 Hydropower Plant could encourage these species to enter the turbines and result in injury and mortality.

Baseline Conditions

About one third of the sampled fish assemblages have a requirement for migration. Migrating species occur both upstream and downstream of the rapids/falls. These species typically move between upstream spawning grounds and downstream feeding grounds. Migrating fish use the dominant flow direction for movement and might thus accumulate at the Hydropower Plant intake where they are at risk of entering the scheme and passing through the turbines.

Impact Assessment

The regular operation of the power plant involves a risk that fish will become entrained in the turbines or flushed over the spillway with subsequent injury or mortality. The potential for fish entrainment and turbine-induced mortality is mainly related to fish size ie, smaller fish and juveniles are more likely to survive turbine passage than larger fish. Survival rates also depend on turbine technology; Kaplan turbines (which are proposed for the Kaiha 2 hydropower plant) are considered 'fish- friendly' with lower mortality rates than other turbine alternatives.

The pre-mitigation impact on fish due to physical injury or death associated with turbine stress is assessed to be moderate negative during operation.

Table 8.20 Pre-Mitigation Impact Assessment

Type of Impact		
Direct		
Rating of Impacts		
Characteristic	Designation	Summary of Reasoning
Extent	Local	The local population of fish likely to be entrained may be impacted.
Duration	Long term	The impact will occur for the lifetime of the operation but will be exacerbated during the transition between wet and dry seasons.
Scale	Not defined	The scale of fish injury or mortality cannot be numerically defined but is likely to increase in occurrence during periods of downstream movement (the transition September to December).
Frequency	Intermittently	Fish entrainment may occur on a continuous basis but will be more intense during September to December.
Likelihood	Possible	Fish mortalities and injury are possible during normal operations.
Magnitude		
Medium		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
Medium		
One third of the observed fish are likely to move downstream and may suffer from physical injury when entering the scheme.		
Significance Rating Before Mitigation		
Moderate Negative		

Mitigation Measures

The following mitigation measures will be incorporated into the site management:

- Installation of a fish screen (or reductions in trash rack openings) at the intake to reduce fish entrainment and mortality. The sizing of the fish screen should be the smallest that does not affect the flow of water. If monitoring shows this size to be insufficient the next step would be an electric current deterrent or a chute next to the intake (a chute would reduce the volume of water available to produce electricity).

Table 8.21 Residual Impact Significance

Impact	Project Phase	Significance (Pre Mitigation)	Residual Impact Significance (Post Mitigation)
Fish injury and mortality due to passing through the turbines	Operation	Moderate Negative	Minor Negative

8.1.11

Loss of Forest Habitat due to Reservoir Inundation, Hydropower Plant Footprint, Access Road, Construction Camp and Laydown Areas during Construction and Operations*Potential Impacts*

The hydropower plant will require forest clearing for construction of the dam (including flooding of the reservoir area), penstock, powerhouse, access road, construction camp and laydown areas.

Baseline Conditions

The Hydropower Plant site and access road comprises mainly close canopy gallery forest with high tree density, tree heights ranging between 40 and 50 meters and a significant proportion of trees with dbh of over 100 cm. The forest canopy is healthy. No form of recent agricultural activities was observed, but there are signs of old timber and wood extraction. The common tree species are *Albizia zigia*, *Albizia adianthifolia*, *Cathormion altissimum*, *Cathomium rhombifolium*, *Pterocarpus santalinoides*, *Pentaclethra macrophylla*, *Pycnanthus angolensis*, *Uapaca heudelotii* and *Amphimas pterocarpoides*.

This habitat supports a rich diversity of floral and faunal species and represents the highest diversity within in the wider project area, including the potential presence of sensitive flora and fauna.

Impact Assessment

Vegetation clearance in the direct impact zone will cause loss of areas of natural habitats. The reservoir that will be created will extend over 50 ha at full supply level with additional habitat lost to other hydropower components. The total loss of habitat is therefore estimated at 60 ha.

Based on the analysis provided, the impact loss of forest habitat will be a major negative impact pre-mitigation.

Table 8.22 *Pre-Mitigation Impact Assessment*

Type of Impact		
Negative		
Rating of Impacts		
Characteristic	Designation	Summary of Reasoning
Extent	Local to Regional	Gallery forests serve as important corridors for movements of a wide diversity of species. Severance of this corridor will therefore affect a wider area than the actual footprint of the project.
Duration	Permanent	Loss of habitat through inundation of the reservoir will be permanent
Scale	Moderate	The loss of habitat is estimated at approximately 60 ha, but is habitat of exceptionally high ecological value
Magnitude		
Large		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
High		
This natural habitat supports a rich diversity of floral and faunal species and represents the highest diversity within in the wider project area, including potential critical habitat species.		
Significance Rating Before Mitigation		
Major Negative		

Mitigation Measures

There is no mitigation that will entirely alleviate the loss of terrestrial habitat within the reservoir area. Minimisation measures to avoid patches of forest will have minimal impact and will not alter the significance of the impact although these have been recommended below. Offsetting measures could be considered to address the high residual impact.

The following mitigation measures will be incorporated into a **Biodiversity Management Plan** and implemented in site management:

- Except where vegetation clearing outside of the reservoir area is required for permanent works or excavation operations, all trees and vegetation shall be preserved. Forest patches not needed for the dam construction will be left undisturbed as much as possible.
- Preclearing checks will be conducted by a competent ecologist, and trees that can be spared from destruction will be clearly marked and construction teams instructed not to damage these trees.
- The area upstream and downstream of the reservoir that is within the Project's control will be managed as a protected area. The exact area required is to be determined prior to construction through biomonitoring, with the aim of offsetting losses and where possible to achieve net gain in comparable habitat. Submissions will be made to the Department of Forest Conservation to pursue formal gazettement of this area.

- Implement mitigation measures for road construction as provided in *Section 8.1.1*
- Undertake biodiversity monitoring prior to construction to determine the size of offset and additional measures required to ensure no net loss of habitat. After monitoring but before construction, compile and implement a plan for offsetting losses.

Table 8.23 *Residual Impact Significance*

Impact	Project Phase	Significance (Pre Mitigation)	Residual Impact Significance (Post Mitigation)
Loss Of Forest Habitat due to Reservoir Inundation, Hydropower Plant Footprint, Access Road, Construction Camp and Laydown Areas	Construction	Major negative	Major negative

8.1.12***Loss of Forest Habitat due to Construction of the Transmission Line****Potential Impacts*

Construction of the transmission grid will require some forest clearing for construction, however, it is expected that clearing will be kept to a minimum and vegetation cut back instead where possible.

Despite the limited project footprint, there is a risk that valuable flora and fauna will be adversely affected by the vegetation clearing.

There is also the potential for pesticides to be used in the vegetation clearance. Further, there is a potential for accidental fuel and oil spills from construction machinery, releases of insulating oils used for the transformers as well as leaching of creosote near the treated poles to poison and kill vegetation.

Baseline Conditions

The habitats along the transmission lines exist as a combination of both natural and modified habitat. Landcover mapping within 1km of project activities reveals that 74% of area represents natural habitat, while 26% represents modified habitat. However, the extent of natural habitat impacted by the transmission lines is expected to be less, as the routes follow existing roads that already experience some disturbance, and the reservoir area which is entirely natural will not be impacted by transmission lines.

Impact Assessment

Loss of habitat will occur all along the transmission lines where these pass through natural habitat. Transmission lines will be constructed along existing roads where some disturbance already exists. Impacts will last the duration of the operational phase.

Based on the analysis provided, the impact of loss of forest habitat due to clearing and construction of the transmission lines will be moderate negative pre-mitigation.

Table 8.24 *Pre-Mitigation Impact Assessment*

Type of Impact		
Negative		
Rating of Impacts		
Characteristic	Designation	Summary of Reasoning
Extent	Regional	Loss of habitat will occur all along the transmission lines where these pass through natural habitat.
Duration	Long Term	Impacts will last the duration of the operational phase.
Scale	Moderate	Transmission lines will be constructed along existing roads where some disturbance already exists.
Magnitude		
Medium Magnitude		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
Medium Sensitivity		
The transmission lines will expand the disturbance effect of existing road corridors. These corridors already exhibit some disturbance, but impacts will expand into adjacent natural habitat		
Significance Rating Before Mitigation		
Moderate Negative Significance		

Mitigation Measures

The following mitigation measures will be incorporated into the site management:

- Avoid natural habitats when planning locations of movable components such as equipment laydown areas, construction camps and toilet facilities. Modified habitats within the transmission route corridor will instead be targeted for such activities.
- Vegetation clearing to be restricted to the minimum area required for the RoW.
- Removal of mature trees for the construction of ancillary infrastructure will be avoided wherever possible. Such trees will be individually identified in advance and marked for retention within the marked extent of clearing.
- Vegetation clearing will be through mechanical means and herbicides will not be used.
- Manual labour will be used in preference to heavy machinery to avoid or minimise soil compaction, destruction of the herbaceous layer and exposure of the soil to wind and water erosion.
- Vegetation management of the RoW will be conducted on a regular basis to avoid large-scale disruptions to the vegetation, woody vegetation will only be cropped above 0.5 meter height, and the development of a stable ground cover will be promoted.

- Ongoing vegetation management will avoid all forms of soil disturbances within natural habitats.
- Pesticides should be targeted only at invasive species and used as specified in a Pesticides Management Plan as required in *Section 8.1.1*
- There will be no clearing of riparian zones beyond the selective removal of tall growing trees. Lower vegetation will be left intact. Riparian zones are to be designated by an aquatic ecologist prior to construction.
- Ensure there will be limited change to the hydrology or flow patterns of rivers and streams through implementing mitigation measures recommended in *Section 8.1.1, 8.1.2 and 8.1.4.*
- Ancillary infrastructure sites (such as borrow pits, camp sites, material storage piles) will be rehabilitated as per the Rehabilitation Plan to establish a stable vegetation cover as soon as these areas are no longer required.
- Soil profiles of each ancillary site will be restored and the upper soil surface planted with non-invasive native grass species and a variety of indigenous trees that occur in the greater area.
- Clear demarcation of construction and clearing zones will be implemented in advance of any activities. The extent of clearing within the approved worksite areas will be clearly marked with pegs and/or danger tape at 50 m intervals or less.
- Existing roads will be used for construction and operational access whenever possible.
- Implement a Waste Management Plan as required in *Section 8.1.1.*
- Contractors will comply with all emergency procedures prior to commencing activities on the site, to minimise the occurrence of emergency events and the negative impact these events cause on surrounding habitats.

Table 8.25 *Residual Impact Significance*

Impact	Project Phase	Significance (Pre Mitigation)	Residual Impact Significance (Post Mitigation)
Loss of Forest Habitat due to Clearing and Construction of the Transmission Line	Construction	Moderate Negative	Moderate to Minor Negative

8.1.13

Displacement and Loss of Fauna Due to Disturbance from Hydropower Plant and Access Road Construction Activities*Potential Impacts*

Given the peri-urban nature of the Diesel Power Plant site it is not anticipated that fauna will be displaced due to restoration of the existing substation building.

During the construction phase, disturbance will be created through the clearing of gallery forest trees, noise will be generated from vehicular movements, sand and aggregate processing, concrete mixing, excavation machinery and blasting of rocks. The presence of large teams of construction workers will serve as a continuous disturbance throughout the construction phase. The disturbance is likely to affect wildlife in general and trigger animals to avoid or escape from the project area. The presence of construction teams will raise the demand for bushmeat from surrounding forests, causing a depletion of wildlife over the greater area. Increased traffic will result in roadkill and injuries of fauna crossing roads.

The impoundment of the river will convert the current riverbanks into an aquatic environment, this will require that some animals are physically removed from the area to minimise animals being trapped by the rising water levels. Examples of such animals might include young birds in nests, tortoises, chameleons, frogs, some snakes, invertebrates, fossorial species and any injured animals. The water level rise will reduce the abundance of terrestrial animals in the direct impact zone, but many species might adjust their range to adapt to the habitats created along the shores of the reservoir.

Baseline Conditions

The habitats along the transmission lines exist as a combination of both natural and modified habitat. Landcover mapping within 1km of project activities reveals that 74% of area represents natural habitat, while 26% represents modified habitat. However, the extent of natural habitat impacted by the transmission lines is expected to be less, as the routes follow existing roads that already experience some disturbance, and the reservoir area which is entirely natural will not be impacted by transmission lines.

Impact Assessment

Loss of wildlife could occur over a wide area to supply the bush meat demand generated by construction teams. Wildlife populations have a reduced capacity to recover if depleted down to low levels. Evacuation of the area by wildlife, and impacts of bush meat hunting will decline with increasing distance from the Project site, however the near area is expected to become totally depleted of fauna during the construction phase.

Based on the analysis provided, the impact disturbance to fauna will be a major negative pre-mitigation.

Table 8.26 *Pre-mitigation Impact Assessment*

Type of Impact		
Negative		
Rating of Impacts		
Characteristic	Designation	Summary of Reasoning
Extent	Regional	Loss of wildlife could occur over a wide area to supply the bush meat demand generated by construction teams
Duration	Long Term	Wildlife populations have a reduced capacity to recover if depleted down to low levels.
Scale	Moderate	Evacuation of the area by wildlife, and impacts of bush meat hunting will decline with increasing distance from the project site, however the near area is expected to become totally depleted of fauna during the construction phase.
Magnitude		
Large Magnitude		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
High Sensitivity		
Four endangered species (Western Chimpanzee, Red Colobus Monkey, Pygmy Hippopotamus and the Hooded Vulture) and one critically endangered species (Slender-snouted Crocodile) are known to occur within the project area. The adjacent Key Biodiversity Area is recognised due to the presence of these and other important species, such as Forest Elephant.		
Significance Rating Before Mitigation		
Major Negative Impact Significance		

Mitigation Measures

The following mitigation measures will be incorporated into the site management:

- Noise impacts will be reduced through scheduling noisy activities during daytime hours and instructing the workforce to avoid unnecessary noise.
- Establish a protected area upstream and downstream of the dam.
- Conduct animal rescue operations during the initial filling of the reservoir. Rescue operations will be conducted by competent forest ecologists with veterinary support for handling potentially dangerous species.
- Formulate and implement a policy that prohibits any form of hunting, any killing of animals, purchase, consumption or trade in bush meat and keeping of pets by construction employees.
- Thorough checks conducted for all forms of fauna prior to any vegetation clearing and a proactive approach will be adopted to prevent the loss of fauna without obstructing construction activities. The following procedures should be applied (but not limited to):

- Areas of natural vegetation designated to be cleared should be checked by a competent faunal ecologist experienced in forest habitats at least three months prior to clearing, and all fauna would need be noted.
- Any evidence of active breeding or residence in burrows should be highlighted and advice from competent conservation bodies obtained on safe translocation of the species at risk to appropriate and safe locations.
- Appropriate veterinary services would need to be involved in the translocation or forced movement of any medium-sized or large mammals during construction, examples being animals having fallen into holes, become trapped or entangled by fences, crept inside vehicles or trapped within construction camps.
- Competent forest ecologists will be on site the day prior to vegetation clearing and during clearing operations to safely translocate any animals encountered that are not able to evacuate the site on their own accord. Examples of such animals might include young birds in nests, tortoises, chameleons, frogs, some snakes, invertebrates, fossorial species and any injured animals.
- Vehicle speeds within the Project area will be reduced through implementation of speed control measures and the regular enforcement of legislation.
- Induction programmes will be developed for staff and contractors to raise the awareness of the diversity of fauna present, importance of protecting wildlife, risks associated with large wildlife and how to react when confronted by different species of large wildlife, and requirements to actively prevent the loss of any animals including snakes and other species commonly considered to be vermin.
- Staff and contractors involved in construction activities would need to be confined to the construction footprint and required access roads to reach those sites. Access into adjacent protected areas and natural habitats should not be allowed.
- Staff will be appointed or trained onsite to safely capture and translocate venomous snakes without harm to the snakes.
- Contact details will be kept available (based on prior arrangement) for a snake bite specialist who is able to provide advice to local doctors in the event of a venomous snake bite incident. Snake bites are rare events and most doctors do not have training or experience in treatment.
- Support will be provided to the Department of Forest Conservation to raise their capacity and control the illegal bush meat trade and conduct anti-poaching operations in the surrounding areas.

Table 8.27 ***Residual Impact Significance***

Impact	Project Phase	Significance (Pre Mitigation)	Residual Impact Significance (Post Mitigation)
Displacement and loss of fauna due to disturbance from Hydropower Plant and access road construction	Construction	Major Negative	Moderate Negative

8.1.14

Increased Pressure on Natural Resources due to Increased Ease of Access as a Result of Construction and Operation of a New Access Road*Potential Impacts*

Due to construction of the access road, the previously largely inaccessible area will be easier to access by people who may enter to hunt for bushmeat, extract illegal timber, produce charcoal, undertake slash and burn agriculture, hunt, and fish.

Baseline Conditions

There are several plant species listed as vulnerable (VU) and near threatened (NT) by IUCN in the area, mainly at the proposed dam site and access road, which also includes endangered and critically endangered fauna.

Impact Assessment

The population influx is generally assumed to increase the pressure on natural resources.

Areas affected by increased access will be limited to the new roads that are constructed and near vicinity. Roads are unlikely to disappear even after closure of the project. The project area will be disturbed through construction activities or habitat lost through inundation.

Based on the analysis provided, the impact of increased natural resource use due to increased access will be a moderate negative impact pre-mitigation.

Table 8.28 *Pre-Mitigation Impact Assessment*

Type of Impact		
Negative		
Rating of Impacts		
Characteristic	Designation	Summary of Reasoning
Extent	Local	Areas affected by increased access will be limited to the new roads that are constructed and near vicinity
Duration	Permanent	Roads are unlikely to disappear even after closure of the project.
Scale	Low	The project area will be disturbed through construction activities or habitat lost through inundation.
Magnitude		
Medium to Low Magnitude		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
High Sensitivity		
There are several plant species listed as vulnerable (VU) and near threatened (NT) by IUCN in the area, mainly at the proposed dam site and access road, which includes endangered and critically endangered fauna.		
Significance Rating Before Mitigation		
Moderate Negative		

Mitigation Measures

The following mitigation measures will be incorporated into the site management:

- Access to the project site will be controlled by checkpoints.
- Establish a protected area upstream and downstream of the dam.
- Fauna are to be translocated as recommended.
- Vegetation that is cleared will be made available to local communities to allow maximum use of available resources, including timber and firewood.
- Workers shall be prohibited from collecting firewood from areas that are not disturbed by project activities.
- Workers shall be prohibited from collecting firewood, hunting and/or setting snares.

Table 8.29 *Residual Impact Significance*

Impact	Project Phase	Significance (Pre Mitigation)	Residual Impact Significance (Post Mitigation)
Increased pressure on natural resources due to increased access as a result of new access road	Construction and Operations	Moderate Negative	Moderate to Minor Negative

8.1.15 *Risk of Increased Incidence of Invasive and Alien Plant Species due to Hydropower Plant, Associated Infrastructure, Access Road, Transmission Lines and Diesel Power Plant Construction*

Potential Impacts

The IUCN rates the presence of Invasive and Alien Plant (IAP) species globally as the second most significant threat to biodiversity. Alien species can be introduced either accidentally or intentionally, and there is a growing global awareness of the problems associated with alien and invasive species. Although only a small percentage of alien species have the potential to become invasive, their impact is marked and usually irreversible, displacing native species and leading to degradation of habitats.

Site clearance and soil disturbances create opportunities for IAPs to establish. Extensive soil disturbance will occur during the construction phase and creates abundant potential for the establishment of invasive plants.

Large infestations of IAPs can develop, and if not controlled can serve as source populations for the spread into new areas. These have a high potential to suppress the indigenous flora and change the structure and composition of the vegetation (and hence faunal habitat) as they spread.

Construction vehicles can accidentally gather invasive plant material and disperse seeds through normal movements. Construction equipment and vehicles, landscaping or rehabilitation could potentially introduce IAPs.

Baseline Conditions

High quality habitat currently exists at the Hydropower Plant site and access road route whilst the Diesel Power Plant and transmission route is more degraded. At least one non-native plant species has already been introduced to the project area, the invasive shrub *Chromolaena odorata* (Triffid weed). It is difficult to get rid of this species once it has become established, and further introductions of exotic species may cause the spread of more IAP species with a resulting decrease in biodiversity.

Impact Assessment

The spread of IAPs is expected to be restricted to the construction footprint and areas of soil disturbance. Many infestations of IAPs are extremely persistent once established, unless active control measures are implemented.

A diversity of IAP species are likely to present a risk of being spread. Each species has its own unique patterns of infestation, invasiveness and level of impact to the affected environment, and no single estimate of scale can be provided.

Based on the analysis provided, the impact of increased risk of alien plant infestation due to construction activities will be a moderate negative impact pre-mitigation.

Table 8.30 *Pre-Mitigation Impact Assessment*

Type of Impact		
Negative, Unplanned, Indirect		
Rating of Impacts		
Characteristic	Designation	Summary of Reasoning
Extent	Local	The spread of IAPs is expected to be restricted to the construction footprint and areas of soil disturbance.
Duration	Long Term	Many infestations of IAPs are extremely persistent once established, unless active control measures are implemented.
Scale	Variable (Low to large)	A diversity of IAP species are likely to present a risk of being spread. Each species has its own unique patterns of infestation, invasiveness and level of impact to the affected environment, and no single estimate of scale can be provided.
Magnitude		
Medium Magnitude		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
Medium Sensitivity		
As with scale, a single definition of sensitivity is difficult to define, but affected habitats will include the full range of modified, natural and critical types.		
Significance Rating Before Mitigation		
Moderate Negative Impact		

Mitigation Measures

The following mitigation measures will be incorporated into the site management:

- Develop and implement an IAP management plan.
- Biological control measures may only be applied if these specific measures have been approved for application in Liberia. Alternatively, manual control of IAPs would be applied in preference to application of herbicides or other chemicals. An herbicide/pesticide management plan as per Section 8.1.1 will be implemented should the use of herbicides/pesticides be required.

Table 8.31 *Residual Impact Significance*

Impact	Project Phase	Significance (Pre Mitigation)	Residual Impact Significance (Post Mitigation)
Increased Incidence of Alien Plant Species due to Hydropower Plant, Associated	Construction	Moderate Negative	Minor Negative

Impact	Project Phase	Significance (Pre Mitigation)	Residual Impact Significance (Post Mitigation)
Infrastructure, Access Road, Transmission Lines and Diesel Power Plant Construction Activities			

8.1.16 *Physical Injury to Birds and Bats due to Operations of Transmission Line*

Potential Impacts

Transmission lines are recognised as one of the most important causes of bird mortality internationally. Transmission lines present a risk to birds in two ways: (i) Flying birds frequently do not see thin wires and collide into these leading to fatal injuries, (ii) birds are attracted to tall structures to perch, roost and nest (on the towers). Large birds have wingspans that can simultaneously touch both live and earth wires leading to electrocution. Some birds are more vulnerable to impacts from transmission lines. The location and the design of transmission lines have important bearings on the extent of these impacts.

Baseline Conditions

Threatened bird species identified along the transmission line routes include Hooded Vulture (EN), Yellow-casqued Hornbill (VU), Brown-cheeked Hornbill (NT) and Black-headed Rufous Warbler (NT). Hooded Vultures have a wide wingspan and are at risk of electrocution, while both Hooded Vultures and Yellow-casqued Hornbill may be at risk of collisions with exposed wires.

Impact Assessment

The planned transmission lines will become a danger for birds and flying or climbing animals, including bats. Accidental kills can occur as a result of collision between the flying animal and a power cable, or it can occur if a climbing or resting animal happens to short circuit the conductors. In general, collision risk increases with voltage level, and the risk is relatively low for 33 kV lines.

In addition to the physical risk of injury from collision with electric lines, birds and climbing animals run a risk of electrocution injury should they complete an electric circuit by touching two energised components or an energised and a ground component. Risk of electrocution is higher for large birds such as vultures.

Based on the analysis provided, the risk of electrocution and collisions of birds and bats with transmission lines will be a moderate negative impact pre-mitigation.

Table 8.32 *Pre-Mitigation Impact Assessment*

Type of Impact		
Negative		
Rating of Impacts		
Characteristic	Designation	Summary of Reasoning
Extent	Regional	Loss of birds and bats has the potential to occur anywhere along the transmission lines, and bird species at risk are wide-ranging, thus increasing the extent of impact.
Duration	Long Term	Impacts will last the duration of the operational phase.
Scale	Moderate	The surrounding forest habitat provides abundant opportunities for birds to perch and nest, and transmission lines will offer limited additional attraction.
Magnitude		
Medium Magnitude		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
High Sensitivity		
Critically Endangered Hooded Vultures have been observed in the Project Area		
Significance Rating Before Mitigation		
Moderate Negative Impact		

Mitigation Measures

The following mitigation measures will be incorporated into the site management:

- Install spikes or other devices above insulators to prevent birds from perching and roosting at these points and minimise electrocutions.
- Install visibility devices onto the electrical cables in riparian habitats where the highest risk of collision occurs.
- Monitor collision and electrocution of birds for five years whereafter the specialist undertaking the monitoring can determine the need for more monitoring.
- National birding institutions should be involved in this monitoring to contribute towards understanding of impacts in Liberia. Results of monitoring will determine the need for installation of additional visibility devices.
- Advances in technology can be expected and removal of an upper earth line must be considered in future.

Table 8.33 ***Residual Impact Significance***

Impact	Project Phase	Significance (Pre Mitigation)	Residual Impact Significance (Post Mitigation)
Risk of Electrocution and Collisions of Birds and Bats with Transmission Lines	Construction and Operations	Moderate Negative	Moderate to Minor Negative

8.1.17

Disturbance of Fauna (excluding birds) due to Transmission Line Construction*Potential Impacts*

Construction of the transmission line will have impacts on fauna through habitat alterations including habitat fragmentation (described in earlier impact), a disturbance effect through noise and human presence, increased road kills from vehicle traffic and an increased risk of poaching pressure by workers or indirectly as a result of an increased demand for bushmeat.

Primates, such as monkeys and baboons, may climb the transmission line towers and be at risk of electrocution or falling from heights during the operational phase of the transmission line. This risk is easily mitigated.

Baseline Conditions

A wide diversity of fauna has been demonstrated during baseline studies to occur along the transmission line routes, which includes nine primate, five carnivore, two pig, 11 antelope, three pangolin, and many rodent species. Important threatened species included endangered western chimpanzee, endangered red colobus monkey and vulnerable diana monkey.

Impact Assessment

Natural habitats cover much of the transmission line route, and areas where naturally occurring fauna may be impacted are widespread. Populations of large fauna at risk of being hunted for bushmeat are depleted and this risk is therefore considered to be *small*, and can be addressed through application of best practice mitigation measures.

Based on the analysis provided, the impact disturbance to fauna will be a major negative impact pre-mitigation.

*Pre-mitigation Impact Significance***Table 8.34 Pre-Mitigation Impact Assessment**

Type of Impact		
Negative		
Rating of Impacts		
Characteristic	Designation	Summary of Reasoning
Extent	Regional	The loss of habitat is assessed as regional and a similar extent applies to the loss and disturbance of fauna.
Duration	Long Term	Impacts will last the duration of the operational phase.
Scale	Moderate	Transmission lines will be constructed along existing roads where some disturbance already exists.
Magnitude		
Large Magnitude		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
High Sensitivity		
A wide diversity of faunal species exists including two endangered primates.		
Significance Rating Before Mitigation		
Major Negative Significance		

Mitigation Measures

The following mitigation measures will be incorporated into the site management:

- An induction programme will be developed for contractors and all workers that will include the importance of conserving the environment including protection of fauna.
- Movement of construction workers will be restricted to the RoW and predetermined access routes.
- A wildlife protection policy will be enforced for construction workers and RoW clearing teams, and will include:
 - Hunting, catching of birds and fishing will be prohibited;
 - Workers will be prohibited from possessing firearms and any hunting, trapping or fishing devices;
 - No engagement in wildlife trade will be tolerated;
 - Keeping of pets in construction sites will not be tolerated; and
 - There will be no improper disposal of waste food.
- Thorough checks conducted for all forms of fauna prior to any vegetation clearing and a proactive approach will be adopted to prevent the loss of fauna without obstructing construction activities. The following procedures should be applied (but not limited to):

- Areas of natural vegetation designated to be cleared should be checked by a competent faunal ecologist experienced in forest habitats at least one month prior to clearing, and all fauna would need be noted.
- Any evidence of active breeding or residence in burrows should be highlighted and advice from competent conservation bodies obtained on safe translocation of the species at risk to appropriate and safe locations.
- Competent forest ecologists will be on site the day prior to vegetation clearing and during clearing operations to safely translocate any animals encountered that are not able to evacuate the site on their own accord. Examples of such animals might include young birds in nests, tortoises, chameleons, frogs, some snakes, invertebrates, fossorial species and any injured animals.
- Staff with training will be appointed or staff onsite will be trained to safely capture and translocate venomous snakes without harm to the snakes.
- Contact details will be kept available (based on prior arrangement) for a snake bite specialist who is able to provide advice to local doctors in the event of a venomous snake bite incident. Snake bites are rare events and most doctors do not have training or experience in treatment.
- Towers will be fitted with devices such as barbed wire coils and spikes to prevent primates (and people) from climbing these structures.
- Speed limits will be specified at a level appropriate to the road conditions and strictly enforced.
- Night driving will be restricted to the extent possible.
- Faunal monitoring to be included in the avifaunal monitoring programme described in *Section 8.1.16*.
- Measures will be taken to minimise dust, noise and control of surface runoff as per *Sections 8.1.1, 8.1.2 and 0*.

Table 8.35 ***Residual Impact Significance***

Impact	Project Phase	Significance (Pre Mitigation)	Residual Impact Significance (Post Mitigation)
Disturbance of Fauna (excluding birds) due to Transmission Line Construction Activities	Construction	Major Negative	Moderate Negative

8.1.18

Loss of Fertile Soil for the Construction of the Hydropower Plant Footprint, Access Road, Transmission Line, Construction Camp and Laydown Area*Potential Impacts*

During the construction phase, fertile topsoil will be impacted by activities like vegetation stripping, grading, soil removal, backfilling, compacting, excavation and disposal of surplus soil in a previously demarcated area. Exposure of the ground and removal of vegetation cover will make the soil vulnerable to erosion by wind and runoff. The construction and flooding of the reservoir area as well as access roads and other supporting infrastructure will have the greatest impact on topsoil. The area to be affected by the reservoir is currently estimated at 405 ha. The following construction activities will result in the generation of bare soil surfaces that will be at risk of erosion:

- Removal of topsoil during the construction phase;
- Creating impenetrable surfaces during the construction phase where soil will be sealed off and ecosystem functioning be affected; and
- Flooding of the reservoir area.

The construction of the Diesel Power Plant is not expected to fertile topsoil as the proposed location is within an existing building with road access.

Baseline Conditions

Soil provides nutrients to plants through complex nutrient cycles including the carbon and nitrogen cycle that is dependent on soil microorganisms. The project area is habitat to a mixture of closed forest, grassland and open forest. The soil forms in these areas provide the growth medium and nutrients required by this vegetation.

Soil has a water storage function that is affected by the structural and textural properties of the soil. Hydromorphic soils are most likely present in areas in the landscape that store large volumes of water and support wetland habitats. Other roles related to water management include the purification of water as well as flood mitigation (a very important feature on the proposed project site, especially also in terms of water retention during heavy rainfall events).

In a structural role, the soil surface provides physical support to living organisms including microorganisms, plants, animals and humans.

Impact Assessment

The most significant impact is the topsoil that will either be stripped and stockpiled in areas where surface infrastructure will be constructed or sealed off by infrastructure and flooding of the reservoir. This will cause major

disturbance to the functionality and productivity of the soil and may also result in a loss of topsoil and the ecosystem services associated with the soil.

Removal of vegetation from the surface will increase the risk of soil erosion caused by water movement (and perhaps also wind) over the soil surface of the topsoil stockpiles and areas cleared of vegetation. The impacts of soil erosion are both direct and indirect. The direct impacts are the reduction in soil quality which results from the loss of nutrient-rich upper layers of the soil and the reduced water-holding capacity of severely eroded soils. The off-site indirect impacts of soil erosion include the disruption of riparian ecosystems and sedimentation.

Chemical soil pollution may occur as a result of oil and fuel spills from construction vehicles associated with the project. This impact will be localised within the site boundaries but when it occurs, must be mitigated and managed immediately to prevent the impact from affecting areas outside of the site boundary.

The significance of loss of topsoil is considered to be moderate negative with and without mitigation.

Table 8.36 **Pre-mitigation Impact Assessment**

Type of Impact		
Direct, indirect		
Rating of Impacts		
Characteristic	Designation	Summary of Reasoning
Extent	Local	This impact is expected to extend up to a maximum of 100 m from the Project construction site and can thus be considered local in extent.
Duration	Permanent	This is a short-term impact expected to occur during the construction phase.
Scale	405 ha	The impact on soil as a resource is restricted to the actual footprint of the Project construction site and thus has the potential to impact 120 ha.
Frequency	Continuous	The impact will happen whenever in situ profiles are disturbed. However, as a result of the permanent nature of this impact (flooded area and areas permanently altered), this impact is considered to be continuous.
Magnitude		
Small		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
High		
The soil in the footprint area as a resource supporting a number of land uses as well as habitats is highly important		
Significance Rating Before Mitigation		
Moderate negative		

Mitigation Measures

The following mitigation measures will be incorporated into the site management:

- The project footprint should be kept as small as possible.
- Topsoil stockpiles should be revegetated within 2 months after topsoil stripping.
- Temporary structures (ablution facilities for construction workers, etc) should be used as far as possible for the infrastructure associated with the construction phase.
- Use existing roads as far as reasonable.

Table 8.37 *Residual Impact Significance*

Impact	Project Phase	Significance (Pre Mitigation)	Residual Impact Significance (Post Mitigation)
Loss of Fertile Topsoil for Hydropower Plant Footprint, Access Road, Transmission Line, Construction Camp and Laydown Area	Construction	Moderate negative	Moderate negative

8.1.19***Impact of Change in Land Use and Capability for Construction and Operation of the Hydropower Plant Footprint, Access Road, Transmission Line, Construction Camp and Laydown Area****Potential Impacts*

The impact on topsoil described in *Section 8.1.1* (erosion and chemical spills) and *8.1.18* (loss of fertile topsoil) will affect the land uses in the area as well as the land capability. As noted above soil provides nutrients for plants, has a water storage function and provides a physical space to support living organisms including people.

Baseline Conditions

Closed and open forest make up some 80%, bareland 6%, waterbodies 2.5 %and grassland 11.6% of the reservoir area.

Impact Assessment

The main impact on land use will be the total loss of a number of current land uses caused by the flooding at the reservoir. The cumulative impact on land use in the project area is that portions of land that was previously not used for agriculture may now be stripped of natural vegetation as economic displacement of local communities will trigger the need for more productive land.

The land capability of the areas where the proposed reservoir will be, will change completely from the current land capability (associated with the current land cover) to a waterbody (once it will be flooded). It is not anticipated that the rest of the project infrastructure will alter the land capability drastically except where the soil will be sealed off by infrastructure.

The diesel power plant will be located in an existing building and hence would not affect land use or land capability.

The significance of loss of topsoil is considered to be moderate negative with and without mitigation.

Table 8.38 *Pre-mitigation Impact Assessment*

Type of Impact		
Direct		
Rating of Impacts		
Characteristic	Designation	Summary of Reasoning
Extent	Local	This impact is expected to be restricted to the Project site and access roads and can thus be considered local in extent.
Duration	Permanent	This is a permanent impact expected to occur throughout the operational phase.
Scale	Project area of influence	The impact is expected to be restricted to the areas where the project footprint will disturb current in situ soil profiles and the land capability of these
Frequency	Once off	The impact occurs when construction activities change the land capability and the change is permanent.
Magnitude		
Medium		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
Medium		
The soil as receptor is considered medium sensitive to the construction activities and will definitely lose land capability.		
Significance Rating Before Mitigation		
Moderate negative		

Mitigation measures

The following mitigation measures will be incorporated into the site management:

- Keep the project footprint as small as possible.

Table 8.39 *Residual Impact Significance*

Impact	Project Phase	Significance (Pre Mitigation)	Residual Impact Significance (Post Mitigation)
Change in Land Use and Capability for Hydropower Plant Footprint, Access Road, Transmission Line, Construction Camp and Laydown Area	Construction	Moderate negative	Moderate negative

8.1.20

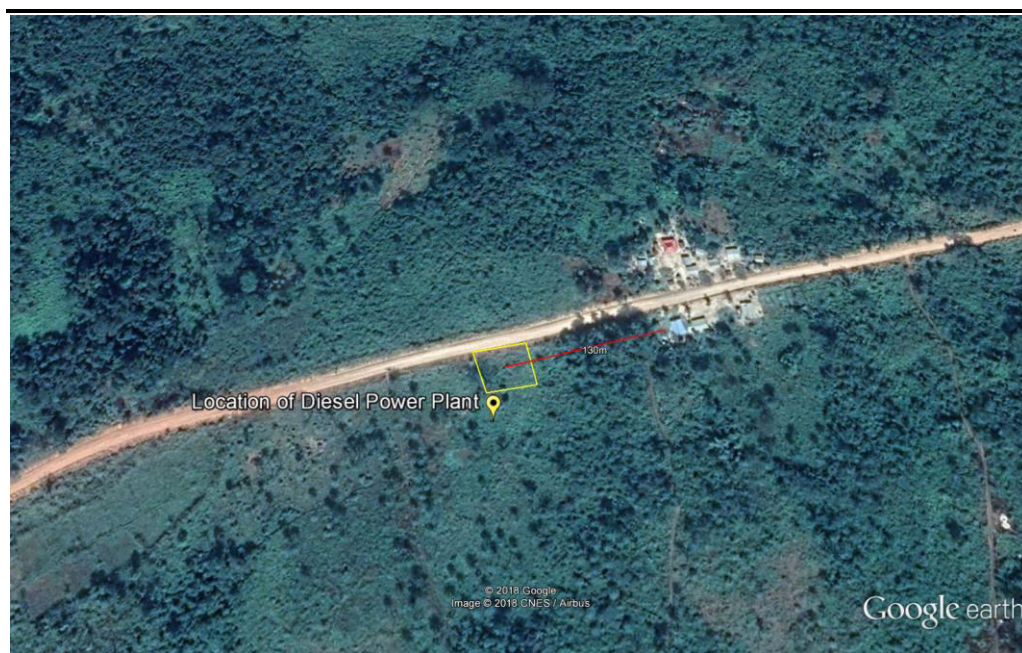
Reduced Air Quality due to Operation of the Diesel Power Plant*Potential Impacts*

The main impact to air quality during operation will be from increased emissions arising from the 1.8 MW diesel power plant during the dry season. A study of air emissions was conducted for the ESIA including emissions modelling analysis for criteria pollutants, including nitrogen oxide (NO_x), carbon monoxide (CO), particulate matter (PM) and sulphur dioxide (SO₂) that will be emitted from the proposed diesel power plant.

Baseline Conditions

The Diesel Power Plant will be located in a sparsely populated place in Balawatta Town, about 3 km from the town of Voinjama on the road to Kolahun City. . The exact location and the details of the site layout have not been finalised, but based on preliminary design, the generator exhaust will be between 100m and 150m from the nearest structure. The surrounding terrain is relatively flat and therefore the receptor and source elevations were set to zero.

Figure 8.5 ***Location of Diesel Power Plant***



Source: Google Earth (accessed 15 November 2018)

Impact Assessment

Stack parameters used to represent a diesel generator are presented in Table 8.40. The building dimensions, including height of the main building (5 meters), were confirmed by the Project and were used to determine

downwash impacts from the main building that will be housing the stacks (one stack per generator was assumed).

Table 8.40 **Stack Parameters**

Equipment Description	Manufacturer and Model	Capacity	Power Output	Stack Height	Stack Gas Temperature	Stack Inside Diameter	Exhaust Flowrate	Stack Gas Exit Velocity
		hp	kW	m	K	m	acmh	m/s
600 kW Diesel Generator	Caterpillar C18 (60 HZ)	804	600	10.0	672.0	0.2	1626.6	24.9

Table 8.41 summarizes the maximum hourly emission rates for NO_x, CO, PM and SO₂. It was conservatively assumed that these generators would be operating continuously although they are proposed to be operated only in the dry season at varying capacity depending on electricity demand (eg, demand would be lower at night).

Table 8.41 **Emission Rates for Criteria Pollutants**

Equipment Description	Capacity	Power Output	NO _x	CO	PM	SO ₂	NO _x	CO	PM	SO ₂
	hp	kW	g/hp-hr				g/s			
600 kW Diesel Generator	804	600	10.89	2.49	0.32	3.67	2.43	0.56	0.07	0.82
Note:										
Emission Factor from AP-42, Chapter 3.4, (10/96) Large Stationary Diesel & All Stationary Dual Fuel Engine										
Sulfur content in Diesel is assumed to be 0.5% (5000 ppm)										

Table 8.42 presents the list of parameters used to generate the meteorological data using MAKEMET, a companion program to the AERSCREEN dispersion model (described further below). MAKEMET was used to generate worst-case meteorological conditions for a particular site. The temperature range was determined using the local temperature profile and the surface characteristics were determined by assuming the surrounding landscape is best characterized as deciduous forest.

Table 8.42 **Parameters Used to Generate Meteorological Data**

Min Temperature	Max Temperature	Anemometer Height	Wind Speed	Albedo	Bowen Ratio	Surface Roughness
K	K	m	m/s			m
287.6	306.7	10	0.5	0.215	0.875	0.9

The assessment used the United States Environmental Protection Agency's (USEPA) conservative air dispersion model AERSCREEN in this modelling analysis. AERSCREEN is a screening model aimed to predict the impact from a single source. Therefore, in this modelling analysis, it is appropriate to use AERSCREEN to predict the impact from a single generator and adjust the final

impact by a factor of three in order to recognize the impact from all three generators. The maximum 1-hour concentrations produced by AERSCREEN were converted to concentrations at different averaging periods by multiplying by factors as recommended by USEPA. Modelled pollutant concentrations in the ambient air are compared to the World Health Organization (WHO) guideline concentrations.

The modelled concentrations for all criteria pollutants meet the WHO guidelines for all averaging period at all sensitive locations for the operational period (as well as discrete receptors placed up to 2,000 meters away from the stack in 25-meter intervals). The most significant pollutant/averaging time impacts, at just over 80% of the WHO 1-hour guideline, is for NO₂

Table 8.43 summarizes the maximum modelled impacts at the FDA (sensitive receptor closest to the stack). As shown, the results presented reflect the maximum over all sensitive receptors and illustrate that the highest modelled concentrations for all criteria pollutants meet the WHO guidelines. It should also be noted that the maximum predicted concentrations occur closer to the stack and decrease rapidly with distance from the stack.

Table 8.43 *Modelled Impacts at the Nearest Receptor Compared to Ambient Air Quality Guidelines (µg/m³)*

Pollutant	Averaging Period	WHO Guidelines	Modelled Concentrations (µg/m ³)	Percent of Relevant Guideline (%)
		(µg/m ³)	Concentration at 150m	Concentration at 150 m
NO ₂	1-hour	200	160.3	80.2%
	Annual	40	16.0	40.1%
SO ₂	10-min	500	31.0	6.2%
	24-hour	20	13.0	65.1%
PM ₁₀	24-hour	50	15.9	31.8%
	Annual	20	2.6	13.2%
PM _{2.5}	24-hour	25	15.9	63.5%
	Annual	10	2.6	26.5%
CO	1-hour	30000	373.2	1.2%
	8-hour	10000	335.9	3.4%

Note:

- 10-min is calculated using the 1/5th power law
- 8-hr, 24-hr and annual are calculated using scaling ratios of 0.90, 0.60 and 0.10, respectively.
- PVMRM approach has been applied for the conversion of NO_x to NO₂ and in-stack ratio 0.2 has been applied.

Note that the model results are conservative, including assumptions of low wind speed and continuous operations of the generators. Above all, AERSCREEN, the modelling programme used, is intended to be a conservative screening model. It is unlikely that the constant operation of

these generators and calm wind conditions would happen at the same time. Consequently, the maximum predicted emissions concentrations will be felt far less than is predicted by the model hence emissions from the proposed backup generators will have a minimal air quality impact in the neighbourhood of the Diesel Power Plant.

This impact level would lead to an impact assessment of minor negative.

Table 8.44 *Pre-Mitigation Impact Assessment*

Type of Impact		
Direct		
Rating of Impacts		
Characteristic	Designation	Summary of Reasoning
Extent	Local	The emissions will only be experienced within a short distance of the Diesel Power Plant.
Duration	Long term	The Diesel Power Plant will operate as a back up generator for the life of the project.
Scale	10	A number of sensitive receptors are located in vicinity to the Diesel Power Plant.
Frequency	Often	The Diesel Power Plant will operate throughout the dry season at various capacity levels.
Magnitude		
Small		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
Medium		
The closest receptors are closer than 150m.		
Significance Rating Before Mitigation		
Minor negative		

Mitigation Measures

No mitigation is proposed for the 1.8 MW installation of diesel generators. However, any subsequent addition of capacity to the proposed diesel generators is to be modelled at the time of imminent operation of the add-on.

Table 8.45 *Residual Impact Significance*

Impact	Project Phase	Significance (Pre Mitigation)	Residual Impact Significance (Post Mitigation)
Reduced air quality due to operation of diesel generators	Operation	Minor negative	Minor negative

8.1.21

Increase in GHG Emissions due to the Construction of the Hydropower Plant and Access Road and Operation of Diesel Generators*Potential Impacts*

The greenhouse effect occurs on a global basis and the point source of emissions is irrelevant when considering the future impact on the climate. CO₂ has a residence time in the atmosphere of approximately 100 years by which time emissions from a single point source have merged with other anthropogenic and natural (e.g. volcanic) greenhouse gas emissions. It is not possible to link emissions from a single source – such as the Project – to particular impacts in the broader study area.

Impact Assessment

The assessment does not consider the physical impacts of climate change resulting from increasing GHG emissions, but instead assesses the impact of the project's GHG emissions by way of:

- Understanding of the scale of the project's GHG emissions relative to Liberia's annual national greenhouse gas emissions;
- Understanding the scale the project's GHG emissions with reference to magnitude ratings for project-wide GHG emissions from various international lender organisations or groupings, including the IFC Performance Standards, the European Bank for Reconstruction and Development (EBRD) GHG assessment methodology, and the Equator Principles (EP).

A carbon footprint is a measure of the estimated GHG emissions produced directly and indirectly by an individual, organisation, facility or product. The carbon footprint for the Project has been estimated in accordance with the GHG Protocol: Corporate Accounting & Reporting Standard (henceforth referred to as the GHG Protocol), developed by the World Business Council for Sustainable Development (WBCSD) and the World Resources Institute (WRI).

The scope of the carbon footprint includes direct GHG emissions from sources owned or under the operational control of the Kaiha Hydropower project ('Scope 1' emissions). There is currently no grid supply of energy and thus no indirect emissions from the consumption of purchased electricity ('Scope 2' emissions) has been calculated. In line with the ESIA scope, emissions have been calculated for construction phase and the operational phase. The timeframe for the phases of the project are illustrated in *Table 8.46* below, together with confirmation of which phases are in the scope of the GHG assessment.

Table 8.46 *Project Phases in Scope*

Phase	Timeframe	Duration	In / Out of Scope
Construction	2019-2020	24 months	In Scope
Operations	2021-2040	20 years	In Scope
Operations – Post 2040	Post 2040	To be confirmed	Out of Scope

Further details on the sources of emissions from the Kaiha Hydropower project during the construction and operations phases are given in Table 8.47 below.

Table 8.47 *Project GHG Emissions Sources*

Project Phase	GHG Emissions Scope	Emissions sources
Construction*	Scope 1 - Land use change	Carbon losses in biomass due to disturbances
Operations**	Scope 1 - Land use change	Carbon loss in organic soils
	Scope 1 - Mobile combustion emissions	Mobile vehicles - maintenance and operations (trucks)
	Scope 1 - Mobile combustion emissions	Mobile vehicles - maintenance and operations (bakkie)
	Scope 1 - Stationary combustion emissions	Synchronous diesel generators (black start)
	Scope 1 - Stationary combustion emissions	Diesel generators (customer supply unmet demand)
	Scope 1 - Land use change	Hydro power plant (flooded land)

* Note that no grid electricity consumption (a Scope 2 emissions source) is expected during the construction phase. Additionally, emissions associated with the use of chemicals, and mobile equipment are considered to be negligible and are not included in the GHG emissions calculations.

**Emissions associated with the use of chemicals, and other back-up generators are considered to be negligible and are not included in the GHG emissions calculations

This assessment does not consider the physical impacts of climate change resulting from increasing GHG emissions because it is not possible to link emissions from a single source – such as the Project - to particular impacts in the broader study area.

A further limitation to the study was the uncertainty of the extent to which the Diesel Power Plant will be operated (frequency, length of time, etc.) which therefore had to be estimated. In the current GHG estimates the emissions from these generators account for between 66% and 85% of the plant's annual emissions. This means that the bulk of the plant's emissions are based on estimates instead of actual or properly projected values.

Definition of Magnitude

An additional perspective on the magnitude of the Project's GHG emissions is provided by standards that are applied within other developments. *Table 8.48* shows a magnitude scale for project-wide GHG emissions that is derived

from, and in line with, a number of current international lender organisations or groupings, such as IFC Performance Standards¹, the European Bank for Reconstruction and Development (EBRD) GHG assessment methodology² and the Equator Principles (EP)³.

Table 8.48 *Definition of Magnitude for GHG Emissions*

Project-Wide GHG Emissions / annum	Magnitude Rating
>1,000,000 tonnes CO ₂ e	Very Large
100,000 – 1,000,000 tonnes CO ₂ e	Large
25,000 – 100,000 tonnes CO ₂ e	Medium
5,000 – 25,000 tonnes CO ₂ e	Small
<5,000 tonnes CO ₂ e	Negligible

The magnitude scale shown in Table 8.48 draws together a number of reporting thresholds adopted by the IFC, EBRD and EP, described below.

IFC Performance Standards

The IFC Performance Standard 3: Resource Efficiency and Pollution Prevention defines a reporting threshold for annual GHG emissions of 25,000 tonnes CO₂e, and requires clients to ‘...consider alternatives and implement technically and financially feasible and cost-effective options to reduce project-related GHG emissions during the design and operation of the project’.

EBRD

An annual GHG emissions threshold of 25,000 t CO₂e has also been adopted by the EBRD within its new Environmental and Social Policy, which entered into force in November 2014. This updated policy reduces the GHG reporting threshold within projects that the EBRD supports from 100,000 to 25,000 tCO₂e per year, and requires annual client quantification and reporting of these emissions. EBRD guidance on assessment of GHG emissions also defines a series of categories and thresholds for different project types (shown in Table 8.49).

Table 8.49 *EBRD GHG Emissions Reporting Categories*

GHG Emissions / annum	Magnitude Description
> 1,000,000 tCO ₂ e	High
100,000 – 1,000,000 tCO ₂ e	Medium-High
20,000 – 100,000 tCO ₂ e	Medium-Low
< 20,000 tCO ₂ e	Low
Not defined	Negligible

¹ International Finance Corporation Performance Standard 3 – Resource Efficiency and Pollution Prevention (2012)

² EBRD Methodology for Assessment of Greenhouse Gas Emissions (2010)

<http://www.ebrd.com/downloads/about/sustainability/ghgguide.pdf>

³ <http://www.equator-principles.com/index.php/ep3>

Equator Principles

The EPs require all projects, in all locations, to conduct an alternatives analysis to evaluate less GHG intensive alternatives when combined Scope 1 and Scope 2 operational emissions are expected to be more than 100,000 tonnes of CO₂ equivalent annually. In addition, the EP require that:

'...the client (should) report publicly on an annual basis on GHG emission levels (combined Scope 1 and Scope 2 Emissions) during the operational phase for Projects emitting over 100,000 tonnes of CO₂ equivalent annually. Clients will be encouraged to report publicly on Projects emitting over 25,000 tonnes.'

Data Sources

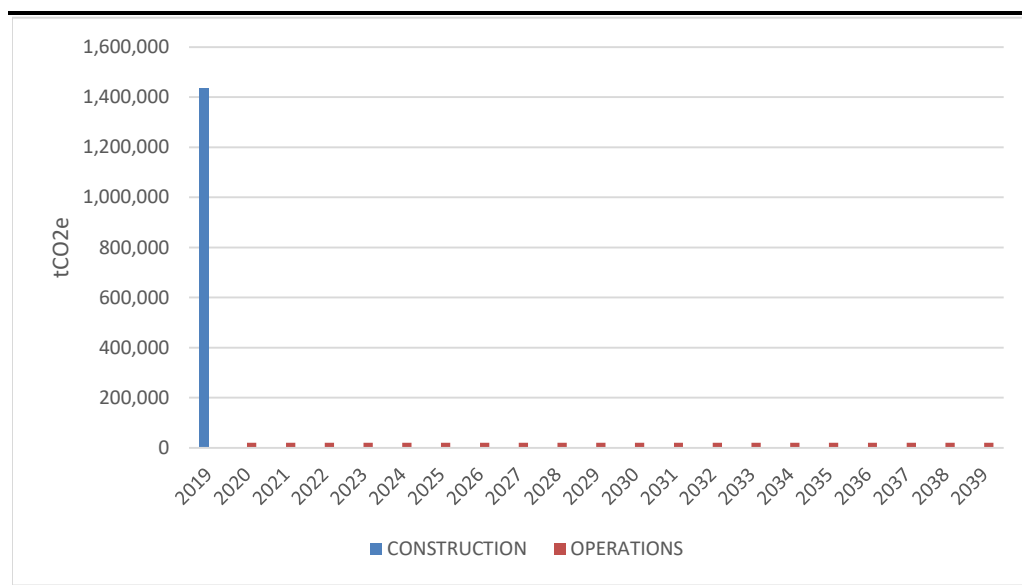
As noted before, GHG emissions from the Project are assessed by applying emissions factors to activity data relating to any GHG-causing project activities.

The Project was unable to provide specific updated information on GHG for the assessment thus information from the initial Feasibility Report (Multi Consult) together with information collated from the different specialist studies was used. As there is currently no grid electricity available, no Scope 2 activity data was requested. Using the data provided by different specialist studies, and supplementing this with information from the Feasibility Study and/or web-based research where required, the relevant GHG emissions factors were applied in order to estimate total emissions of GHGs, expressed as Carbon Dioxide Equivalents (CO₂e), per year.

Figure 8.6 summarises of the project's emissions across the construction and operations phases. Detailed results, summarising emissions by activity for each phase, are given in the sections that follow.

Figure 8.6

Summary of estimated GHG emissions arising from the construction (2019-2020) and operations (2021 – 2040) of the Kaiha Hydropower Project



Construction and Operations

Estimated emissions during years 2019 and 2020 of the construction phase are summarised in Table 8.50 below. Project documents suggest no grid electricity supply and thus no Scope 2 emissions are included below.

Table 8.50 *Estimated GHG Emissions arising from Project Construction*

Construction Activity	Estimated Total Emissions – 2019 (t CO ₂ e)	Estimated Total Emissions – 2020 (t CO ₂ e)	Data Source, Notes and Assumptions
Carbon losses in biomass due to disturbances	1 423 372	0	Data sourced from the Landcover assessment as well as the Soils assessment. It assumed that the land use change emissions due to the disturbance of land occurs for only one year (i.e. year in which the biomass/soil was disturbed). Vegetation area removal applies a 100m buffer.
Carbon loss in organic soils	12 775	0	Data sourced from the Landcover assessment as well as the Soils assessment. It assumed that the land use change emissions due to the disturbance of soils occurs for only one year (i.e. year in which the biomass/soil was disturbed). As there was no quantitative data on soil removed, it was assumed the vegetation area affected was the same as the soil area affected.
TOTAL EMISSIONS (tCO₂e)	1 436 147	0	

Table 8.51 *Estimated Annual GHG Emissions arising from the Operation of the Kaiha Hydropower Project*

Operational Activity	Estimated Annual Emissions (t CO ₂ e)	Data Source*, Notes and Assumptions
Mobile vehicles - maintenance and operations (trucks)	6.96	Assume 1 truck per week sent in for maintenance, travelling from Kolahun (45km). Average diesel consumption per dump/tipper truck assumed to be 55 l/100km
Mobile vehicles - maintenance and operations (bakkie)	1.39	Assume 2 bakkies per week sent in for maintenance, travelling a return trip from and to Kolahun (45km). Average diesel consumption per bakkie assumed to be 11 l/100km
Synchronous diesel generators (black start)	17 488	Information obtained from Feasibility Report (page 67) where 4 units of 400V, with 2 being at 500MW and the other 2 at 750MW. Assume 1 hour run time per week therefore run capacity = 1250MWx1 hoursx52 weeks = 520 000MWh per year. Where 1MWh = 3.6GJ therefore 1 872 000 GJ. To convert to litres, divide by energy factor of 0.036 GJ/litre of diesel = 52 155 688 litres
Diesel generators (customer supply unmet demand)	368*	Diesel generators (customer supply, unmet demand). This aligns with Table 21 of Feasibility Report (page 81) showing ratio of hydro generation and diesel generation over 20 years. Demand in GWh converted to litres then associated emissions calculated.
Hydro power plant (flooded land)	2142	CO ₂ emissions from land converted to flooded land as well as CH ₄ emissions from flooded lands.
TOTAL EMISSIONS (tCO₂e)	19 966	

*Note that these are average emissions over a 20 year period of operation.

The impact assessment is conducted by determining how the proposed activities will affect the state of the environment described in the baseline. As noted before in the case of GHG emissions, this process is complicated by the fact that the impact of GHGs on the environment cannot be quantified within a defined space and time.

The greenhouse effect occurs on a global basis and the point source of emissions is irrelevant when considering the future impact on the climate. CO₂ has a residence time in the atmosphere of approximately 100 years by which time emissions from a single point source have merged with other anthropogenic and natural (eg, volcanic) greenhouse gas emissions. It is not possible to link

emissions from a single source such as the Project to particular impacts in the broader study area.

This impact assessment, therefore, focuses on the magnitude of the estimated annual emissions from the project relative a GHG magnitude rating scale based on international lender standards and relative to Liberia's current and future projected national GHG emissions (*Table 8.53*).

Table 8.52 *Magnitude scale for project-wide GHG emissions based on wider standards*

Project-Wide GHG Emissions / annum	Magnitude Rating
>1,000,000 tonnes CO ₂ e	Very Large
100,000 – 1,000,000 tonnes CO ₂ e	Large
25,000 – 100,000 tonnes CO ₂ e	Medium
5,000 – 25,000 tonnes CO ₂ e	Small
<5,000 tonnes CO ₂ e	Negligible

Table 8.53 *Estimated GHG emissions from the Kaiha Hydropower Project GHG emissions for Liberia*

Year	A - Estimated annual emissions – Liberia (tCO ₂ e) ¹	B - Estimated annual emissions – Liberia (tCO ₂ e), factoring in GHG reductions in INDC	Estimated annual emissions – Kaiha Hydropower project (tCO ₂ e)	Kaiha Hydropower project % contribution to total national emissions relative to A (INDC excluded) and B (INDC included - <i>italics</i>)
2019	4 125 222	4 125 222	1 436 147	34.81%(34.81%)
2020	4 261 106	4 261 106		
2021	4 401 467	4 401 467	19 679	0.45%(0.45%)
2022	4 546 452	4 546 452	19 679	0.43%(0.43%)
2023	4 696 212	4 696 212	19 679	0.42%(0.42%)
2024	4 850 905	4 850 905	19 679	0.41%(0.41%)
2025	5 010 694	5 010 694	19 706	0.39%(0.39%)
2026	5 175 747	5 175 747	19 733	0.38%(0.38%)
2027	5 346 236	5 346 236	19 733	0.37%(0.37%)
2028	5 522 341	5 522 341	19 760	0.36%(0.36%)
2029	5 704 247	5 704 247	19 760	0.35%(0.35%)
2030	5 892 145	4 505 000	19 787	0.34%(0.44%)
2031	6 086 232	4 653 395	19 867	0.33%(0.43%)
2032	6 286 713	4 653 395	19 921	0.32%(0.43%)
2033	6 493 797	4 653 395	19 974	0.31%(0.43%)
2034	6 707 703	4 653 395	20 028	0.30%(0.43%)
2035	6 928 655	4 653 395	20 082	0.29%(0.43%)
2036	7 156 885	4 653 395	20 270	0.28%(0.44%)
2037	7 392 633	4 653 395	20 350	0.28%(0.44%)
2038	7 636 146	4 653 395	20 458	0.27%(0.44%)
2039	7 887 681	4 653 395	20 538	0.26% (0.44%)
2040	8 147 502	4 653 395	20 646	0.25% (0.44%)

¹ Based on Liberia's national GHG emissions in 2011 (source: CAIT Climate Data Explorer. 2017. Washington, DC: World Resources Institute. Available online at: <http://cait2.wri.org/profile/Liberia> (Accessed 2018.04.20)), and actual and estimated GDP growth rates (source: WorldBank Global Economic Prospects (Liberia GDP Growth), accessed 2018.04.20. Available online at: <http://www.worldbank.org/en/publication/global-economic-prospects>)

Based on the above magnitude scale, together with consideration of the magnitude of the project's emissions relative to Liberia's national emissions, the magnitude of the project's GHG impacts is considered to be **Medium**. However, it is important to note that the impact during the construction phase is considered to be **Very Large** in the access of 1 000 000 tCO₂e, while this is estimated to decrease during the operation phase to a magnitude of **Small**. It should be noted that significance in this case is not assessed based on a combination of magnitude and likelihood, since likelihood is irrelevant in the context of GHG emissions given that increased levels of GHG emissions will result from the Project, and given the body of scientific evidence linking GHG emissions to global climate change impacts.

This impact level would lead to an impact assessment of moderate significance.

Table 8.54 *Pre-Mitigation Impact Assessment*

Type of Impact		
Direct		
Rating of Impacts		
Characteristic	Designation	Summary of Reasoning
Extent	Local	The emissions will only be experienced within a short distance of the Diesel Power Plant.
Duration	Long term	The Diesel Power Plant will operate as a back up generator for the life of the project.
Scale	9	A total of 9 sensitive receptors are located in close vicinity (<580m) to the Diesel Power Plant.
Frequency	Often	The Diesel Power Plant will operate throughout the dry season at various capacity levels.
Magnitude		
Small		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
Medium		
The closest receptors (closer than 250 m) include the FDA, which is only occupied during the day five days a week, and a farm house which would be occupied more frequently and hence may experience longer periods of exposure.		
Significance Rating Before Mitigation		
Minor negative		

Mitigation Measures

Annual emissions associated with the project are largest during year 2019 (and possibly 2020) which is the construction phase (1 436 147) tCO₂e, compared to total annual emissions during operations of 399 329 tCO₂e. The value is driven by land use change for the construction of the access road and the hydropower plant. During the first 20 years of operations, the highest emissions are associated with generator use at approximately 17 500 tCO₂e annually. Bearing this in mind, mitigation measures associated with both the construction and operations phases are highlighted below.

The following measures will help to reduce GHG emissions during the construction phase:

- Minimise unnecessary land disturbance during the construction of the access road and hydropower plant, including avoiding unnecessary damage or destruction of existing vegetated forest and other biomass-rich areas. This can be done by developing a code of construction practice which highlights how vegetation disturbance and removal will be minimised.
- Assess opportunities for the productive use of biomass material (especially forest wood) subsequent to land clearance. This could include the creation of wood-related products or use of waste material as a biomass fuel. Burning cleared vegetation, or leaving it to decompose, can result in significant GHG emissions and should be avoided.

Other aspects to consider during the construction phase may include:

- Minimise fuel consumption by vehicles and machinery used for the earth and track work, by minimising idling (shutting down equipment when not in use), developing and implementing a regular equipment and vehicle maintenance plan to avoid a reduction in equipment efficiency over time; considering energy efficiency during the procurement of equipment (for example by comparing fuel consumption rates); implementing driver training for mobile equipment operators to minimise fuel consumption; ensuring vehicles and equipment are used at their optimal / designed capacity (ie, not overloaded); using energy efficient timetabling to minimise equipment idling and prevent unnecessary trips; and through a program to encourage awareness of energy efficiency amongst personnel (for example through training and signage on equipment).

As noted, the diesel used to power generators used either for start-up or to contribute towards the unmet demand results in approximately 17 500 tCO₂e. The following measures will help to reduce GHG emissions during the operations phase:

- Maximise the efficiency of the diesel generators for power generation through the following measures: procuring generators with a high inherent efficiency (i.e. minimum diesel consumption per kWh generated); deploying the correct sized diesel generators to match power requirements (for example using larger generators during the day when all operations are running, and smaller generators in the evenings when load has been reduced); minimising idling of generators; carrying out regular maintenance in accordance with operator specifications; and maximising fuel quality (the latter will also assist in reducing air quality

impacts), Procurement of generators using alternative energy (e.g. solar photovoltaic array, wind etc.), or low carbon fuels / biofuels should also be considered.

The development and implementation of a GHG management plan is critical if the GHG emissions are to be managed over time. Since GHG emissions are primarily driven by land use change and energy consumption, this can take the form of a combined land/energy and GHG management plan. Key elements of a land/energy / GHG management plan include:

- Measuring GHG emissions and energy consumption during operations on an annual basis, such that key sources of emissions can be identified, and emissions trends can be tracked over time. Note that it is a requirement of the IFC Performance Standards that *'...for projects that are expected to or currently produce more than 25 000 tonnes of CO₂e-equivalent annually... quantification of GHG emissions will be conducted by the client annually in accordance with internationally recognized methodologies and good practice.*
- Setting a GHG emissions reduction target. Such targets can be absolute (ie, targeting an absolute reduction of total GHG emissions expressed in tCO₂e); as a percentage reduction, against the baseline value; or 'intensity based' (ie, targeting a reduction of GHG emissions (in tCO₂e) per tonne of coal exported or against any other suitable operational metric).
- Identifying and implementing land/energy / GHG reduction projects to reduce emissions associated with the hydropower operations. The GHG inventory can be used to focus efforts on the most emissions intensive areas or activities, or areas in which there is potential for improved efficiency and therefore energy / GHG savings.
- Allocating responsibility to key individuals such that someone (or a team of individuals) is responsible and accountable for land management, energy consumption and GHG emissions;
- Communicating the plan to staff at to ensure buy-in and participation;
- Encouraging employee-led energy management initiatives – whereby staff responsible for operations in each area are encouraged to propose and implement energy management initiatives; and
- Reporting progress over time with respect to annual energy consumption and GHG emissions, energy / GHG reductions achieved through the implementation of efficiency measures, and progress towards any reduction targets that have been set.

Table 8.55 **Residual Impact Significance**

Impact	Project Phase	Significance (Pre Mitigation)	Residual Impact Significance (Post Mitigation)
Residual Impact Significance for Increase in GHG Emissions due to the Construction of the	Operation	Minor negative	Minor negative

Impact	Project Phase	Significance (Pre Mitigation)	Residual Impact Significance (Post Mitigation)
Hydropower Plant and Access Road and Operation of Diesel Generators			

8.1.22 *Risk of Climate Change Related External Factors on Operation of the Hydropower Plant*

Potential Impacts

Climate change will likely affect operations in a multitude of difficult to predict ways. Some operations may be naturally more resilient than others but as a general rule, those likely to be at risk from changes in the frequency and/or intensity of extreme weather and gradual changes in weather variables include those:

- With a history of weather related damages and disruptions;
- That have been or could be disrupted by flooding (either on site, in the surrounding area or within the supply chain);
- That are dependent on seasonal temperatures or weather; and
- With operating envelopes/ design standards keyed to weather/ hydrological extremes (eg 1:100 flood; 2-year/ 24-hour rainfall event; 100km/hr wind; or a Category 3 hurricane etc).

Weather and climate can impact operations in a number of ways, including (but not limited to):

- Supply chain disruptions
- Reduced production
- Physical damage to buildings/infrastructure/fleet
- Flooding of buildings/sites/equipment
- Electricity trips
- Water shortages
- Impacts on staff health
- Evacuations of staff
- Shortage of raw materials
- Reduction in efficiency of equipment
- Increased maintenance/clean up costs
- License/law contraventions (unplanned overflows, groundwater contamination)

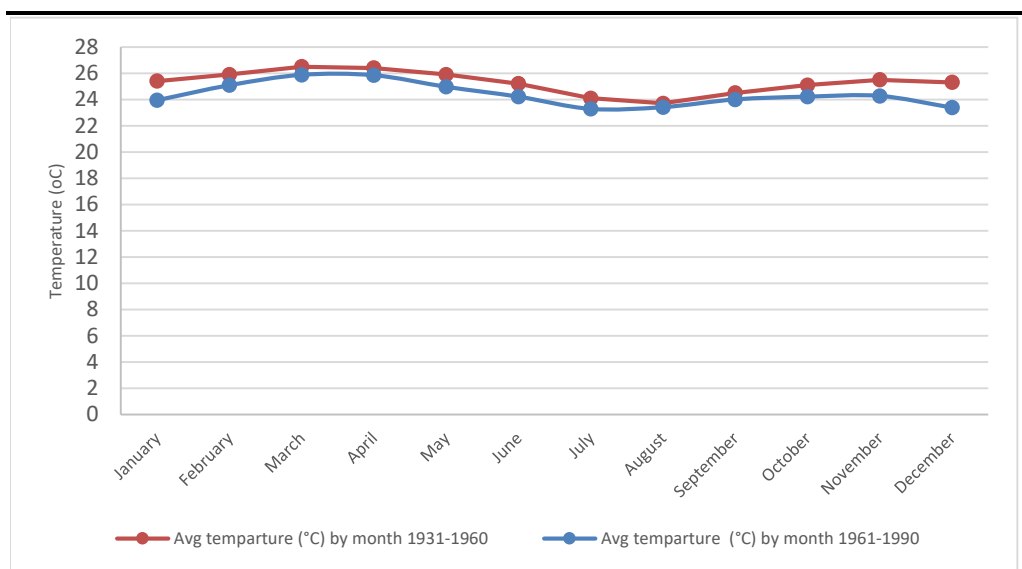
Baseline Conditions

The monthly distribution of average temperatures shows a historical high of 27°C in March while the historical low shows 23°C in December.

The area receives approximately 400mm of rain during rainy and approximately 11mm during seasons where not much rain is expected.

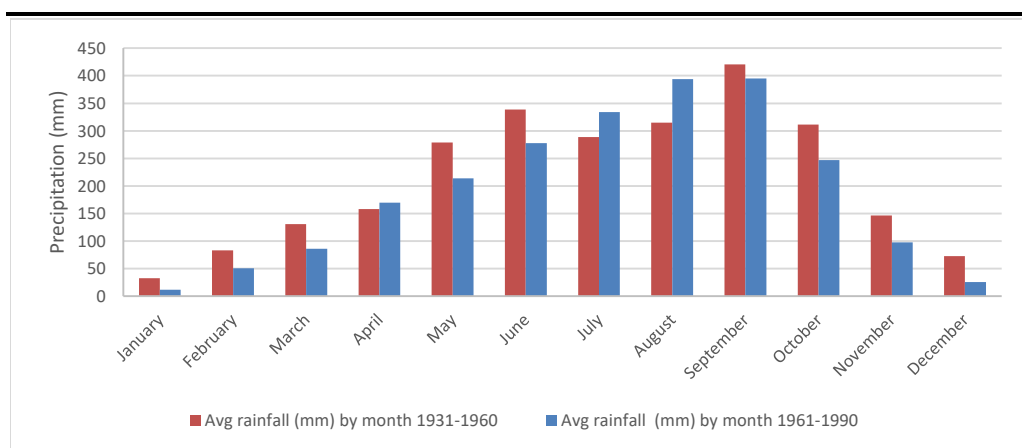
More detailed analysis of historical temperature and rainfall trends is shown below.

Figure 8.7

Seasonal Averages in Temperatures from the Mbaloma area

Source: World Bank Climate Data Knowledge Portal. CRU data. For 1931-1960 (http://sdwebx.worldbank.org/climateportal/index.cfm?page=country_historical_climate&ThisRegion=Africa&ThisCCode=LBR). For 1960 - 1990 (http://sdwebx.worldbank.org/climateportal/index.cfm?page=country_historical_climate&ThisRegion=Africa&ThisCCode=LBR)

Figure 8.8

Seasonal Averages in Rainfall for Mbaloma area

Source: World Bank Climate Data Knowledge Portal. CRU data. For 1931-1960 (http://sdwebx.worldbank.org/climateportal/index.cfm?page=country_historical_climate&ThisRegion=Africa&ThisCCode=LBR). For 1960 - 1990 (http://sdwebx.worldbank.org/climateportal/index.cfm?page=country_historical_climate&ThisRegion=Africa&ThisCCode=LBR)

Impact Assessment

Conducting a Climate Risk and Adaptation Assessment (CRA) allows us to understand how weather is currently affecting a site/operation, what the risks are and how these risks might change in the future. Thereafter, based on the findings, appropriate adaptation measures can be recommended for the site/

operation to implement to reduce the risks posed by current weather and future climate.

Essentially, climate risk is a combination of a weather/climate event, vulnerability of the operation as well as exposure of the operation. The nature and severity of the weather events and climate change will influence the risk of adverse impacts. Exposure can be described as the presence of assets, people, infrastructure in places that could be adversely affected by the weather and climate change.

For the current assessment, the climate context was understood by gathering historical data for the site. Models were then reviewed of potential future climate change events and how these would affect key patterns such as rainfall, temperatures etc.

The following figures show different results for climate change projections. Given the inherent uncertainties in predicting the future, climate change projections are used to develop future climate scenarios. High, Medium and Low scenarios are developed for the physical impacts most likely to affect the asset and projections are relative to a base case mean of 1980-2000 and have been sourced from CMIP5,RCP8.5.

Figure 8.9

Climate Projections for Liberia (precipitation)

Variable	Projected change (Low, Medium and High climate impact scenario)		Data sources / additional comments
Precipitation (change in annual average total rainfall)	Low	DJF:-7%,MAM:-10% JJA:0%,SON:5%	Projections relative to a base case mean of 1980-2000. Source CMIP5,RCP8.5
	Medium	DJF: -9%,MAM:-11% JJA: -0%;SON:7%	
	High	DJF:-13 %,MAM: -20% JJA: -2% , SON:10%	
Precipitation (change in 5 consecutive day annual maximum amount)	Low	+8%	Projections relative to a base case mean of 1980-2000. Source CMIP5,RCP8.5
	Medium	+9%	
	High	+15%.	
Precipitation (change in 99 percentile (1:100 year) precipitation event)	Low	+31%	Projections relative to a base case mean of 1980-2000. Source CMIP5,RCP8.5
	Medium	+36%	
	High	+50%.	
Precipitation (change in 95 percentile (1:20 year) precipitation event)	Low	+11%	Projections relative to a base case mean of 1980-2000. Source CMIP5,RCP8.5
	Medium	+20%	
	High	+25%	
Precipitation (#Days with at least <1mm)	Low	+3%	Projections relative to a base case mean of 1980-2000. Source CMIP5,RCP8.5
	Medium	+10%	
	High	+16%	

Figure 8.10 *Climate projections for Liberia (temperature)*

Variable		Projected change (Low, Medium and High climate impact scenario)	Data sources / additional comments
Change in average temperature	Low	DJF: +7% JJA: +13%	Projections relative to a base case mean of 1980-2000. Source CMIP5,RCP8.5
	Medium	DJF: +11% JJA: +21%	
	High	DJF: +20% JJA: +38%	
Change in average maximum temperature	Low	DJF: +5% JJA: -7%	Projections relative to a base case mean of 1980-2000. Source CMIP5,RCP8.5
	Medium	DJF: +9% JJA: -12%	
	High	DJF: +17% JJA: -21%	
Change in average minimum temperature	Low	DJF: +9% JJA: +25%	Projections relative to a base case mean of 1980-2000. Source CMIP5,RCP8.5
	Medium	DJF: +15% JJA: +42%	
	High	DJF: +26% JJA: +76%	

Figure 8.11 *Climate projections for Liberia (other)*

Variable		Projected change (Low, Medium and High climate impact scenario)	Data sources / additional comments
Drought	Low	DJF:+2%,MAM:-12% JJA:+48%,SON:-14%	Projections: Precipitation minus Evaporation as net available water. JJA is in deficit and deficit increases; SON is in deficit and deficit decreases. Source CMIP5,RCP8.5
	Medium	DJF: -7%,MAM:-19% JJA: +88%;SON:-33%	
	High	DJF:-11 %,MAM: -29% JJA: +115% , SON:-58%	
Cold spell duration (maximum consecutive days with less than 1 mm precipitation)	Low	-3.4 days	Projections relative to a base case mean of 1980-2000. Source CMIP5,RCP8.5
	Medium	-4.0 days	
	High	-4.0 days	
Warm spell duration (maximum consecutive days with less than 1 mm precipitation)	Low	+52.4 days	Projections relative to a base case mean of 1980-2000. Source CMIP5,RCP8.5
	Medium	+124.0 days	
	High	+235.5 days	
Evaporation	Low	DJF:+1%, MAM:-3%, JJA:-2%, SON:0%	Projections relative to a base case mean of 1980-2000. Source CMIP5,RCP8.5 (obtained from UK GIS Database Tool)
	Medium	DJF:0%, MAM:-4%, JJA:-2%, SON:0%	
	High	DJF:0%, MAM:-6%, JJA:-5%, SON:-2%	

Table 8.56 Results of Climate Change Risk Assessment

Risk	Risk (Present)	Risk (2050s)	Residual Risk (2050s, after adaptation)
High temperatures result in reduced thermal efficiency	Low	Medium	Medium
High temperatures and heatwave conditions pose a health risk to the workforce	Medium	Medium	Low
High temperatures and heatwave events result in spontaneous combustion at the coal stockpiles	Low	Low	Low
Wildfires in the wider area disrupt access to the site and damage utilities infrastructure	Low	Medium	Low
Lower than normal precipitation levels and increased drought result in water shortages *	High	High	High
Lower than normal precipitation levels and increased drought create water quality issues *	Medium	High	High
High wind speeds / wind gusts damage infrastructure	Low	Medium	Low
Flood events affect the site causing equipment damage / operational disruption	Medium	Medium	Low
Flood events affect the site causing polluted water overflows	Medium	High	Low
Flood events affect the wider area resulting in reduced / lack of accessibility to the site	Medium	Medium	Medium
Dry spells / drought events result in increased dust generation	Low	Medium	Low
Dry spells / drought events affect communities and threatens social license to operate	Medium	High	Medium

8.2 *SOCIO-ECONOMIC ENVIRONMENT*

8.2.1 *Increased Employment, Skills Enhancement and Local Business Due to the Construction of the Hydropower Plant, Associated Infrastructure, Transmission Lines and Diesel Power Plant*

Potential Impacts

The Project is expected to generate positive impacts on the local economy and livelihoods in terms of:

- Employment and skills enhancement; and
- Local business opportunities through the procurement of goods/services and new opportunities making use of a reliable source of electricity.

Positive impacts in terms of direct employment on the Project will be associated with the construction phase and will therefore be temporary in nature. The termination of construction contracts will occur once construction activities are completed. Workers who have relocated to the area for the Project are likely to leave the area in search of other opportunities, especially if they are permanent employees of contractors and subcontractors.

Those who have worked on the Project will have an advantage when seeking alternative jobs on similar projects due to the experience and any training received through this Project. Additionally, supplementary positive impacts may develop if the opportunity is seized upon by the communities to develop business opportunities around a reliable and more accessible electricity grid.

Baseline Conditions

The area is characterised by very limited industrial developments and is at the time of writing the only proposed development project, which may offer alternative employment opportunities in the area.

Employment opportunities in the project area are limited with the main source of livelihood in the project area being agriculture, mainly practiced for subsistence purposes. According to IED (2016a), there are no major industries, agro-processing plants, or any other large enterprise in the area except for small mills which are usually owner-operated. The main formal employers in the project area are the government institutions like schools, local administration, health centres, and private firms like banks, fuel dealers and NGO's.

Impact Assessment

Approximately 150 workers are expected to be employed during the peak of the construction period. However, given the local population's limited educational backgrounds and skills, most of the local residents will only be in position to take on semi-skilled and unskilled labour. The project is also

expected to create local business opportunities for the resident population. Local entrepreneurs will be encouraged to offer services as suppliers (of agri-produce for example) and sub-contractors (particularly in service provision such as cleaning, clearing and catering services). In addition, the improved cash flow among the local population will increase their purchasing power resulting in good business for those already engaged in trade. Construction and upgrade of roads will further contribute to more efficient transportation services and better access to markets.

The significance of the impact is rated as moderate positive.

Table 8.57 *Pre-Mitigation Impact Assessment*

Type of Impact		
Direct, indirect and induced positive impact		
Rating of Impacts		
Characteristic	Designation	Summary of Reasoning
Extent	Regional	Employment will be created at a local and regional level depending on skills and capacity availability, as such the extent will be regional.
Duration	Short term	The duration will be short-term, for the duration of the construction phase and work contracts will vary in length, based on the type of work being performed.
Scale	Large	For those who are able to secure employment on the Project the scale will be medium, as they secure an income for the duration of their contract.
Frequency	Constant	The frequency of the impact will be constant for the duration of the construction phase.
Magnitude		
Medium		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
Medium		
Given the capacity of the local workforce to fill unskilled and semi-skilled employment positions, together with the opportunity to increase skills and work experience, the vulnerability is medium.		
Significance Rating Before Mitigation		
Moderate positive		

Mitigation Measures (enhancements)

The following measures will be implemented to ensure that employment of local people is maximised:

- Establish a recruitment policy, which prioritises the employment of local residents (originating from towns in the Project area), over non-locals.
- Set criteria for prioritising local residents and then other people from Liberia as part of the recruitment process. Women should receive preference in non-labour intensive positions to encourage and promote gender equality.

- All contractors will be required to recruit in terms of the Project's recruitment policy, where practical.
- Prevent child labour by not employing minors of less than 18 years of age.
- Meet with the tribal authorities and local government to access any available skills/employment-seekers database for the area. This database is to be updated and made available to the appointed contractors.
- Job opportunities and criteria for skills and experience needed will be advertised through local media, at least three months ahead of recruitment. This information should also be provided to all relevant authorities, community representatives and organisations on the interested and affected party database.
- No employment will take place at the entrance to the site. Only formal channels for employment will be used.
- Monitor on-the-job performance and training through performance reviews. Training needs will be identified and provided by the Project.
- A local procurement policy will be implemented to ensure that local procurement is maximised, the policy will include:
 - Reasonable targets for using local suppliers.
 - A clause of none discrimination on any grounds of gender, ethnicity, religion.
 - Criteria for monitoring local procurement and reporting on supplier performance management.
- Clearly communicate the criteria and tendering process prior to the commencement of construction activities; and
- The procurement policy and tendering requirements must be easily accessible to potential suppliers.

The following management measures will be implemented to enhance skills development and on-the-job training:

- Develop internal training 'certification' or reference letter provisions to those who receive internal training.
- Develop training plans according to each permanent employee's work agreement and relevant to their job description.

Table 8.58 ***Residual Impact Significance***

Impact	Project Phase	Significance (Pre-mitigation)	Residual Impact Significance (Post-mitigation)
Increased Employment, Skills Enhancement and Local Business Due to the Construction of the Hydropower Plant, Associated Infrastructure, Transmission Lines and Diesel Power Plant	Construction and Decommissioning	Moderate positive	Moderate positive

8.2.2 *Increased Employment, Skills Enhancement and Local Business due to the Operation of the Hydropower Plant and Diesel Power Plant*

Potential Impacts

The Project is expected to generate positive impacts on the local economy and livelihoods during operation in terms of:

- Employment and skills enhancement; and
- Local business opportunities through the procurement of goods/services and new opportunities making use of a reliable source of electricity.

Baseline Conditions

The area is characterised by very limited industrial developments and is at the time of writing the only proposed development project, which may offer alternative employment opportunities in the area. Employment opportunities in the project area are limited with the main source of livelihood in the project area being agriculture, mainly practiced for subsistence purposes. According to IED (2016a), there are no major industries, agro-processing plants, or any other large enterprise in the area except for small mills which are usually owner-operated. The main formal employers in the project area are the government institutions like schools, local administration, health centres, and private firms like banks, fuel dealers and NGOs.

A total of approximately 30 towns will be connected to the grid, including the cities of Kolahun/Kolba, Foya and Voinjama. The total number of consumers in these towns is assumed to be around 10,200 in 2019, increasing to almost 15,900 after 20 years.

Impact Assessment

The project will create limited direct employment of permanent employees for the operation of the power plant and a handful on temporary basis under maintenance contracts. The number of workers is substantially lower compared to the available job seekers but it will result in job security and improved cash flow for those permanent employees.

Similar to the construction phase, local workers are expected to show competency to fill unskilled and semi-skilled positions at first, whilst a limited number of people may be sufficiently qualified for skilled positions. Semi-skilled and skilled positions will initially be recruited from elsewhere in the region and Liberia.

Over time, however, local workers will be able to fill more of the semi-skilled and skilled positions as training will be provided by the Project to the local workforce, to improve skills levels relevant to the Project.

During the operation phase the contracts that were in place during the construction phase will be terminated and procurement opportunities will be centred on maintenance activities and providing goods and services to the project.

For those companies that meet eligibility criteria, who become approved suppliers and enter the supply chain, there will be long-lasting and sustained benefits to the businesses and their employees through increased experience, capacity and training. As such, during the operation phase there will be opportunity for local business growth and development.

The main objective of the project however is to provide affordable electricity supply to rural and urban communities in Lofa County. According to IED (2016a), households will have reduced energy costs, creating more disposable incomes and opportunities to better their livelihood (*Table 8.59, Table 8.60*). In particular, the provision of electricity supply is expected to reduce the domestic workload especially on women and children.

Table 8.59 *Avoided Costs for Households*

	Low	Medium	High
Current ability to pay (USD per month per household)	10	21	38
Future electricity bills (USD per month per household)	5	12	32
Avoided costs (USD per month per household)	5	9	6

Source: IED (2016a)

Table 8.60 *Total Economic Benefits to Households*

	Low	Medium	High
Avoided costs for all end-uses	5	9	6
Consumer surplus for lighting	17	21	40
Consumer surplus for phone charging	2.7	3.7	4.4
Economic benefits of electrification per household per month	25	34	50

Source: IED (2016a)

Improving infrastructure, particularly access to electricity, is critical when looking at barriers to business opportunities and job growth in sub-Saharan Africa. According to the 2016 UN Human Development Report (HDR) report, nearly 7 out of 10 businesses cite lack of access to a reliable source of power as a main constraint to doing business, before access to finance and corruption. Fundamentally, reliable electricity expands the number and variety of business and job opportunities available.

Additionally, electricity also leads to the creation of new markets, which provide more opportunities for individuals to earn an income and uplift themselves, their families and their communities out of poverty. Other advantages include, longer and alternative working hours and business opportunities that allow access to untapped markets.

It is also critical to remember that a lack consistent access to reliable electricity can influence businesses negatively and contribute to leakages in the economy. As a whole, the West-African manufacturing enterprises experience power outages around 56 days a year on average. As a result, firms lose six percent of sales revenues in the informal sector. Where back-up generators are limited, losses can be as high as twenty percent. These losses have severe consequences for the growth of - and investment potential into the wider economy.

The significance of the impact is rated as Major positive.

Table 8.61 *Pre-Mitigation Impact Assessment*

Type of Impact		
Direct, indirect and induced impact		
Rating of Impacts		
Characteristic	Designation	Summary of Reasoning
Extent	Regional	Employment will be created at a local and regional level depending on skills and capacity availability, as such the extent will be regional.
Duration	Long term	The duration of the operation phase
Scale	Large	For those who are able to secure employment or develop businesses with the improved access to electricity the scale will be large, as they secure long-term, stable income.
Frequency	Constant	The frequency will be constant for the duration of the operation phase.
Magnitude		
Large		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
Low		
There is limited employment and procurement opportunities during the operation phase, as well as a lack of appropriate skills. However, there are over 10, 000 potential electricity consumers as well as numerous small business that stand to benefit, hence the vulnerability is medium.		
Significance Rating Before Mitigation		
Major positive		

Mitigation Measures (enhancement)

The mitigation/enhancement measure provided for the operation phase include the following:

- Implement construction phase measures to enhance employment, skills training and on the job development during the operation phase.

- Break down procurement requirement to its smallest parts. This will allow numerous small businesses to benefit from the project.
- All contractors will be required to adhere to the procurement and employment policies and procedures of the project. Contractors will be discouraged from bringing in-migrant workers into the area unless the skills required cannot be found in the project area and project affected districts.
- The project will ensure that the appointed project contractors and suppliers have access to Health, Safety, Environmental and Quality training as required by the project. This will help to ensure that they have future opportunities to provide goods and services to the sectors.
- Establish a grievance protocol and procedures, as described in the IFC *Good Practice Note Addressing Grievances from Project-Affected Communities* (2009) and other related or updated documents, whereby people can raise concerns and issues regarding all project-related activities.

Table 8.62 ***Residual Impact Significance***

Impact	Project Phase	Significance (Pre-mitigation)	Residual Impact Significance (Post-mitigation)
Increased Employment, Skills Enhancement and Local Business due to the Operation of the Hydropower Plant and Diesel Power Plant	Operation	Major positive	Major positive

8.2.3

Land Tenure, Ownership and Use (Economic Displacement)

Potential Impact

International development and finance organisations recognise that development projects which displace people involuntarily generally give rise to severe economic, social, and environmental problems. Production systems are dismantled; productive assets and income sources are lost; people are relocated to environments where their productive skills may be less applicable and the competition for resources greater; community structures and social networks are weakened; kin groups are dispersed; and cultural identity, traditional authority, and the potential for mutual help are diminished. Involuntary and voluntary resettlement may cause long-term hardship, impoverishment, and environmental damage unless appropriate measures are carefully planned and carried out.

Baseline Conditions

Loss of land will particularly affect those households reliant on one natural resource-based livelihood activity. Local farmers rely on shifting cultivation combined with growing of permanent (cash) crops such as coffee, cacao and oil palm. Crops such as coffee and cacao cannot survive without the shade from large trees that may be cut down. Vulnerability of affected people is heightened by dependency on agricultural and other land based activities and limited education to take advantage of other economic opportunities, where these exist. Fishing currently takes place at the waterfall which forms the site of the hydropower plant. Most of the fishing is practiced along the slow-flowing reaches, i.e. upstream or downstream (Madina) of the Kaiha 2 waterfall

Impact Assessment

The number of households that will be affected by physical and/ or economic displacement by the project has been not yet been estimated at this point.

Physical Displacement

The project land required consists of the Kaiha 2 hydropower site with its associated facilities and the 115 km transmission line corridor of 10 m width. The normal practise in the affected towns is that chiefs are responsible for land allocation and that no monetary value is attached to the land (except in the urban centres). Based on stakeholder consultations, the project will be granted land for the power plant and access road as a donation through voluntary allocation by the chiefs, while the transmission lines will be routed within the existing road reserve (75 feet / 23 m on each side of the road centre line). No physical displacement is foreseen at the time.

Economic Displacement

Economic displacement with reference to land based livelihood activities can result in:

- Loss of initial investment (time and resources) for establishing crops;
- Stress and ill-health as a result of disruption to livelihoods;
- Increased food insecurity and potential for nutritional diseases;
- Reduced income and economic activity within the communities; and
- Tensions between stakeholders and project developers.

This loss of land may also result indirectly from the development promoting new land uses in the project area (that will generate a higher economic return) and as a result land currently been utilised for land based livelihoods no longer being available. Given the uncertainty associated with this indirect impact, no further assessment has been undertaken thereof in this report although this should remain as a recommendation for further land use planning undertaken at the local level.

Households facing economic displacement will experience disruption to their livelihoods and without support are unlikely to be able to re-establish their current livelihoods. The amount of productive land that will be lost as a result of the project is not yet known, nor the exact number of people that will be affected.

The significance of the impact will be major negative.

Table 8.63 *Pre-Mitigation Impact Assessment*

Type of Impact		
Direct, negative impact		
Rating of Impacts		
Characteristic	Designation	Summary of Reasoning
Extent	Local	Any displacement will be limited to the footprint of the project.
Duration	Long term	The proceeds from one harvest are directly invested into the next crop planting activities hence disruption of this investment cycle will impact many future crops. This is more evident when considering fruit bearing trees, as they take a prolonged period of time to yield fruits and reach peak production capacity.
Scale	Large	This impact would be felt by a large number of people (in relation to the project size and footprint).
Frequency	One-off	The impact will happen once at the start of the project.
Magnitude		
Large		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
Medium		
Subsistence farming relies heavily on previous harvests and mature fruit trees hence are vulnerable to disruption.		
Significance Rating Before Mitigation		
Major negative		

Mitigation Measures

The specific mitigation measures required are the following:

- Position infrastructure to avoid and/or minimise resettlement as far as practicable, taking into account feasibility of the location, as well as safety and legislative restrictions.
- Prepare a Resettlement Action Plan or Livelihoods Restoration Plan in line with national requirements and international standards, especially World Bank Safeguard Policy OP 4.12¹.
- Establish a community development programme. Consult with affected communities and, in partnership with them, identify community development initiatives, based on their development priorities.
- Implement the grievance mechanism and disseminate information regarding the grievance mechanism. Stakeholders should be made aware of the key guiding principles of the mechanism, as well as how and where they can submit any grievances.

Table 8.64 *Residual Impact Significance*

Impact	Project Phase	Significance (Pre-mitigation)	Residual Impact Significance (Post-mitigation)
Land Tenure, Ownership and Use (Economic Displacement)	Construction	Major negative	Minor negative

¹ In addition to meeting the requirements of the referenced international requirement, Project must comply with applicable national law, including those laws implementing host country obligations under international law.

8.2.4

Increased Pressure on Local Infrastructure and Services

Potential Impacts

The expected population influx will exert pressure on the underdeveloped local infrastructure and services including water supply, sanitation, and health services. As noted from the baseline, the water supply facilities are inadequate, the sanitation coverage and practices are poor, and the health service delivery already operates with substantial challenges. The increase in migrants may result in an increased demand for shelter and possibly exacerbate the existing housing shortages in the project area.

Baseline Conditions

The population within the Project area has been stable and can be attributed to the lack economic opportunities. There is limited existing formal services and infrastructure in the area, and health services are under pressure, however a traditional way of life has developed and may accommodate some of the challenges associated with a lack of service provision.

Impact Assessment

Escalating demands will also be placed on health services with the predicted influx of people to the area. Given that the health care facilities are already stressed it is predicted that indicators such as the number of people per health care practitioner and the number of people per hospital bed will increase. It is important to note that during the operational phase, there will limited formal employment opportunities emanating from the project but the access to an improved electricity system has the potential to lure immigrants into the area, the number of immigrants however cannot be accurately predicted at this stage.

The significance of the impact is rated as moderate negative. The impact is reversible as social infrastructure and services can be improved to address the impact.

Table 8.65 *Pre-Mitigation Impact Assessment*

Type of Impact		
Indirect		
Rating of Impacts		
Characteristic	Designation	Summary of Reasoning
Extent	Local	The impact will be felt within the towns that are to be electrified.
Duration	Long term	The impacts will be long-term as the influx may not be limited to the construction phase as with other development projects.
Scale	Medium	The project is not expected to attract large volumes of in-migration and the degree of change for local population will therefore be notable but will not dominate over existing conditions.
Frequency		The frequency of the impacts will not be uniform, but will be felt often until in-migration stabilises and upgrades to infrastructure are undertaken.
Magnitude		
Medium		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
Medium		
The population within the project area has been stable and can be attributed to the lack economic opportunities. There is limited existing formal services and infrastructure in the area, and health services are under pressure, however a traditional way of life has developed and may accommodate some of the challenges associated with a lack of service provision.		
Significance Rating Before Mitigation		
Moderate negative		

Mitigation Measures

The following mitigation measures will apply to the project:

- Provide adequate health care to project workers and their families so as to avoid adding additional pressure on the existing health facilities.
- Conduct preventive health campaigns for the communities with particular focus on water and sanitation related diseases.
- Implement a grievance procedure that is easily accessible to the local community, through which complaints related to contractor or employee behaviour can be lodged and responded to. The project will respond in a serious manner to any such complaints. Key steps include:
 - Circulation of contact details of 'grievance officer' or other key project contact.
 - Awareness raising among the local community regarding the grievance procedure and how it works.
 - Establishment of a grievance register to be updated and maintained by the project.

- Implement management measures associated with the prioritization of local labour, as outlined in *Section 8.2.1*.

Table 8.66 *Residual Impact Significance*

Impact	Project Phase	Significance (Pre-mitigation)	Residual Impact Significance (Post-mitigation)
Increased Pressure on Local Infrastructure and Services	Construction and Operations	Moderate negative	Moderate negative

8.2.5

Risk of Major Flooding and Related Catastrophic Impacts Due to Dam Failure during Operations*Potential Impacts*

In hydropower projects with any type of reservoirs, dam failure can lead to extensive downstream flooding with potentially catastrophic consequences, including loss of life and destruction of property, depending on the characteristics of land use downstream of the dam.

Baseline Conditions

Nearest town downstream of the Hydropower Plant is Mania, located approximately 500 m from the river, located 4 km downstream of the dam.

Impact Assessment

According to the IFC *Good Practice Note Environmental, Health, and Safety Guidelines for Hydropower Projects* (March 2018) many factors can cause partial or total dam failure, including overtopping because of inadequate spillway design, debris blockage of spillways, or settlement of the dam crest. Foundation defects, including settlement and slope stability, can also lead to dam failures. Seepage can occur around hydraulic structures, such as pipes and spillways, through animal burrows, around roots of woody vegetation and through cracks in dams, dam appurtenances, and dam foundations. Seepage can speed erosion in embankment dams. These problems can compromise the structural integrity of the dam. Other causes of dam failures include structural failure of the materials used in dam construction and inadequate maintenance. Dam failure can also be caused by seismic events.

The significance of the impact is considered to be moderate negative prior to mitigation.

Table 8.67 *Pre-Mitigation Impact Assessment*

Type of Impact		
Unplanned, Indirect		
Rating of Impacts		
Characteristic	Designation	Summary of Reasoning
Extent	Local	The river is largely unpopulated below Mania village, located 4 km downstream of the Hydropower Plant.
Duration	Short to long term	Effects such as flooding of fields or prevention of fishing will be short term while loss of life or damage to property will be long term
Scale	Small	The impact is unlikely to extend beyond Mania.
Frequency	Once	The dam is unlikely to fail more than once.
Magnitude		
Medium		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
Medium		
The town of Mania downstream is reliant on agriculture and fishing. Should the river flood this could potentially affect these livelihoods.		
Significance Rating Before Mitigation		
Moderate negative		

Mitigation Measures

The following mitigation measures are recommended:

- Design, operate and maintain structures according to international specifications. Design should consider the specific risks and hazards associated with geotechnical stability or hydraulic failure and the associated risks to downstream human health and safety, economic assets and ecosystems.
- Conduct risk assessment (for example Failure Mode Effects and Criticality Analysis) to identify conceivable failures as well as their probabilities and consequences) in accordance with internationally accepted practices. Through this approach dam safety programs can identify the elements of the physical infrastructure and the operating procedures that need to be routinely inspected, monitored and adjusted to achieve the acceptable level of risk.
- Prepare and follow a dam safety and emergency response management plan that defines the operating procedures and specifications to protect the physical health and safety of people (residents, worker and visitors) and their socio-economic regime, the physical environment and its ecological habitats and the integrity of the hydropower dam and associated project components to ensure sustainable, safe optimal performance.
- Define an **Emergency Preparedness and Response System** in compliance with the IFC *Good Practice Note Environmental, Health, and Safety Guidelines*

for Hydropower Projects (March 2018) periodically reviewed and revised, at least every 5 years, to reflect changing conditions.

Table 8.68 *Residual Impact Significance*

Impact	Project Phase	Significance (Pre Mitigation)	Residual Impact Significance (Post Mitigation)
Catastrophic drift due to dam failure	Construction, Operation	Moderate negative	Minor negative

8.2.6

Increased Health and Safety Risk for Community Associated with Influx of People during Construction of the Hydropower Plant and Diesel Power Plant*Potential Impacts*

Construction projects in settings with high unemployment rates tend to attract many job seekers, some of whom can pose security threats by getting involved in criminal activities (eg, thefts).

The short distance to the international borders (Guinea and Sierra Leone) is expected to aggravate the situation further. The security threat is a risk to both the local residents and to the project (eg, stealing and selling of project equipment and materials).

The presence of development projects often affects the health, safety and security of the communities in various ways including but not limited to:

- Changed social structure that may result from strained worker-community interactions.
- Negative social impacts and increased pressure on health care resources associated with in-migration.
- Increased incomes in the local community that may be used for drugs, alcohol and prostitution.
- Physical risk of injury associated with construction and decommissioning activities.

It is important to note at this time that some of the potential impacts that have been identified in the following subdivisions are in some cases based on perception within the local communities. Perception is the process by which an individual selects, organises, and interprets information to create a meaningful picture of their social environment. Perception depends not only on the physical stimuli, but also on the stimuli's relation to the surrounding social environment and on conditions and preconceptions within the individual. The key point is that perception can vary widely among individuals exposed to the same reality (Robbins et al., 2008). Factors influencing perception can include attitudes, motives, interests, experience and expectations.

Development projects offer people a unique opportunity for employment as well as access to better services and infrastructure or at least the perception thereof. Such opportunities are rare in this region of Liberia and job seekers travel from their place of origin to perceived sources of employment. This trend results in substantial economic migration within region and general Liberia. It is however important to consider that in any influx situation there are two distinct types of in-migration namely:

- Formal Influx of People; and
- Informal Influx of People (induced influx).

Formal Influx of People

The formal influx of people relates to those people who will be formally employed by the project, i.e. the construction team. It is expected that this group of people will enter and remain in the area for a specific time period (i.e. the duration of the construction phase), after which they will be demobilised and leave the area.

Even without considering the current population growth rate of 2.1% per year of people moving into the area for the moment (this will be discussed further under the informal influx of people), the formal influx of people in the form of the construction team will lead to a temporary population growth rate. This unnatural growth rate can be restricted by employing a large contingent of local workers. This sudden increase in the population will impact on aspects such as housing and basic services and can lead to conflict where cultural differences occur and where there is competition for limited resources (jobs, water, sanitation, etc.).

Informal Influx of People

The informal influx of people refers to people in the form of job seekers who enter the area in search of employment. This group of people can consist of locals returning home and/or people who are new comers to the area who enter the area with the sole purpose of trying to secure a job.

In general it is very difficult to determine what impact this group will have on the natural growth rate of the area as it is not possible to accurately predict the number of people (as opposed to the set number of people who will form part of the construction team). However, the influx of job seekers together with the influx of the construction team will have a cumulative effect on the population growth rate.

It is expected that the unnatural growth rate will decline as people who are unsuccessful in securing a position will be discouraged from remaining in the area. Stringent mitigation measures have to be implemented prior to the construction phase in an attempt to discourage people from moving into the area.

As is the case with the influx of construction workers, the actual in-migration of unemployed jobseekers might not yield a significant change to the community (although that is dependent on the uncertain number of jobseekers), but their presence can lead to a number of change processes and impacts, such as the expansion of informal settlements giving rise to an additional demand on basic services, conflict situations over job opportunities and other limited resources, etc. These have been discussed alongside the

presence of construction workers under the various relevant change processes as cumulative impacts.

Baseline Conditions

The current population growth rate is 2.1% per year of people moving into the area, which is a relatively high growth rate when one looks at country growth rates across the world.

Teenage pregnancies are already of concern in region, and according to the UN 2016 HDR report, there has been a general increase in the numbers of recorded teenage pregnancies. The HDR further notes that violence and substance abuse are also common and that the HIV/ AIDS is increasing.

Impact Assessment

As mentioned above, the physical formal and informal influx of people would not result in notable impacts, but rather their actions and beliefs that differ from the receiving environment, which would cause impacts.

This point can be seen when you consider the increase in disposable income within a project Area (among project workers, both local and external) which often results in a change in spending habits and behaviour, bring about an increase in alcohol and drug abuse, increased incidences of prostitution and casual sexual relations. These changes in the social fabric very often poses a direct threat to community health and safety. Anticipated impacts associated with the presence of the workforce are:

- Increased incidence of alcohol and drug use;
- Increase in the spread of HIV/ Aids, Ebola and other STIs;
- Increased incidence of teenage or unwanted pregnancies; and
- Increase in prostitution.

It is estimated that there will be approximately 150 people (formal influx) employed during the peak construction phase. The project will seek to maximise the employment of local people, thereby reducing the size of the external workforce, however an external workforce will be required. The external workforce (largely comprised of semi-skilled and skilled workers) will be housed in an onsite temporary worker accommodation.

Onsite construction activities will require a considerable amount of local labour, mainly unskilled and semi-skilled workers with little experience from large-scale construction projects. It is likely that the limited experience could result in an increased risk of occupational accidents.

When considering safety of the employees, there is a risk of hearing damage from increased noise, risk of accidents (including risk of falls from elevated positions during construction, and an increased risk of electrocution should activities not follow operational guidelines and safety measures.

The impacts related to the presence of the workforce and jobseekers in the project area will be indirect and negative as the presence of a mostly male workforce, with an increased disposable income may adversely impact on health, safety and security of the local community through a likely increase in illegal or antisocial behaviour. Those affected by antisocial behaviour, such as the victims of abuse, women with unwanted pregnancies and people living with HIV/ AIDS, will be affected in the long-term/permanently and will lead to a fundamental change in their life, and/ or health status, particularly for those affected by violence, unwanted pregnancies or HIV/ AIDS. For those affected, the impact will be largely irreversible.

Additional to these impacts from the formal influx of people during the construction phase, traffic volumes will increase on the main roads, creating public health risks including traffic accidents, dust and noise. This will negatively affect other road users such as cyclists, motorists and particularly school children.

During the operation phase, there will be limited formal employment opportunities and the external construction workforce will likely leave the area. However, the provision of affordable electricity is likely to cause a form of population growth triggered by economic development. This could be through the return of previously displaced people or those who voluntarily migrated to Monrovia or other urban centres in search of better opportunities, business entrepreneurs, large-scale agricultural projects and probably more industries. This can again provide a breeding ground for the social pathologies.

The significance of the impact is rated as moderate negative overall, but the significance will be of high negative to those affected by unwanted pregnancies and HIV/ AIDS.

Table 8.69 Pre-Mitigation Impact Assessment

Type of Impact		
Indirect		
Rating of Impacts		
Characteristic	Designation	Summary of Reasoning
Extent	Local	While the workforce will be in the project area for a limited time during the construction phase, jobseekers may stay in the area.
Duration	Permanent	Those affected by antisocial behaviour, such as the victims of abuse, women with unwanted pregnancies and people living with HIV/ AIDS, will be affected in the long-term/permanently.
Scale	Large	For those affected by violence, unwanted pregnancies or HIV/ AIDS it will lead to a fundamental change in their life, and/or health status.
Frequency	Constant	The frequency of the impacts will not be uniform, but may be felt often. For those affected by unwanted pregnancies or HIV/ Aids the frequency will be constant.
Magnitude		
Medium		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
Medium		
Teenage pregnancies are already of concern in region, and according to the UN 2016 HDR report, there has been a general increase in the numbers of recorded teenage pregnancies. The HDR further notes that violence and substance abuse are also common and that the HIV/ AIDS is increasing. In light of this, the vulnerability of receptors is considered medium, however, teenage girls are considered to be highly sensitive to this impact.		
Significance Rating Before Mitigation		
Moderate negative overall, but the significance will be of high negative to those affected by unwanted pregnancies and HIV/ AIDS.		

Mitigation Measures

The following mitigation measures are recommended:

- Disseminate traffic management plans in the project area, through campaigns in schools and communities.
- Where local security systems exist, consider supporting these to strengthen community policing and crime-handling measures.
- Ensure project sites are secured against unauthorized access.
- Ensure that the conduct of security personnel complies with good international practice.
- Include best practice health and safety provisions in the construction contracts and ensure strict compliance with national legislation and the World Bank Group EHS Guidelines.
- Ensure all project vehicle drivers are well trained and have a full and up to date license to operate their vehicles.

- Institute speed limits and traffic controls for project vehicles and equipment.
- The workers' camp standards in regard to quality, management and provision of basic social services must comply with the IFC/EBRD guidance on workers' accommodation.
- Establish a grievance mechanism for workers.
- Ensure project sites are secured against unauthorized access.
- Develop an induction programme, including a Code of Conduct, for all workers directly related to the project. A copy of the Code of Conduct is to be presented to all workers and signed by each person. The Code of Conduct must address the following aspects:
 - Respect for local residents and customs;
 - Zero tolerance of bribery or corruption;
 - Zero tolerance of illegal activities by construction personnel including: unlicensed prostitution; sexual relations with minors under 18 years of age; illegal sale or purchase of alcohol; sale, purchase or consumption of drugs; illegal gambling or fighting;
 - No alcohol and drugs policy during working time or at times that will affect ability to work;
 - Description of disciplinary measures for infringement of the code and company rules. If workers are found to be in contravention of the code of conduct, which they signed at the commencement of their contract, they will face disciplinary procedures that could result in dismissal.
- Implement a grievance procedure that is easily accessible to the local community, through which complaints related to contractor or employee behaviour can be lodged and responded to. The project will respond in a serious manner to any such complaints. Key steps include:
 - Circulation of contact details of 'grievance officer' or other key project contact;
 - Awareness raising among the local community regarding the grievance procedure and how it works; and
 - Establishment of a grievance register to be updated and maintained by the project.
- Develop and implement an HIV/AIDS policy and information document for all workers directly related to the project. The information document will address factual health issues as well as behaviour change issues around the transmission and infection of HIV/AIDS.

- Conduct public health campaigns addressing issues of behavioural change, water and sanitation, malaria, HIV/ AIDS, Ebola, etc.

Table 8.70 *Residual Impact Significance*

Impact	Project Phase	Significance (Pre-mitigation)	Residual Impact Significance (Post-mitigation)
Increased Health and Safety Risk for Community Associated with Influx of People during Construction of the Hydropower Plant and Diesel Power Plant	Construction and Decommissioning	Moderate negative overall, but the significance will be of high negative to those affected by unwanted pregnancies and HIV/ AIDS.	Minor to Moderate negative

8.2.7

Increased Nuisance Factors and Changes in Sense of Place due to Hydropower Plant and Access Roads*Potential Impacts*

Noise will be generated from vehicular movements, quarrying, sand and aggregate processing, concrete mixing, excavation machinery and blasting operations. Also, the presence of workers on site will serve as a continuous source of low-level noise emissions.

Increased dust levels arising from construction machinery, excavations, rock blasting, cement mixing and road construction will be experienced. Emissions of small particles from diesel trucks as well as road dust are difficult to quantify but the impacts will be intermittent and short term. In addition to emissions of particles, there will be minor emissions of NO_x and SO₂ from construction machinery, vehicles and diesel generators.

Baseline Conditions

Due to the remoteness of the Project sites, the low traffic volumes on the main roads, and the absence of any major industrial activities, noise levels are considered insignificant.

The climatic conditions in the project area are typical of the region at large with good ambient air quality.

Impact Assessment

The term 'sense of place' is used to refer to the feelings people have for particular locations and the meaning they gain from a relationship with these places.

A sense of place is one of the fundamental 'felt' senses a person develops along with the sense of self and sense of community. A sense of place is commonly associated with local areas: the places where people live and work. The characteristics that influence sense of place are:

- Physical features that make a place special or unique;
- Features that create an abiding connection to a place; and
- The spirituality of a place.

The assessment of sense of place then from a social perspective relates to people's perception of the project in relation to the area. Typically a study area such as this one can consist of three distinct (public) interest groups: (1) people living in poverty who are often unemployed; (2) residents within the project area, but located some distance from the site; and (3) landowners surrounding the project site. These groups are all affected in different ways by the project and therefore it follows that their interest in the project would differ, hence

their sense of place would be affected in different ways. This can be explained by the following examples:

- People living in poverty who are unemployed would expect positive impacts from the project (that of being employed) – often with little to no regard for the longer term impacts (visual impacts, increase in social ills, presence of the proposed project, etc.). For this group of people the placement a new source of employment close to their area of residence would in all likelihood be regarded as a positive impact on their sense of place as it could create a sense of development in their areas that could improve their quality of life, and at the same time enable them to easily access perceived job opportunities.
- Private landowners on farms and small holdings surrounding the site are more aware of the potential negative impacts that the proposed project might have on their quality of life (e.g. impacts on agricultural land, social ills, etc.). This implies that their sense of place will be negatively affected as they are accustomed to a different way of life, which is often described as ‘pristine’ and ‘unique’ with a greater sense of preserving natural resources for future generations. Research has shown that this group have a higher degree of place attachment and that those who had more to lose financially also displayed a stronger sense of place attachment (Bonaiuto et al., 2002).
- People who are located some distance from the project site would probably not be acutely aware of the development and therefore it is unlikely that it would affect their sense of place to the degree that it would the two previous groups.

In addition to considering the psychosocial and emotional aspects, an assessment of sense of place also considers the physical placement of a proposed project within a demarcated site area. Sensitive areas in this regard should consider that there is a risk that cultural sites will be affected during the construction phase, especially resulting from bush clearing for the transmission lines. The scale of impact is unknown, mainly due to the secrecy surrounding the religious practices and cultural sites. However, based on stakeholder consultations, the impact is not considered as a critical issue. It should also be noted that the physical footprint of the project is relatively small.

In line with the above mentioned, whilst in the construction phase of the project it is expected that activities could give rise to many changes that can cause some nuisance to the surrounding communities which includes:

- Dust from traffic and construction activities; and
- Noise from traffic and construction activities.

It is expected that the activities surrounding the construction of and traffic to the proposed project site, access road and the supporting transmission lines

and will generate dust and noise that will most likely have an impact on immediate surrounding areas at least. These nuisance factors may also give rise to perceptions that project activities are negatively influencing community health. While each of the above mentioned impacts are considered to be largely manageable, the combined effect of the noise, dust and traffic impacts are likely to have a negative impact on the sense of place for some stakeholders.

It is anticipated that the significance of the impact will be **Moderate negative**.

Table 8.71 *Pre-Mitigation Impact Assessment*

Type of Impact		
Direct impact		
Rating of Impacts		
Characteristic	Designation	Summary of Reasoning
Extent	Local	The impact will local, limited to the site and immediate surrounds, as well as the local transport routes.
Duration	Short term	The impact will be for the duration of the construction phase.
Scale	Medium	Optimisation of location of project infrastructure will reduce numbers affected.
Frequency	Often to constant	The frequency of the impact will vary depending on construction activities, but it will be often as it relates to nuisance factors, and constant as it relates to sense of place.
Magnitude		
Medium		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
Medium		
The vulnerability of receptors is considered small to medium, as traffic volumes in the area are low, and road users will find the increased traffic volumes irritating.		
Significance Rating Before Mitigation		
Moderate negative		

Mitigation measures

The following mitigation measures will be incorporated into the site management:

- Noisy installations shall be located at an adequate distance from residential area to reduce the level of noise to an acceptable level, where possible.
- Noisy activities shall be scheduled to daytime hours (07h00-18h00).
- Noise control devices shall be installed in construction equipment if noise levels exceed the applicable guidelines.
- The workforce shall be instructed to avoid unnecessary noise.
- Implement all mitigation measures for the Diesel Power Plant.

- Implement dust and noise mitigation measures as identified within the various specialist studies. Use dust suppression methods such as spraying water on roads, as required, to avoid dust dispersion from construction traffic.
- Cover loose/friable loads on trucks eg, through use of tarp trucks to minimize loss and dust creation during transportation.
- Maintain and store piles of loose/friable materials and soil in a suitable manner (eg, covered) to minimize dust dispersion.
- Make sure that particulate matter will be considered in the air quality monitoring program for construction, mainly around residential areas.
- Develop and implement a grievance mechanism to address stakeholder concerns related to the project in a timely manner.

Table 8.72 *Residual Impact Significance*

Impact	Project Phase	Significance (Pre-mitigation)	Residual Impact Significance (Post-mitigation)
Increased Nuisance Factors and Changes in Sense of Place due to Hydropower Plant and Access Roads	Construction	Moderate negative	Minor negative

8.2.8

Loss of Visual Amenity and Sense of Place of the Waterfall due to Construction of the Hydropower Plant, Dam and Access Road*Potential Impacts*

The only place where the natural landscape will be significantly altered is at the hydropower plant where the dam will become a dominant structure and the rapids will be subject to substantial reductions in river flow. The natural beauty and sense of place of the site will be lost, however the site does not stand out relative to other waterfalls/rapids in Liberia and hence is unlikely to attract many, if any, tourists after the site is made more accessible.

Baseline Conditions

Despite the relatively pristine nature of the Hydropower Plant site it is currently fairly inaccessible (it is reached via a 5.5 km footpath) and is not visited for aesthetic beauty by tourists. Hunters and fisherman are likely to be the only visitors to the site and, based on interviews, do not hold the site in specific high regard.

Impact Assessment

During the wet season large volumes of water will flow over the spillway and waterfall/rapids and it is unlikely that the flow volumes will be noticeably different to the eye. The waterfalls/rapids will however be bracketed by the dam and Hydropower Plant infrastructure.

During the dry season the benefit of releasing a minimum/environmental flow (when there is no overflow from the dam) would only marginally improve the aesthetic appearance of the waterfall/rapids, as the dry season discharge is very low even under natural conditions. Release of an environmental flow, such as the 1% low flow (0.34 m³/s) or 10% of the dry season flow (0.36 m³/s based on February-March flows), into the 60 m diversion reach would not prevent the landscape from being dominated by the dam and other human influences. However, as environmental flow is widely considered as a standard requirement in modern hydropower development, it is recommended to install a pipe through the dam to ensure a constant release of at least 0.35 m³/s into the bypassed reach at all times.

Although not very likely, the Hydropower Plant itself may be of local tourism value as there is no other location with such large infrastructure in the project area.

Given that the site is not visited for aesthetic value or sense of place the loss of visual amenity and sense of place is considered to be negligible.

Table 8.73 *Pre-Mitigation Impact Assessment*

Type of Impact		
Direct		
Rating of Impacts		
Characteristic	Designation	Summary of Reasoning
Extent	Local	The impact will only be felt at the Hydropower Plant site.
Duration	Long term	The loss will endure for the life of the project.
Scale	12 ha	The waterfall and rapids with immediately adjacent riverine vegetation cover an area of approximately 12 ha.
Frequency	Constant	The Hydropower Plant infrastructure will be visible at all times.
Magnitude		
Small		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
Low		
The site is not visited for aesthetics or sense of place and is unlikely to attract tourists even if it were more accessible.		
Significance Rating Before Mitigation		
Negligible		

Mitigation Measures

The following mitigation measures will be incorporated into the site management:

- An environmental flow of at least 0.35 m³/s, shall be released into the bypassed reach at all times.
- Project components shall be designed in such a way that they fit within the natural setting of the site.
- All disturbed surfaces shall be subject to landscaping, including revegetation using local topsoil and native plant species.
- Temporary construction facilities shall be demolished and the sites restored to the pre-construction state.
- Excess material shall be disposed of in terms of the WMP.

Table 8.74 *Residual Impact Significance*

Impact	Project Phase	Significance (Pre Mitigation)	Residual Impact Significance (Post Mitigation)
Loss of visual amenity and sense of place of the waterfall due to construction of the Hydropower	Construction, operation	Negligible	Negligible

Impact	Project Phase	Significance (Pre Mitigation)	Residual Impact Significance (Post Mitigation)
Plant, dam and access road			

8.2.9

Disturbance of Local Communities due to Noise from Operation of the Diesel Generators*Potential Impact*

The terms 'sound' and 'noise' tend to be used interchangeably, but noise can be defined as unwanted sound, whereas sound is a normal and desirable part of life. However, when noise is imposed on people it can lead to disturbance, annoyance and other undesirable effects.

Noise will be generated from the operation of the 3 x 600 kW (1.8 MW) diesel generators during the operation phase of the project. ERM conducted a noise analysis to evaluate impacts from the backup diesel generators.

Baseline Conditions

The diesel power plant will be located in a sparsely populated area on the outskirts of Voinjama Town and is surrounded mostly by farm houses and institutional facilities. Noise sensitive receptors (NSRs) surrounding the diesel power plant are the same as those identified for air quality.

Impact Assessment

A noise analysis using the source sound data (including directivity effects for exhaust stack opening), receptor locations, and sound propagation parameters (hemispherical radiation, atmospheric absorption, ground effects, and meteorological conditions favourable to sound propagation) was conducted to inform the assessment. The noise analysis also accounts for engineering noise controls required to reduce noise levels to as low as practicable.

It was conservatively assumed that these generators would be operating continuously although they are proposed to be operated only in the dry season at varying capacity depending on electricity demand (eg, demand would be lower at night). The major noise sources associated with the diesel generators are as follows:

- Air intake opening (inlet louvers);
- Discharge air opening (outlet louvers) with radiator fan close to discharge; and
- Exhaust stack.

The diesel generators will be housed in an enclosure. *Figure 8.12* shows typical plan views of a diesel generator inside an enclosed room, with and without screens/sound walls on the outside of the intake and/ or discharge openings.

Noise emissions from the diesel power plant's daytime and night time operations were calculated following methods identified within ISO 9613 Part 2 for propagation of noise¹.

The analysis incorporates identifiable noise source data, ground absorption (assumed porous or soft ground conditions), hemispherical radiation or spreading, atmospheric absorption (assumed a temperature of 30 degree Celsius and 70 percent relative humidity), and accounted for directivity effects for exhaust stack opening. The analysis assumed meteorological conditions favourable to sound propagation per ISO 9613 Part 2 (downwind propagation with wind speeds between 1 and 5 meters per second).

Figure 8.12 *Typical Plan Views of a Diesel Generator Inside an Enclosed Room*

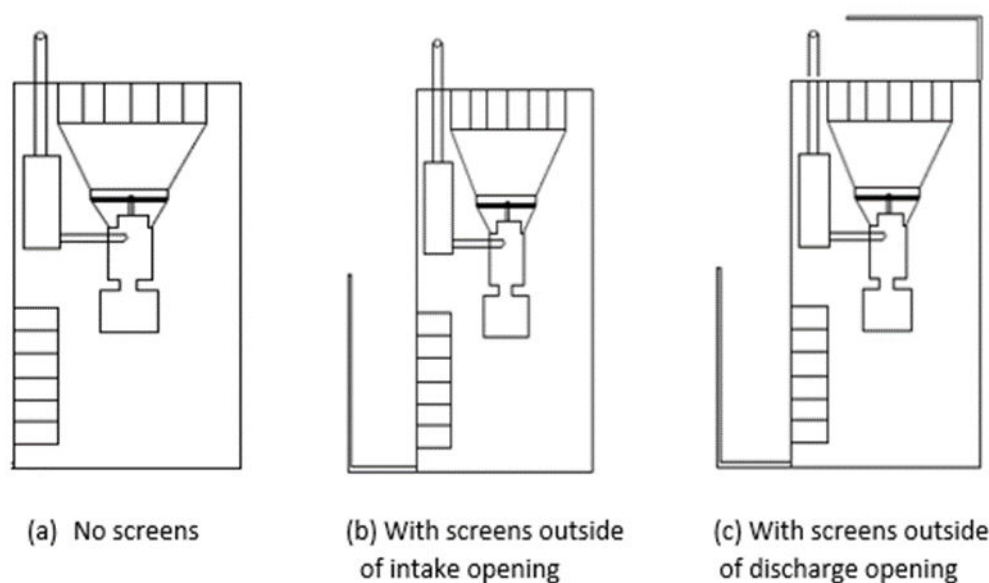


Table 8.75 presents representative noise emission profiles for major noise sources associated with the Diesel Power Plant during normal operation. The table also includes recommended noise controls to ensure noise emitted to the environment is as minimal as practicable. The sound pressure levels at 15 m from the major noise sources were based on measured data obtained from a similar diesel generator but modified to reflect the differences in power ratings. Modelled noise levels are compared to the World Bank Group EHS Guideline limits and Liberia's maximum permissible noise levels.

¹ ISO 9613-2: Acoustics –Attenuation of sound during propagation outdoors – Part 2: General method of calculation. First edition 1996-12-15.

Table 8.75 *Noise Emission Profile for Enclosed Diesel Generators with Noise Controls*

Major Noise Sources	Noise Controls	Overall A-weighted Sound Power Level, dB(A)	Reference A-weighted Sound Pressure Level at 15 meter, dB(A)
Generator air intake opening (inlet louvers) (3 units)	Enclosure with 4" thick lining on two adjacent walls of room, duct silencers (residential grade), and 3 m high solid screen/barrier on outside of intake opening	96.8	65.3
Generator discharge opening (outlet louvers) with radiator fan close to discharge (3 units)	Enclosure with 4" thick lining on two adjacent walls of room, duct silencers (residential grade), and 3 m high solid screen/barrier on outside of discharge opening	96.8	65.3
Generator exhaust stack, directivity included (3 units)	Critical grade silencer, vertical facing (0 degree)	92.8	61.3
TOTAL		101	69.1

Table 8.76 summarizes the predicted noise contribution at the nearest NSRs during daytime and night time, respectively. Higher noise levels occur at NSRs closer to the diesel-engine generators and decrease with distance from the generators. The modelled noise levels meet the EHS Guideline daytime and night time noise guidelines at all NSRs. During daytime, the predicted noise levels meet the Liberia noise limits at all NSRs except for the FDA. The predicted noise levels during night time exceed the Liberia noise limits at all NSRs. It should be noted that the night time limits do not apply to the FDA and Agricultural Training Facility (ATF) because these institutional facilities do not operate during night time hours.

While baseline noise levels were not collected at any of the NSRs, that baseline sound levels at the NSRs are likely already higher than the stringent day and night limits in Liberia for residential and institutional receptors. Consequently, the predicted noise levels due to the diesel generators are not expected to result in noise increases above baseline levels at any of the NSRs. In addition, the predicted noise results are conservative, including assumptions of continuous operations of the backup generators when electricity demand and hence generator use is likely to drop significantly by 22h00 in the evening. Therefore, the conclusion of this study is that predicted noise levels from the proposed backup generators will have a minor noise impact, particularly at night time, in the neighbourhood of the backup diesel power plant.

Table 8.76 *Predicted Noise Levels at Nearest Noise Sensitive Receptors and Comparison to Daytime Noise Limits*

NSR Identifier	Noise Sensitive Receptor Description	Receptor Type	Approximate Distance from Generator Stack (meter)	Predicted Noise Levels, dB(A)	Comply with EHS Guideline Daytime Noise Limit? (Yes/No) ¹	Comply with Liberia Daytime Noise Limit? (Yes/No) ²
H	Forestry Development Agency (FDA)	Institutional	150	48.3	Yes	No
E, G	Farm House, Unfinished Building	Residential	225	44.4	Yes	Yes
C, F	Farm Houses	Residential	275	42.5	Yes	Yes
D	Agriculture Training Facility (ATF)	Institutional	300	41.6	Yes	Yes
I	Dwelling Home	Residential	425	38.2	Yes	Yes
B	Farm House	Residential	450	37.7	Yes	Yes
A	Farm House	Residential	575	35.2	Yes	Yes

¹ World Bank Group daytime noise limit for residential and institutional receptors is 55 dB (A)

² Liberia daytime noise limit for residential and institutional receptors are 50 and 45 dB(A), respectively.

Table 8.77 *Predicted Noise Levels at Nearest Noise Sensitive Receptors and Comparison to World Bank Group and Liberian Night time Noise Limits*

NSR Identifier	Noise Sensitive Receptor (NSR)	Receptor Type	Approximate Distance from Generator Stack (meter)	Predicted Noise Levels, dB(A)	Comply with EHS Guideline Night time Noise Limit? (Yes/No) ¹	Comply with Liberia Night time Noise Limit? (Yes/No) ²
H	Forestry Development Agency (FDA)	Institutional	150	48.3	N/A	N/A
E, G	Farm House, Unfinished Building	Residential	225	44.4	Yes	No
C, F	Farm Houses	Residential	275	42.5	Yes	No
D	Agriculture Training Facility (ATF)	Institutional	300	41.6	N/A	N/A
I	Dwelling Home	Residential	425	38.2	Yes	No
B	Farm House	Residential	450	37.7	Yes	No
A	Farm House	Residential	575	35.2	Yes	No

N/A = not applicable; these institutional facilities (FDA and ATF) do not operate during night time hours

¹ World Bank Group night-time noise limit for residential and institutional receptors is 45 dB(A)

² Liberia night-time noise limit for residential and institutional receptors is 35 dB(A).

It is anticipated that the predicted noise levels from the proposed backup generators will have a minor impact, particularly at night time, in the neighbourhood of the diesel power plant.

Table 8.78 *Pre-Mitigation Impact Assessment*

Type of Impact		
Direct		
Rating of Impacts		
Characteristic	Designation	Summary of Reasoning
Extent	Local	The noise will only be heard within a short distance of the Diesel Power Plant.
Duration	Long term	The Diesel Power Plant will operate as a back up generator for the life of the project.
Scale	9	A total of 9 sensitive receptors are located in close vicinity (<580m) to the Diesel Power Plant.
Frequency	Often	The Diesel Power Plant will operate throughout the dry season at various capacity levels.
Magnitude		
Medium		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
Low		
The noise levels experienced by the nine sensitive receptors are likely already high in relation to the Liberian noise limits.		
Significance Rating Before Mitigation		
Minor negative		

Mitigation Measures

The following mitigation measures will be incorporated into the site management:

- Implement a 24-hour pre-construction noise-monitoring program at the affected NSAs to determine if existing noise levels are within the Liberia limits.
- If pre-construction noise levels show that the regulatory limits are currently being exceeded (particularly existing night time levels), the project noise impacts would be determined based on an increase above existing levels (ie, noise increase above existing levels should not exceed 3 dB).
- Install a sound wall on the northern and western portion of the diesel power plant building. The sound wall should have a minimum surface density of 10 kg/m², no gaps, and be high enough to block the line-of-sight between the noise source and the NSRs.
- To maintain positive community relations, keep the public informed about the construction and operation plans and efforts to minimize noise, and establish procedures for prompt response and corrective action with regard to noise complaints.

Table 8.79 ***Residual Impact Significance***

Impact	Project Phase	Significance (Pre Mitigation)	Residual Impact Significance (Post Mitigation)
Disturbance of local communities due to noise from operation of the diesel generators	Operation	Minor negative	Minor negative

8.2.10

Risk of Loss of Cultural Heritage due to Construction of Hydropower Plant Infrastructure, Access Roads and Transmission Lines*Potential Impacts*

There is a risk that cultural sites will be affected during the construction phase, particularly from bush clearing. Impacts to cultural heritage resources are divided into two broad categories: direct and indirect. Direct impacts consist of physical disturbance or damage to a resource that alters, positively or negatively, the resource's scientific or cultural value. Indirect impacts are the result of changes to a resource's environment or natural setting that alter its cultural value or project activities that restrict or limit stakeholder access to a resource.

Baseline Conditions

The cultural heritage baseline study suggest there is the potential for undiscovered archaeological resources to be present within the proposed project area.

The cultural heritage baseline suggests there is the potential for two principal types of living heritage resources: religious buildings (churches, mosques, etc.) and cemeteries (individual and community) and sites associated with Sande, Poro, or other local secret societies. The religious buildings and large cemeteries are likely to be located within or near villages and towns. Small family cemeteries are likely to be found near existing or former house locations across the landscape. Due to the need for secrecy, the secret society compounds, enclosures, or clearings are likely to be located away from settlements and houses.

The cultural heritage baseline identified two principal types of built heritage resources: historic and modern Western Sudan style houses and historic Euro-American style buildings. The Holy Cross Episcopal Mission building in Bolahun was the only historic Euro-American style building identified that may be located within the project area. If additional built heritage resources are present they are most likely to occur along the access road from Mbaloma town to Kolahun town and the proposed transmission lines running through existing towns and villages.

The cultural heritage baseline suggests there is a high potential for Sande, Poro, or other secret society enclosures, compounds, clearings, or other sites within or near the project area.

Table 8.80 contains a summary of the sensitivities of the various types of cultural heritage resources that could be present in the project area.

Table 8.80

Sensitivity of Potential Cultural Heritage Resources Identified in the Baseline Study

Resource Type	Site Types	World Bank Group (IFC) Classification	Sensitivity
Archaeological Sites	Late Stone Age and Iron Age small artefact scatters, isolated artefact finds, temporary camp or resource procurement or iron smelting sites.	Replicable	Low
	Middle Stone Age open air or rock sheltersites, Late Stone Age and Iron Age settlement sites, “Old Town” historic village sites.	Non-Replicable	Medium
Built Heritage	Modern Western Sudan style structures; middle to late 20 th century Euro-American style buildings.	Replicable	Low
	Late 19 th -early 20 th century Euro-American style buildings and Western Sudan style structures. Historic Mosques and cemeteries.	Non-replicable	Medium
Living Heritage	Small shrines and monuments. Individual family cemeteries.	Replicable	Low
	Modern and historic churches, mosques, community cemeteries. Poro, Sande, and other secret society ritual locations (enclosures, compounds, forest clearings, etc.)	Non-replicable	Medium

Impact Assessment**Archaeological Resources**

Ground disturbing construction activities (vegetation removal, topsoil stripping, grading, excavation, etc.) to build the power-generating infrastructure (dam, powerhouse, temporary construction facilities, etc.) and new access road, upgraded the existing access road, and construction of the transmission line could cause direct impacts to undiscovered archaeological resources if present.

In addition to construction impacts, creation of the reservoir could impact undiscovered archaeological resources in the inundation area. Sites within the inundation area will be submerged and subsequently buried by the accumulation of sediments at the base of the reservoir, making them inaccessible to stakeholders (i.e. researchers). Annual fluctuations between the LRWL and HRWL will also create an active erosion zone around the perimeter of the reservoir as the water level rises and falls. Any archaeological sites located within this zone will be impacted by erosion and subsequent exposure.

The types of cultural heritage resources that may be present in the project Area have been assessed as low to medium sensitivity resources. The magnitude of any direct impacts to these resources will depend on the extent of impacts, whether a portion of the resource is destroyed or if the entire site is removed. As a result, the significance of potential unmitigated project impacts to undiscovered archaeological resource could range from minor to major depending on the significance of a particular resources and the extent of project impacts.

Built Heritage Resources

The proposed plan to site the transmission line poles are away from all built structures and/or have 7 m of vertical clearance between the power line and structures should prevent construction of the transmission line from negatively affecting any built heritage resources. Construction of the access road could negatively impact built heritage resources, if present, due to construction works and subsequent vehicular traffic causing vibration, dust, or exhaust pollution impacts to built heritage resources. Due to the short duration of these potential impacts during road upgrades and project construction the magnitude of these potential impacts will be negligible to small. Depending on the types of built heritage resources, the significance of these impacts could range from negligible to minor.

Living Heritage Resources

Due to their likely location within settlements, if religious buildings or large community cemeteries are present they could be impacted by upgrades to the access road and construction of the transmission line. Existing project construction plans call for the avoidance of buildings during construction of the transmission line. This built in mitigation, if extended to include cemeteries, should minimize project impacts to these living heritage resources. Construction of the access road could negatively impact these types of living heritage resources, if present, due to construction works and subsequent vehicular traffic causing vibration, dust, or exhaust pollution impacts to these resources. Because these impacts would be relatively short duration (limited to road upgrade and use) and low intensity they are anticipated to be negligible to small magnitude impacts resulting in impacts of negligible to minor significance.

The cultural heritage baseline suggests there is a high potential for Sande, Poro, or other secret society enclosures, compounds, clearings, or other sites within or near the project area. If present these sites could be significantly impacted by construction of the power generating infrastructure and creation of the reservoir. These activities could destroy and/or inundate these sites causing large magnitude impacts to these medium sensitivity resources. Unmitigated, this would result in impacts of major significance to the local community.

All of the types of living heritage resources identified in the baseline study could be affected by indirect impacts due to changes to the setting of resources or by restricting user access to sites. If living heritage resources are located in close proximity to the power plant, access road and transmission line, construction of these elements could adversely affect the setting of the resources due to increased noise, dust, and exhaust. These impacts would be particularly acute during religious rites or ceremonies at religious buildings or cemeteries and during initiation rites at secret society sites. For the secret society sites, the presence of construction staff near these sites could threaten the ability of users to maintain their desired level of secrecy. This change in setting would have significant effects on the cultural value of the sites. Construction activities to upgrade the access road and build the transmission line could also temporarily restrict stakeholder access to sites due to the creation of construction exclusion zones. Depending on the sensitivity of individual resources and duration of the impacts, unmitigated indirect impacts to living heritage sites could range from minor to major significance.

The cultural heritage impact assessment identified a number of potential project impacts to cultural heritage resources (Table 8.81). The cultural heritage baseline did not identify any known cultural heritage resources within the project area and, as a result, the cultural heritage impact did not identify any specific impacts to individual resources.

As previously, the cultural heritage baseline results do, however, suggest there is the potential for undiscovered archaeological built, and living heritage resources in the project area.

Table 8.81 *Summary of Cultural Heritage Impact Assessment Results*

Resource	Site Types	Sensitivity	Potential Impacts	Impact Magnitude	Unmitigated Impact Significance
Archaeological Sites	Late Stone Age and Iron Age small artefact scatters, isolated artefact finds, temporary camp or resource procurement or iron smelting sites.	Low	Direct	Small to Large	Minor to Moderate
	Middle Stone Age open air or rock shelter sites, Late Stone Age and Iron Age settlement sites, "Old Town" historic village sites.	Medium	Direct	Small to Large	Minor to Major
Built Heritage	Modern Western Sudan style structures; middle to late 20 th century Euro-American style buildings.	Low	Indirect	Negligible to Small	Negligible to Minor
	Late 19 th -early 20 th century Euro-American style buildings and Western Sudan style structures. Historic Mosques	Medium	Indirect	Negligible to Small	Negligible to Minor

Resource	Site Types	Sensitivity	Potential Impacts	Impact Magnitude	Unmitigated Impact Significance
	and cemeteries.				
Living Heritage	Small shrines and monuments. Individual family cemeteries.	Low	Direct and Indirect	Small to Large	Minor to Moderate
	Modern and historic churches, mosques, community cemeteries. Poro, Sande, and other secret society ritual locations (enclosures, compounds, forest clearings, etc.)	Medium	Direct and Indirect	Small to Large	Minor to Major

Dependent on the sensitivity of the heritage resource impact as well as the extent (whether it is whether a portion of the resource is destroyed or if the entire site is to be removed) the significance of the impact could range from minor to major.

These activities could destroy and/or inundate living heritage sites causing large magnitude impacts to these medium sensitivity resources. Unmitigated, this would result in impacts of major significance to the local community.

Table 8.82 *Pre-Mitigation Impact Assessment*

Type of Impact		
Unplanned, Direct and Indirect		
Rating of Impacts		
Characteristic	Designation	Summary of Reasoning
Extent	Local to regional	Heritage resources could be of local to regional importance.
Duration	Short to permanent	Impacts could range to construction phase impacts such as vibrations to permanent impacts such as destruction of a heritage site.
Scale	Small	Any impact is likely to be limited to the footprint of a heritage resource.
Frequency	Once to frequently	An impact could be once off (destruction) to frequently (passing traffic causing noise).
Magnitude		
Negligible to large		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
Low to medium		
The types of cultural heritage resources that may be present in the project area have been assessed as low to medium sensitivity resources		
Significance Rating Before Mitigation		
Minor to major negative		

Mitigation Measures

The following mitigation measures will be incorporated into the site management:

- Follow a mitigation hierarchy that prioritizes avoiding impacts to cultural heritage resources. Where avoidance is determined technically and/or financially unfeasible, all efforts should be made to minimize project impacts.
- The removal or relocation of cultural heritage resources should be viewed as the last option to mitigate impacts and, if necessary, be done using the best available techniques as determined by a technical expert and in consultation with cultural heritage stakeholders.
- Develop and implement a chance finds procedure (CFP). A CFP is a project-specific procedure that outlines the actions to be taken if previously unknown cultural heritage is encountered. The CFP should cover at minimum the following elements:
 - Record keeping and expert verification procedures;
 - Chain of custody instructions for movable finds;
 - Clear criteria for potential temporary work stoppages; and
 - Roles, responsibilities, and response times required from both project staff and any relevant heritage authority, as well as any agreed consultation procedures.

- Pre-construction cultural heritage surveys to identify and document undiscovered archaeological resources within the proposed reservoir area.
- Develop and implement a chance finds procedure aligned with World Bank policy requirements for construction of the power generating infrastructure, access road, and transmission line.
- Pre-construction cultural heritage surveys to identify built heritage resources along the existing sections of the proposed access road sections to be upgraded. If resources are found close to the access road develop construction plans to avoid or minimize direct impacts from vibration, dust, and exhaust.
- Undertake pre-construction cultural heritage surveys to identify undiscovered living heritage resources (churches, mosques, cemeteries, etc.) along the transmission line and access road. Engage with stakeholders to schedule construction activities to avoid restricting user access or creating noise or visual disturbances during planned resource uses (i.e. religious services).
- Undertake stakeholder engagement to identify planned project components near Poro, Sande, and other secret society resources and to determine if resources are located within the power generating infrastructure and/or inundation footprints. Members should not be pressured to divulge location of resources. Engage with stakeholders to schedule construction activities to avoid construction in designated areas during planned use of society locations.
- If society resources are located within power generation facilities construction footprint or reservoir inundation areas, the project company should engage stakeholders to develop a plan to relocate society compounds, clearings.

Table 8.83 *Residual Impact Significance*

Impact	Project Phase	Significance (Pre Mitigation)	Residual Impact Significance (Post Mitigation)
Overall:			
Loss of cultural heritage due to Hydropower Plant infrastructure, access roads and transmission lines (overall)	Construction, operation	Minor to major negative	Negligible to Moderate negative
Individual:			
Archaeological sites: Late Stone Age or Iron Age artefacts, temporary camps or smelting site	Construction, operation	Minor to Moderate	Negligible to Minor

Impact	Project Phase	Significance (Pre Mitigation)	Residual Impact Significance (Post Mitigation)
Archaeological sites: Middle Stone Age sites, Late Stone Age or Iron Age settlement sites	Construction, operation	Minor to Major	Negligible to Moderate
Built Heritage: Modern Western Sudan style structures; middle to late 20 th century Euro-American style buildings.	Construction, operation	Negligible to Minor	Negligible
Built Heritage: Late 19 th -early 20 th century Euro-American style buildings and Western Sudan style structures. Historic Mosques and cemeteries.	Construction, operation	Negligible to Minor	Negligible
Living heritage: Small shrines and monuments. Individual family cemeteries.	Construction, operation	Minor to Moderate	Negligible to Minor
Living heritage: Modern and historic churches, mosques, community cemeteries. Poro, Sande, and other secret society ritual locations	Construction, operation	Minor to Major	Minor

8.3

CUMULATIVE IMPACTS

Cumulative impacts are the combined, incremental effects of human activity that pose an environmental risk. They result when the effects of an action are added to, or interact with, other effects in a particular place and within a particular time. With regards to the proposed project no other large infrastructure projects or hydropower projects are currently proposed within the project area that could create cumulative impacts. As such cumulative impacts would not be expected.

9.1 INTRODUCTION

One of the objectives of the ESIA process is to inform the development of a specific Environmental and Social Management Plan (ESMP) providing the costs, timeframes and responsibilities to implement the mitigation and management measures for the construction, operation and decommissioning of the Project.

This Chapter presents the ESMP for the Project based on the information available at the current stage of project development.

The responsibility for the implementation and outcome of the ESMP rests with RREA. RREA shall be committed to manage all the environmental, health, safety and social risks and impacts identified in this ESIA study as elaborated in this section.

9.1.1 ESMP Structure

The structure of this ESMP is set out according to the *Plan, Do, Check, Act* framework, a management tool that allows for a methodical and ongoing approach to managing environmental and social risks. Each of the sections in this Chapter relate to key components of the framework.

Plan, Do, Check, Act is part of international frameworks for quality and environmental management systems including ISO 14 001. The framework is described in *Box 9.1*.

Box 9.1 Environmental and Social Management Framework

Plan

- Define policies and objectives for environmental and social performance;
- Identify environmental and social impacts and risks of the operations;
- Develop mitigations and operational controls to address impacts and risks; and
- Develop a management plan to achieve these objectives.

Do

- Implement management plan; and
- Implement mitigations and operational controls.

Check

- Monitor performance against policies and objectives; and
- Check that mitigations and operational controls are effective.

Act

- Make corrections to plans, mitigations, or controls in response to performance monitoring or out of control events.

9.2 *PLANNING*

9.2.1 *Impact Assessment*

The Project has used the ESIA as a tool within the planning process to identify key impacts of the Project and associated mitigation and management measures. The impact assessment has been conducted for all elements of the Project.

The Project will continue to use the impact assessment process as a planning tool for any future development activities. The mitigation hierarchy applied in this ESIA will continue to be applied.

9.2.2 *Environmental and Social Management Commitments*

Through the Project development and ESIA process, mitigation measures have been identified to address environmental and social impacts associated with Project activities. The Project has made a commitment to implement these to ensure or improve environmental and social performance. These are not recommendations; they are binding. The commitments take a number of forms as summarised in Box 7.2, with the specific actions intended to address a particular environmental or social issue.

Box 9.2 Type of Commitments

Avoidance

During the planning phases, potential impacts to sensitive resources are identified. Where feasible, locations or processes can be changed during the planning or design phases to avoid impact to these areas.

Minimisation

Minimisation involves measures to reduce proposed impacts to a resource.

Management

Management commitments include development of plans and procedures for ensuring that measures to protect the environment actually take place and are of the desired standard of practice. Training is another commitment in this category.

Monitoring

Commitments to monitoring are primarily to ensure the above measures are working properly and delivering the desired (and anticipated) results.

Additionality

Additionality involves actions and contributions which are designed to provide a positive benefit. Examples include assisting with additional domestic water supply to surrounding communities.

9.2.3

Operational Management Plans

Additional detailed policies and plans will need to be developed to support the implementation of the ESMP as specified in the ESMP. For the purpose of this ESMP, these are referred to as ***Operational Management Plans***. Together with this ESMP, these specific plans will form the overall Environmental and Social Management System (ESMS) for the Project.

The Contractor will be responsible for developing the Environmental and Social management Plan (ESMP). The RREA will be responsible for reviewing and approving the Contractor's ESMP.

The timing of the development of the plans may be staged, ensuring that the appropriate focus and level of detail is provided for construction and operational activities.

These management plans will be prepared by RREA, with where appropriate in consultation with other key stakeholders.

Note that procedures for the following are provided in an annex to the ESIA:

- Chance Finds Procedure
- Grievance Mechanism

9.2.4

Contractor Environmental and Social Management Plan

RREA will engage contractors to carry out project activities during both construction and operations. Contractors will be responsible for working in:

- Compliance with relevant national and international EHS legislation and regulations, and with other requirements to which the Project subscribes;
- Conformance with the Project ESMP, and related management plans for specific aspects; and
- Accordance with contractual technical and quality specifications.

The Project's ESMP and related documentation will form part of contractual documentation to which the contractor(s) will be bound. Contractors will be required to develop their own management plans which show how they will comply with environmental and social requirements.

In this way, the ESMP will be implemented and controlled using RREA's and the contractor's management systems. The contractor's management systems will therefore:

- Provide the framework that regulates their activities;
- Define responsibilities and reporting relationships for expediting, mitigation and monitoring actions detailed in the ESMP; and

- Specify the mechanisms for inspecting and auditing to ensure that the agreed actions are implemented.

Contractors will be required to self-monitor against their plan and compliance with the plan will be routinely monitored by RREA directly or by third-parties. Contractors will be required to submit regular reports of monitoring activities and RREA will review these on a regular basis.

Contractors will be reviewed and approved by RREA. An external audit and assurance process will be conducted of the contractors' EHS documentation on an annual basis, the results of which will be disclosed at completion of the process.

9.3 *IMPLEMENTATION*

RREA is committed to providing resources and establishing the systems and components essential to the implementation and control of the ESMP. These include appropriate human resources and specialised skills, training programmes, communication procedures, documentation control and a procedure for the management of change.

9.3.1 *Institutional Arrangements*

The Project will be implemented (constructed and operated) by RREA. RREA is ultimately responsible for the Project's management of environmental and social performance although it may designate other entities to implement certain requirements through delegation or contractual obligation.

Other institutions are likely to include an owner's engineer, construction contractors, financiers/lenders and the relevant government agencies including local administration, as outlined below.

RREA

As Project sponsor, RREA will have the overall responsibility for the implementation of the ESMP and for ensuring compliance with national legislation and international lenders' guidelines for environmental and social performance.

- The RREA Project Manager has overall responsibility for implementation of environmental and social management obligations.

For the purpose of ESMP implementation, RREA will be expected to establish an *Environmental and Social Management Team* and designate at least two appropriately experienced and qualified persons in charge of the environmental and social management of the Project. The two staff shall be assigned as:

- Environmental Compliance Officer (ECO); and
- Community Liaison Officer (CLO).

These roles will be supported with other resources as needed to carry out their responsibilities (eg, during the land acquisition and compensation process).

In addition, RREA shall ensure that there is an appropriate number of health and safety inspectors to oversee worker safety during construction.

The Environmental and Social Management Team will implement the ESMP, either in partnership with professional service providers such as non-governmental organisations (NGOs) and /or consultants (eg, to perform the ECO role).

Contractors

Construction of the Project will be carried out by contractors under the direction of RREA. Contractors will be responsible for implementing ESMP requirements for avoiding or minimising environmental impacts caused by construction activities. It is expected that the construction works will be split into several contracts (eg, civil, electrical, mechanical). Each contractor will be required to have resources responsible for managing and monitoring the environmental and social mitigation measures in accordance with the contractual obligations. The contractors will also be responsible for ensuring that all sub-contractors are in compliance.

Contractors will be required to have adequate resources to implement and manage their environmental and social requirements. At minimum, contractors will have the following staff:

- Project Manager, with overall responsibility for implementation of the contractor's environmental and social management obligations; and
- Environmental, Health and Safety (EHS) Manager, responsible for day-to-day operation of contractor's environmental and social management obligations.

Owner's Engineer

RREA may appoint an owner's engineer to supervise and manage the implementation of the Project on behalf of RREA. The owner's engineer may act as a construction manager during the construction phase and possibly as an operator of the Project during the initial stages of the operation phase. The owner's engineer will typically also be responsible for health and safety management, but could also be delegated with the responsibility to implement other parts of the ESMP.

Consultants and NGOs

The company is likely to delegate certain environmental and social management tasks to external consultants and/or non-governmental organisations (NGOs). Consultants will be needed for some of the specialised monitoring and evaluation activities (eg, ECO), while NGOs might be assigned to deliver community health and safety services, among others. NGOs can also serve as witness to land acquisition and grievance management.

Regulatory Authorities

For purposes of this Project, the regulating body will include all those government institutions responsible for enforcing compliance with national standards in the different areas of specialisation. These will include but not be limited to those represented in the Rural Energy Working Group:

- Ministry of Lands, Mines and Energy;
- Ministry of Health and Social Welfare;
- Ministry of Education;
- Ministry of Planning and Economic Affairs;
- Ministry of Justice;
- Ministry of Internal Affairs;
- Ministry of Gender and Development;
- Ministry of Public Works;
- Liberia Electricity Corporation;
- Liberia Water and Sewer Corporation.

The Environmental Protection Agency (EPA) will be responsible for issuing the environmental impact assessment licence and for compliance monitoring relating to environmental regulations and standards.

The Ministry of Agriculture will provide technical support during the compilation of compensation rates for agricultural products and contribute to livelihood restoration activities as/when relevant.

The local administration at county and district level will be involved in the land acquisition process and serve as the link between the company and the communities. The chiefs at the various levels together with the city mayors will assist in mobilising the people, addressing grievances, and overseeing project implementation.

Financiers

The Project is likely to be backed by grants and loans from international financial institutions. However, until the financing structure has been agreed, the roles and responsibilities of financiers and lenders are unknown.

A requirement of lender policies is usually that the project owner engages a Panel of Experts to provide regular oversight of compliance with the relevant safeguard policies and performance standards. The financiers will normally also request for quarterly progress reports.

9.3.2 *Training and Awareness*

RREA will identify, plan, monitor, and record training needs for personnel whose work may have a significant adverse impact upon the environment or social conditions. RREA recognises that it is important that employees at each relevant function and level are aware of the Project's environmental and social policy; potential impacts of their activities; and roles and responsibilities in achieving conformance with the policy and procedures. Training and awareness-raising therefore forms a key element of this ESMP.

Key staff will, therefore, be appropriately trained in key areas of environmental and social management and operational control with core skills and competencies being validated on an on-going basis. The identification of training and awareness requirements and expediting of the identified training/awareness events will be the responsibility of the RREA Project Manager.

This will be achieved through a formal training process. Employee training will include awareness and competency with respect to:

- Environmental and social impacts that could potentially arise from their activities;
- Legal requirements in relation to environmental and social performance;
- Necessity of conforming to the requirements of the ESIA and ESMP, in order to avoid or reduce those impacts;
- Activity-specific training on waste management practices, documentation systems and community interactions; and
- Roles and responsibilities to achieve that conformity, including those in respect of change management and emergency response.

The ECO is responsible for coordinating training, maintaining employee-training records, and ensuring that these are monitored and reviewed on a regular basis. The ECO will also periodically verify that staff are performing competently through discussion and observation.

Employees responsible for performing site inspections will receive training by drawing on external resources as necessary. Training will be coordinated by the ECO prior to commissioning of the facilities. Upon completion of training

and once deemed competent by management, staff will be ready to train other people.

Similarly, the Project will require that each of the contractors institute training programmes for its personnel. Each contractor is responsible for environmental and social management and awareness training for personnel working on the job sites. The contractors are also responsible for identification of any additional training requirements to maintain required competency levels.

The contractors' training program will be subject to approval by RREA and it will be audited to ensure that:

- Training programs are adequate;
- Personnel requiring training have been trained; and
- Competency is being verified.

9.3.3 *Communication*

RREA will maintain a formal procedure for communications with the regulatory authorities and communities. The ECO is responsible for communication of environmental and social issues to and from regulatory authorities whenever required.

Meetings will be held, as required, between RREA and the appropriate regulatory agency to review environmental and social performance, areas of concern and emerging issues. Dealings will be transparent and stakeholders will have access to personnel and information to address concerns raised.

The CLO will be responsible for disseminating information and coordinating community communications through the course of the Project.

9.3.4 *Documentation*

RREA will control environmental and social management documentation, including management plans; associated procedures; and checklists, forms and reports, through a formal procedure. All records will be kept local to the Project site and will be backed up at several offsite locations (including secure cloud storage facilities). Records will be kept in both hard copy and soft copy formats; and all records will be archived for the life of the project.

Furthermore, the document control procedure will describe the processes that the Project will employ for official communication of both hardcopy and electronic (through the internet) document deliverables. In addition, it will describe the requirement for electronic filing and posting and for assignment of document tracking and control numbers (including revision codes).

The ECO is responsible for maintaining a master list of applicable documents and making sure that this list is communicated to the appropriate parties. The

ECO is responsible for providing notice to the affected parties of changes or revisions to documents, for issuing revised copies and for checking that the information is communicated within that party's organisation appropriately.

The contractors will be required to develop a system for maintaining and controlling its own environmental and social management documentation and describe these systems in their respective ESMP.

9.3.5 *Operational Control Procedures*

Each activity for which a potentially significant environmental or socioeconomic risk or impact is expected will have an operational control associated with it that specifies appropriate procedures, work instructions, best management practices, roles, responsibilities, authorities, monitoring, measurement and record keeping for avoiding or reducing impacts. Operational controls are monitored for compliance and effectiveness on a regular basis through a monitoring and auditing procedure described in the ESMP.

Operational control procedures will be reviewed and, where appropriate, amended to include instructions for planning and minimising impacts, or to at least reference relevant documents that address impact avoidance and mitigation.

9.3.6 *Managing Changes to Project Activities*

Changes in the Project may occur due to unanticipated situations. Adaptive changes may also occur during the course of the Project life cycle. The Project will implement a formal procedure to manage changes in the Project that will apply to all Project activities.

The objective of the procedure is to ensure that the impact of changes on the health and safety of personnel, the environment, plant and equipment are identified and assessed prior to changes being implemented.

The management of change procedure will ensure that:

- Proposed changes have a sound technical, safety, environmental, and commercial justification;
- Changes are reviewed by competent personnel and the impact of changes is reflected in documentation, including operating procedures and drawings;
- Hazards resulting from changes that alter the conditions assessed in the ESIA have been identified and assessed and the impact(s) of changes do not adversely affect the management of health, safety or the environment;

- Changes are communicated to personnel who are provided with the necessary skills, via training, to effectively implement changes; and
- Appropriate RREA person accepts the responsibility for the change.

As information regarding the uncertainties becomes available, the Project ESMP will be updated to include that information in subsequent revisions. Environmental and social, as well as engineering feasibility and cost, considerations will be taken into account when choosing between possible alternatives.

9.3.7 *Summary of Mitigation Requirements*

The predicted impacts, proposed mitigation measures, responsible institutions and estimated costs for the construction and operation phases are summarised and outlined in the below table.

Table 9.1 Summary of ESMP Requirements

Resource or Receptor	Impact Objective	Mitigation Measures	Timeframes	Responsibility	Estimated Cost
PRE-CONSTRUCTION PHASE					
Surface Water	Surface water (and soil) contamination <i>Prevent spillages and clean up accidental spills to avoid water (and land) contamination</i>	<ul style="list-style-type: none"> For Diesel Power Plant and Hydropower Plant permanent fuel storage area, design permanent fuel storage which are roofed and properly bunded to 110% capacity to contain any potential fuel leaks. Allow space for firefighting equipment to be present. Bunds should be equipped with sumps to avoid accumulation of rainwater. 	Prior to construction	RREA	Included in design costs
Aquatic Ecology	Degradation of aquatic habitats <i>Maintain aquatic ecology diversity</i>	<ul style="list-style-type: none"> Include the installation of a fish screen (or reductions in trash rack openings) at the intake to reduce fish entrainment and mortality. The sizing of the fish screen should be the smallest that does not affect the flow of water. Conduct biomonitoring of fish assemblage in the downstream reach of Kaiha River prior to and during operations. Fish monitoring will define flow requirements associated with spawning and the habitat maintenance over the dry reach. The results from the monitoring regime will: (i) inform any assumptions made regarding fish sensitivity in relation to peaking and (ii) monitor the impact of peaking on the receiving fish assemblages (iii) make recommendations where necessary to reduce any negative impacts. 	Prior to construction	RREA	Included in design and monitoring costs
Terrestrial Ecology	Habitat degradation <i>Protect sensitive vegetation and fauna from</i>	<ul style="list-style-type: none"> At least three months prior to clearing of areas of natural vegetation, a competent faunal ecologist experienced in forest habitats shall check the vegetation to be cleared and all fauna would need be noted. 	Prior to construction	RREA	USD 50 000

Resource or Receptor	Impact Objective	Mitigation Measures	Timeframes	Responsibility	Estimated Cost
Land	<i>future disturbances</i>	<ul style="list-style-type: none"> Protect and manage the area upstream and downstream of the reservoir that is within the client's control. 	Prior to construction	RREA	Included in design costs and RAP costs
	Economic Displacement <i>Avoid economic displacement as far as possible and compensate those affected so that they are not worse off than before where not possible</i>	<ul style="list-style-type: none"> Position infrastructure to avoid and/or minimise resettlement as far as practicable, taking into account feasibility of the location, as well as safety and legislative restrictions. Prepare a Resettlement Action Plan or Livelihoods Restoration Plan in line with national requirements and international standards, especially World Bank Safeguard Policy OP 4.12. 			
Public Safety	Dam Failure <i>Safe dam design to minimise risk of dam failure</i>	<ul style="list-style-type: none"> Design dam structures according to international specifications. Design should consider the specific risks and hazards associated with geotechnical stability or hydraulic failure and the associated risks to downstream human health and safety, economic assets and ecosystems. Undertake an appropriate independent review of the dam at the design and construction stages with ongoing monitoring of the physical structures during operation. Do not locate infrastructure not designed to be inundated within the 1:100 year floodline or within a horizontal distance of 100 m (whichever is greater) of the watercourse. Take into account controlled energy dissipation of the water downstream of the dam eg, through baffle blocks after the dam toe. In the design and construction of the turbines, provide a port for extracting water samples from an area of high turbulence exiting the 	Prior to construction	RREA	Included in design costs

Resource or Receptor	Impact Objective	Mitigation Measures	Timeframes	Responsibility	Estimated Cost
Visual Amenity	Visual impact <i>Avoid unsightly project sites/components</i>	<p>turbine for the purpose of monitoring sand concentration.</p> <ul style="list-style-type: none"> Design project components in such a way that they fit within the natural setting of the site. 	Prior to construction	RREA	Included in design costs
Noise	Increase in Ambient Noise <i>Stay within national and international noise limits</i>	<ul style="list-style-type: none"> Implement a 24-hour pre-construction noise-monitoring program at the affected NSAs to determine if existing noise levels are within the Liberia limits. If pre-construction noise levels show that the regulatory limits are currently being exceeded (particularly existing night time levels), the project noise impacts would be determined based on an increase above existing levels (i.e. noise increase above existing levels should not exceed 3 dB). 	Prior to construction	RREA	Included in design and monitoring costs
CONSTRUCTION PHASE					
Surface Water	Contamination of water courses due to soil erosion <i>Prevent erosion and sedimentation of watercourses</i>	<ul style="list-style-type: none"> Construction must take place during the dry season where possible to avoid the risk of rainfall events transporting construction chemicals and sediments downslope. Modify or suspend activities during extreme rainfall and high winds to the extent practical. Apply erosion control measures before the rainy season begins and after each season of construction. Maintain and reapply erosion control measures until vegetation is successfully established. Erosion control practices shall be implemented prior to any major soil disturbance and at areas prone to erosion and where erosion has already occurred and be maintained until permanent protection is established Use geo-textiles shall be used to stabilize soil stockpiles and uncovered soil surfaces during 	During construction	Contractors	Included in construction cost

Resource or Receptor	Impact Objective	Mitigation Measures	Timeframes	Responsibility	Estimated Cost
		<p>the construction phase and to serve as a sediment trap to contain as much soil as possible that might erode away.</p> <ul style="list-style-type: none"> • Sedimentation controls shall be implemented where needed. Sediment control structures include windrows of logging slash, rock berms, sediment catchment basins/ponds, drainage channels, straw bales, brush fences, and silt trap fencing. • Where possible, allow runoff from hard/exposed surfaces to infiltrate the soils rather than discharge direct to the watercourse. • Do not allow surface water or storm water to be concentrated, or to flow down slopes without erosion protection measures and sediment control structures being in place. • In the case of dewatering a construction site, water will be treated, and suspended particles will be removed (e.g. by sending through a sand filter or settling pond). Water removed from a construction site will not be released directly into watercourse. Discharge will occur onto a sump to aid settling of suspended particles or into a well vegetated area which will help trap sediment and residual contaminants. • No stockpiling of any materials may take place adjacent to any of the water resources. • Develop an Erosion Control Plan to address: <ul style="list-style-type: none"> ○ Interim and final erosion control needs and measures how to implement or install those measures. ○ Develop typical drawings for sediment traps, sediment fences, brush barriers, ground cover, sedimentation ponds, check dams, 			

Resource or Receptor	Impact Objective	Mitigation Measures	Timeframes	Responsibility	Estimated Cost
		<p>armoured ditches, and biotechnical measures.</p> <ul style="list-style-type: none"> ○ Protection of side drains of roads with sediment traps and/or gabions to reduce the erosive velocity of water during storm events. ○ Erosion control measures include but are not limited to - the use of sand bags, spoil aggregate, hessian sheets, silt fences, retention or replacement of vegetation and geotextiles such as soil cells which must be used in the protection of slopes. <ul style="list-style-type: none"> • Route access roads to avoid areas with gradients in excess of 8%. Where this is unavoidable, stabilise the road surface. • Provide runoff-control measures such as sloping roads to allow for unrestricted runoff of water and the incorporation of permanent slope diversions which intercept the down-slope flow of runoff and divert this via natural contours and gradual slopes into vegetated areas. • Provide adequate road drainage based on road width, surface material, compaction, and maintenance. • Install erosion control measures as each road section is completed. • Restrict construction vehicles and personnel to the designated construction footprint area. • Monitor roads during the construction phase to ensure adequate maintenance is undertaken. • Route roads to avoid drainage lines, wetlands and riparian areas. As far as possible and reasonable, route roads along existing roads/routes. Where access roads through 			

Resource or Receptor	Impact Objective	Mitigation Measures	Timeframes	Responsibility	Estimated Cost
		<p>drainage lines and riparian zones is unavoidable, only one road is permitted, constructed perpendicular to the drainage line. Avoid roads that follow drainage lines within the floodplain.</p> <ul style="list-style-type: none"> • Use temporary bridges or mats and wide-track vehicles to distribute weight at crossing watercourses if there is no bridge present. • Protect the slopes of all river diversions to limit erosion. • For transmission lines no pylons must be placed within the riparian zone of the watercourse. Rather have lines avoid or span watercourse/wetland/riparian areas. An aquatic ecologist is to be consulted to determine dimensions of riparian areas. • Where practical, employ measures to limit the spread of fly-rock during blasting. • Conduct vegetation management of the RoW on a regular basis to avoid large-scale disruptions to the vegetation. Woody vegetation will only be cropped above 0.5 meter height, and the development of a stable ground cover will be promoted. • Ongoing vegetation management will avoid all forms of soil disturbances within natural habitats. • Compile a Water Quality Monitoring Plan, which includes sedimentation and turbidity. • When stripping soil with excavators and dump trucks, the excavator should only operate on the topsoil layer and the dump trucks must only operate on the basal/non-soil layer and their wheels must not run on soil layers. • Delineate areas to be stripped and place soil stockpiles outside of sensitive areas. 			

Resource or Receptor	Impact Objective	Mitigation Measures	Timeframes	Responsibility	Estimated Cost
Surface Water	Sedimentation of reservoir <i>Increase timespan for reservoir to fill with sediment</i>	<ul style="list-style-type: none"> The operation must follow a detailed stripping plan showing soil units to be stripped, haul routes and the phasing of vehicle movements. Wherever possible, stripping and replacing of soils should be done in a single action. This is both to reduce compaction and also to increase the viability of the seed bank contained in the stripped surface soil horizons. Rehabilitate all areas disturbed by construction as per the Rehabilitation Plan. Promote development and dissemination of improved agricultural practices (both cultural and post-harvest) which enable farmers to obtain more economic benefit from the more intensive utilisation of the best agricultural soils, thereby reducing the pressure to cut and burn erosion-prone forest lands with steeper soils. Provide access to the upstream portion of the reservoir to permit sand and rock extraction from the reservoir for construction purposes. 	During construction	Contractors	Included in construction cost
Surface Water	Surface water (and soil) contamination <i>Prevent spillages and clean up accidental spills to avoid surface water (and soil) contamination</i>	<ul style="list-style-type: none"> Remove any stockpiled soils, waste and equipment from below the reservoir high-water mark prior to filling. In general, locate all equipment, machinery, trucks and camp installations a distance of more than 250 m from water used for human consumption and at least 150 m to any surface water. Collect waste water from the camp site in portable latrines or septic tanks and treat before releasing into a river. Pit latrines may not be used. For access road construction/upgrading and transmission lines portable latrines are to be 	During construction	Contractors	Included in construction cost

Resource or Receptor	Impact Objective	Mitigation Measures	Timeframes	Responsibility	Estimated Cost
		<p>in place along the route where construction is taking place.</p> <ul style="list-style-type: none"> • Compile a Stormwater Management Plan for the site to separate and manage clean and dirty water. This includes the concrete batching, mixing plant and concrete mixer washing facilities. This separation will minimize the volume of water required to be treated prior to release. The Stormwater Management Plan shall include at least the following measures: <ul style="list-style-type: none"> ○ Do not allow the washing of trucks delivering concrete anywhere but within designated wash bays equipped with runoff containment. Implement solutions to clean any dirty water that has suspended oils as a result of cleaning chemicals. ○ Install and maintain oil water separators and grease traps as appropriate at refuelling facilities, workshops, parking areas, fuel storage and containment areas. ○ Vehicles/equipment must not be permitted to be cleaned or serviced in or near aquatic ecosystems. ○ Include measures for management of contaminated or potentially contaminated water or runoff. • Compile a Water Quality Monitoring Plan, which includes pH, oils and grease amongst others. <ul style="list-style-type: none"> ○ Any discharge that may impact the watercourse water quality needs to have routine water quality monitoring to ensure compliance to 			

Resource or Receptor	Impact Objective	Mitigation Measures	Timeframes	Responsibility	Estimated Cost
		<p>any applicable guidelines to prevent pollution.</p> <ul style="list-style-type: none"> ○ Implement protocol in the design of the facility for long-term monitoring of water quality both upstream and downstream of the dam, including monitoring network, water quality parameters, frequency, duration and methodology. ○ Where appropriate, consider involving representatives from Affected Communities to participate in monitoring activities. ○ Retain external experts to verify monitoring information. <ul style="list-style-type: none"> • Compile a Hazardous Materials Management Plan for handling, storage, use and disposal of hazardous materials. Undertake a Hazard Assessment which includes spill scenarios, potential for uncontrolled reactions, consequence analysis, occupational health and safety. Include a Spill Control, Prevention, And Countermeasure Plan (inputted into the site Emergency Preparedness and Response Plan). This includes relevant training requirements for relevant staff. The Hazardous Materials Management Plan shall include at least the following measures: <ul style="list-style-type: none"> ○ Store all hazardous substances, concrete and binding agents in secure, safe and weatherproof facilities, underlain by a bunded concrete slab to protect against soil and water pollution. Storage areas and hazards should be marked. 			

Resource or Receptor	Impact Objective	Mitigation Measures	Timeframes	Responsibility	Estimated Cost
		<ul style="list-style-type: none"> Storage and handling of fuel and hazardous materials shall be kept away from the river. No stockpiling of any construction materials may take place adjacent to any of the water resources. Fuel storage should be done within designated areas only, which are properly bunded to 110% capacity to contain any potential fuel leaks. Firefighting equipment is to be present. For transmission lines and access road construction store fuel at temporary depots within a bunded area, or alternatively in an area underlain by heavy duty PVC sheeting and covered with 100mm of sand. All storage areas and major construction sites shall have spill kits, sand, dust, and other appropriate absorbent materials. The contaminated absorbent and any contaminated soils to be disposed of properly. Alternatively <i>in situ</i> treatment may be considered if this meets the ECO's approval and is allowed in terms of legislation. Use flat impervious surfaces for refuelling and other fluid transfer. Day to day parking of vehicles is to be on hard surfacing wherever possible. Properly service construction vehicles and equipment in order to avoid fluid leaks. Only emergency 			

Resource or Receptor	Impact Objective	Mitigation Measures	Timeframes	Responsibility	Estimated Cost
		<p>and essential repairs of vehicles and equipment may take place on site. Service vehicles and equipment in designated areas with containment drip trays.</p> <ul style="list-style-type: none"> ○ Vehicle and equipment servicing must take place offsite at designated workshops. ○ Oil water separators and grease traps should be installed and maintained as appropriate at refuelling facilities, workshops, parking areas, fuel storage and containment areas. <ul style="list-style-type: none"> • Develop a Hazardous Material (HAZMAT) Register which includes: <ul style="list-style-type: none"> ○ Pesticides and insulating oils/ gases for transformers, amongst others; ○ Name and description (e.g. composition of a mixture); ○ Classification (e.g. code, class or division); ○ Internationally accepted regulatory reporting threshold quantity or national equivalent; ○ Quantity used per month; ○ Characteristic(s) (e.g. flammability, toxicity); and ○ Avoid or, when avoidance is not possible, minimize and control the release of hazardous materials. Consider less hazardous substitutes where hazardous materials are intended to be used. • Develop and implement a Pesticides Management Plan which incorporates at least the following measures: 			

Resource or Receptor	Impact Objective	Mitigation Measures	Timeframes	Responsibility	Estimated Cost
		<ul style="list-style-type: none"> ○ Herbicides/pesticides may only be used for the clearance of IAPs and only as a last resort. ○ Pesticide application should be through targeted application and should remain 32 m away from watercourses. Only physical vegetation clearance is to be done in the vicinity of watercourses to limit runoff contributions. ○ Select chemical pesticides that are low in human toxicity, that are known to be effective against the target species, and that have minimal effects on non-target species and the environment. Package pesticides in safe containers, clearly labelled for safe and proper use. Ensure that pesticides have been manufactured by an entity currently licensed by relevant regulatory agencies. Handle, store, apply and dispose of pesticides in accordance with the Food and Agriculture Organization's International Code of Conduct on the Distribution and Use of Pesticides. ○ Contamination of soils, groundwater, or surface water resources, due to accidental spills during transfer, mixing, and storage of pesticides should be prevented by following the hazardous materials storage and handling recommendations. • Compile a Waste management Plan, in accordance with the World Bank Group General EHS Guidelines (April 2007) section 			

Resource or Receptor	Impact Objective	Mitigation Measures	Timeframes	Responsibility	Estimated Cost
		<p>1.6 and including a reputable waste management company and licensed disposal site, which will include the following measures, amongst others:</p> <ul style="list-style-type: none"> ○ Dispose of all visible remains of excess cement and concrete after the completion of tasks. Dispose of in the approved manner (solid waste concrete may be treated as inert construction rubble, but wet cement and liquid slurry, as well as cement powder must be treated as hazardous waste). ○ Properly treat and safely dispose of solid waste generated during construction, including at campsites, in demarcated waste disposal sites. Raise awareness within the workforce to properly dispose of the waste. ○ No dumping of any building rubble, soil, litter, organic matter or chemical substances should occur within watercourses. Dumping and temporary storage of the above should only occur at predetermined locations approved by the ECO. ○ Where waste generation cannot be avoided, reduce the generation of waste, and recover and reuse waste in a manner that is safe for human health and the environment. Where waste cannot be recovered or reused, the contractor will treat, destroy, or dispose of it in an environmentally sound manner. 			

Resource or Receptor	Impact Objective	Mitigation Measures	Timeframes	Responsibility	Estimated Cost
		<ul style="list-style-type: none"> ○ Provide an appropriate number of ablution facilities for workers at worksites. ○ Use temporary structures (ablution facilities and construction camps for construction workers, etc) as far as possible for infrastructure associated with the construction phase only ○ ○ Include measures for the collection, storage and disposal of waste petroleum products and used oils at authorised facilities. <ul style="list-style-type: none"> • Accidental spills or any contaminated water will be isolated and treated as soon as possible. An emergency spill procedure will be drafted (to be approved by the ECO), and the construction team will be versed in identifying and responding to accidental spill events. • Removal and disposal of the aboveground fuel tanks at the Diesel Power Plant site shall include: <ul style="list-style-type: none"> ○ Remove and containerise any residual liquids and sludges from the above-ground storage tanks at the Diesel Power Plant site, such that no recoverable product and less than one inch of material remains in the tank. Transport and dispose liquid/sludge off-site at a landfill licensed to accept hazardous waste and in compliance with local law. A spillkit shall be on hand during removal of the storage tanks. ○ Before commencing tank removal activities the tanks should be inerted 			

Resource or Receptor	Impact Objective	Mitigation Measures	Timeframes	Responsibility	Estimated Cost
Aquatic Ecology	Hydrology <i>Allow ecological process to continue in as near to natural state as feasible</i>	<p>so as to remove the risk of explosion. Proven inerting methods include hydrophobic foam fill, nitrogen foam fill, nitrogen gas purging, water fill, dry ice, combustion of gas and cleaning-degassing. The presence of vapours shall be checked with a combustible gas meter.</p> <ul style="list-style-type: none"> ○ Disconnect, cut, remove and dispose of the tanks in accordance with local regulations. Any tank cutting shall be performed in accordance with a risk assessment and management plan for hot works specific to the tank removal to ensure risks to workers are mitigated. Piping from tanks to storage or burning equipment shall be removed and disposed off-site at a landfill licensed to accept hazardous waste and in compliance with local law. • Permanent sanitary water treatment facilities shall be installed for the operation phase. • Release a minimum flow through the flushing gate equal to at least 50% of the inflow at the time of impoundment during the initial filling of the reservoir. • Ensure reservoir filling occurs during the rainy season (May – November, preferably June - September). • Release an environmental flow of at least 0.35 m³/s into the bypassed reach at all times. Once biomonitoring has been undertaken the environmental flow shall be amended to the flow volumes and regimes as required by an aquatic ecologist. 			
			During construction	RREA	No cost

Resource or Receptor	Impact Objective	Mitigation Measures	Timeframes	Responsibility	Estimated Cost
Terrestrial Ecology	Vegetation clearing <i>Reduce vegetation clearing to the minimum required</i>	<ul style="list-style-type: none"> • Should any water be required to be abstracted from the watercourse for construction purposes, this should be done in a way not to impact the flow. This abstraction may require regulatory permissions. • Compile a Biodiversity Management Plan, which includes the mitigation measures relating to biodiversity. • Clear the smallest footprint necessary for construction, with clearance done in a phased approach as and when necessary. • Preserve all trees and vegetation except where vegetation clearing is required for permanent works or excavation operations. Forest patches not needed for the dam construction will be left undisturbed as much as possible. • Avoid removal of mature trees for the construction of ancillary infrastructure wherever possible. Such trees will be individually identified in advance and marked for retention within the marked extent of clearing. • Restrict vegetation clearance along the transmission line to the right of way (RoW). For transmission lines vegetation may not need to be completely removed but could be cut back to allow for at least the substrate plant matter to prevail on site where possible. • Avoid natural habitats when planning locations of movable components such as equipment laydown areas, construction camps and toilet facilities. Modified habitats within the RoW/transmission route/corridor will instead be targeted for such activities. • Vegetation clearing will be through mechanical means and herbicides will not be used. 	During construction	Contractors	Included in construction cost

Resource or Receptor	Impact Objective	Mitigation Measures	Timeframes	Responsibility	Estimated Cost
		<ul style="list-style-type: none"> Manual labour will be used in preference to heavy machinery to avoid or minimise soil compaction, destruction of the herbaceous layer and exposure of the soil to wind and water erosion. All disturbed areas must be rehabilitated as soon as construction in an area is complete or near complete and not left until the end of the project to be rehabilitated. Undertake soil and vegetation rehabilitation measures through a formalised Rehabilitation Plan. The Rehabilitation Plan shall include at least the following: <ul style="list-style-type: none"> Landscape, including revegetation using local topsoil and plant species native to the local area, all disturbed surfaces. Re-profile any channel banks that will be affected as per the original soil horizon structure and re-vegetate with indigenous species. Remove any contaminated soil and rehabilitate the affected area immediately. Alternatively <i>in situ</i> treatment may be considered if this meets the ECO's approval and is allowed in terms of legislation. Clear the site of all inert waste and rubble, including surplus rock, foundations and batching plant aggregates. Load and haul excess spoil and inert rubble to fill in borrow pits or to approved disposal sites. Stabilise all sloped areas after completion of works. 			

Resource or Receptor	Impact Objective	Mitigation Measures	Timeframes	Responsibility	Estimated Cost
		<ul style="list-style-type: none"> Contour and minimize length and steepness of slopes. Line steep channel and slopes and mulch exposed areas. In general, slopes steeper than 1(V):3(H) or slopes where the soils are by nature dispersive or sandy, must be stabilised. Near vertical slopes of 1(V):1(H) or 1(V):2(H) must be stabilised using hard structures, preferably with a natural look, and with facilities allowing for plant growth. Retain and store excavated topsoil and subsoil for later use in rehabilitation. Position stockpiles on the higher side of a disturbed area, and above a 1:50 year flood line wherever possible, protected to avoid erosion. Topsoil is to be handled twice only – once to strip and stockpile, and once to replace and level. Replace topsoil in the same area from where it was stripped. Topsoil stockpiles shall not exceed 2 m in height and the slopes of stockpiles shall not be steeper than 1 vertical to 2.5 horizontal. Topsoil stockpiles shall not be stored for a period longer than one year. Revegetate (seed) topsoil stockpiles within 2 months after topsoil stripping. Cover and seed completed long-term stockpiles as soon as is practicable in order to stabilise surfaces. 			

Resource or Receptor	Impact Objective	Mitigation Measures	Timeframes	Responsibility	Estimated Cost
		<ul style="list-style-type: none"> ○ Maintain topsoil stockpiles for rehabilitation purposes not for use as a filling material for roads, etc. ○ Prevent the contamination of topsoil stockpiles by prohibiting dumping of waste next to or on the stockpiles. Contamination can also be caused by dust from product stockpiles, or dust suppression with contaminated water. Cover berms and soil stockpiles effectively with non-invasive vegetation or clad with hessian, mulches or tackifiers where it is not possible to re-vegetate as soon as possible. 			
Biodiversity	Pressure on natural resources <i>Allow ecological process to continue as naturally as feasible. Limit habitat degradation to required areas only</i>	<ul style="list-style-type: none"> • Regulate access to the project site. • Prohibit workers from collecting firewood from areas that are not disturbed by project activities • Develop an induction programme for contractors and all workers that will include the importance of conserving the environment. • Allow access to communities to the reservoir area to be inundated prior to flooding to harvest timber and firewood to the maximum possible extent. • Make available vegetation that is cleared to local communities to allow maximum use of available resources, including timber and firewood. • Restrict movement of construction workers to the RoW and predetermined access routes. 	During construction	Contractors	Included in construction cost
Biodiversity	Invasion of IAPs <i>Prevent the introduction of</i>	<ul style="list-style-type: none"> • Develop and implement an IAP Management Plan. The IAP Management Plan shall include at least the following: 	During construction	Contractors	Included in construction cost

Resource or Receptor	Impact Objective	Mitigation Measures	Timeframes	Responsibility	Estimated Cost
	<i>new IAPs to work areas and reduce existing invasions in work areas</i>	<ul style="list-style-type: none"> Objectives: Invasive alien plants (IAPs) are expected to be widespread and established in many of the modified habitats (settlements and cultivated areas) of the project, with the exception of the protected areas. Complete eradication and control is not practically feasible, hence the objective for extensive natural habitats is for implementation of control measures on a regular basis to minimise the occurrence and prevent the spread of these species whilst the objective for modified habitats is implementation of control measures to reduce the occurrence of invasive alien plants to densities that are less than the surrounding areas. Burn on site all alien vegetative and/or seedbearing material removed through control measures to prevent the distribution of seed and fertile vegetative material, regardless of the status of the surrounding areas. Wash vehicles and construction equipment on a regular basis and keep them clean to minimise distribution of seeds and invasive plant material. Conduct daily tyre checks of vehicles to check that seeds, thorns and vegetative material is not being distributed. Keep source areas for construction, such as quarries, borrow pits, vehicle parking and Construction Camps 			

Resource or Receptor	Impact Objective	Mitigation Measures	Timeframes	Responsibility	Estimated Cost
Fauna	Loss of Fauna <i>Limit loss of fauna</i>	<p>clean of IAPs to minimise the presence of seeds that can be dispersed unintentionally.</p> <ul style="list-style-type: none"> ○ Rehabilitate disturbed areas at the earliest opportunity in accordance with the Rehabilitation Plan to minimise the establishment of IAPs. ○ Avoid importation of exotic trees and soil from other places (e.g. for restoration or as ornamentals) 	During construction	Contractors	Included in construction cost
		<ul style="list-style-type: none"> • Only apply biological control measures if these specific measures have been approved for application in Liberia. Alternatively, labour intensive manual control of IAPs would be applied in preference to application of herbicides or other chemicals. • Conduct thorough checks for all forms of fauna prior to any vegetation clearing and a proactive approach will be adopted to prevent the loss of fauna without obstructing construction activities. The following procedures should be applied (but not limited to): <ul style="list-style-type: none"> ○ At least three months prior to clearing of areas of natural vegetation, a competent faunal ecologist experienced in forest habitats shall check the vegetation to be cleared and all fauna would need be noted. ○ Highlight any evidence of active breeding or residence in burrows and obtain advice from competent conservation bodies on safe translocation of the species at risk to appropriate and safe locations. 			

Resource or Receptor	Impact Objective	Mitigation Measures	Timeframes	Responsibility	Estimated Cost
		<ul style="list-style-type: none"> ○ Involve appropriate veterinary services in the translocation or forced movement of any medium-sized or large mammals during construction, examples being animals having fallen into holes, become trapped or entangled by fences, crept inside vehicles or trapped within construction camps. ○ The day prior to vegetation clearing and on the day of clearing, competent forest ecologists will be on site to safely translocate any animals encountered that are not able to evacuate the site on their own accord. Examples of such animals might include young birds in nests, tortoises, chameleons, frogs, some snakes, invertebrates, fossorial species and any injured animals. • Conduct animal rescue operations during the initial filling of the reservoir. Rescue operations will be conducted by competent forest ecologists with veterinary support for handling potentially dangerous species. • Reduce vehicle speeds within the project area through implementation of speed control measures and the regular enforcement of legislation. • Restrict night driving to the extent possible. • Develop induction programmes for staff and contractors to raise the awareness of the importance of conserving the environment, the diversity of fauna present, importance of protecting wildlife, risks associated with large wildlife and how to react when confronted by different species of large wildlife, and 			

Resource or Receptor	Impact Objective	Mitigation Measures	Timeframes	Responsibility	Estimated Cost
		<p>requirements to actively prevent the loss of any animals including snakes and other species commonly considered to be vermin.</p> <ul style="list-style-type: none"> • Confine staff and contractors involved in construction activities to the construction footprint and required access roads to reach those sites. Access into adjacent protected areas and natural habitats is not allowed. • Enforce a wildlife protection policy for construction workers and RoW clearing teams. The policy will include: <ul style="list-style-type: none"> ○ Hunting, setting snares, catching of birds and fishing will be prohibited; ○ Workers will be prohibited from possessing firearms and any hunting, trapping or fishing devices; ○ No engagement in wildlife or bushmeat trade will be tolerated; ○ Keeping of pets in construction sites will not be tolerated; ○ There will be no improper disposal of waste food. • Appoint or train staff onsite to safely capture and translocate venomous snakes without harm to the snakes. • Keep contact details available (based on prior arrangement) for a snake bite specialist who is able to provide advice to local doctors in the event of a venomous snake bite incident. Snake bites are rare events and most doctors do not have training or experience in treatment. • Support the Department of Forest Conservation to raise their capacity and control the illegal bush meat trade and conduct anti-poaching operations in the surrounding areas. 			

Resource or Receptor	Impact Objective	Mitigation Measures	Timeframes	Responsibility	Estimated Cost
Fauna	Electrocution of fauna including birds and bats <i>Avoid the electrocution of animals from the transmission lines</i>	<ul style="list-style-type: none"> • Install spikes above insulators to prevent birds from perching and roosting at these points and minimise electrocutions. • Install visibility devices (bird flappers) onto the electrical cables in riparian habitats where the highest risk of collision occurs. • Fit towers with devices such as barbed wire coils and spikes to prevent primates (and people) from climbing these structures. • Monitor collision and electrocution of birds for five years whereafter the specialist undertaking the monitoring can determine the need for more monitoring. National birding institutions must be involved in this monitoring to contribute towards understanding of impacts in Liberia. Results of monitoring will determine the need for installation of additional visibility devices. 	During construction	Contractors	Included in construction cost
Air Quality	Dust control <i>Keep dust to a level acceptable to the general public and to avoid air quality impacts</i>	<ul style="list-style-type: none"> • Use dust suppression methods such as spraying water on roads, as required but especially in sections close to schools and health centres, to avoid dust dispersion from construction traffic. • Cover loose/friable loads on trucks e.g. through use of tarp trucks to minimize loss and dust creation during transportation. • Maintain and store piles of loose/friable materials and soil in a suitable manner (e.g. covered or dampened as required) to minimize dust dispersion. • Set up dust monitoring sites around effected areas and ensure that the dust and noise levels do not exceed expectable environmental standards for the duration of the construction period. 	During construction	Contractors	Included in construction cost

Resource or Receptor	Impact Objective	Mitigation Measures	Timeframes	Responsibility	Estimated Cost
Macroeconomy	Employment and business opportunities <i>Provide equal opportunities to all to participate in employment and procurement; promote development of local enterprises and women in employment</i>	<ul style="list-style-type: none"> Establish a recruitment policy, which prioritises the employment of local residents (originating from towns in the project area), over foreigners. Set criteria for prioritising local residents and then other people from Liberia as part of the recruitment process. Women should receive preference in non-labour intensive positions to encourage and promote gender equality. Require all contractors to recruit in terms of the project's recruitment policy, where practical. Prevent child labour by not employing minors of less than 18 years of age Meet with the tribal authorities and local government to access any available skills/employment-seekers database for the area. This database is to be updated and made available to the appointed contractors. Advertise job opportunities and criteria for skills and experience needed through local media, at least three months ahead of recruitment. This information should also be provided to all relevant authorities, community representatives and organisations on the interested and affected party database. No employment will take place at the entrance to the site. Only formal channels for employment will be used. Implement a local procurement policy to ensure that local procurement is maximized. The policy will include: <ul style="list-style-type: none"> Reasonable targets for using local suppliers. A clause of none discrimination on any grounds of gender, ethnicity, religion. 	During construction	RREA/ Contractors	<u>Contractor:</u> Included in construction cost <u>RREA:</u> Included in community health, safety and security cost (USD 10,000)

Resource or Receptor	Impact Objective	Mitigation Measures	Timeframes	Responsibility	Estimated Cost
		<ul style="list-style-type: none"> ○ Criteria for monitoring local procurement and reporting on supplier performance management. ○ Clearly communicate the criteria and tendering process prior to the commencement of construction activities; and ○ The procurement policy and tendering requirements must be easily accessible to potential suppliers. <ul style="list-style-type: none"> • Develop internal training 'certification' or reference letter provisions to those who receive internal training. • Develop training plans according to each permanent employee' work agreement and relevant to their job description. • Implement construction phase measures to enhance employment, skills training and on the job development during the operation phase. • Break down procurement requirement to its smallest parts. This will allow numerous small businesses to benefit from the project. • Require all contractors to adhere to the procurement and employment policies and procedures of the project. Contractors will be discouraged from bringing in-migrant workers into the area unless the skills required cannot be found in the project area and project affected districts. • Ensure that the appointed project contractors and suppliers have access to Health, Safety, Environmental and Quality training as required by the project. This will help to ensure that they have future opportunities to provide goods and services to the sectors. 			

Resource or Receptor	Impact Objective	Mitigation Measures	Timeframes	Responsibility	Estimated Cost
		<ul style="list-style-type: none"> Establish a grievance protocol and procedures, as described in the IFC Good Practice Note Addressing Grievances from Project-Affected Communities (2009) and other related or updated documents, whereby people can raise concerns and issues regarding all project-related activities. Monitor on-the-job performance and training through performance reviews. Training needs will be identified and provided by the project. 			
Land	Land acquisition <i>Follow legitimate processes</i>	<ul style="list-style-type: none"> Obtain written documentation that land for the power plant and access road will be donated by the community, followed by processing of a legal land title. Obtain the necessary permissions to install the transmission line within the road reserve. 	During construction	RREA	Included in project planning cost
Land	Physical displacement <i>Avoid physical displacement</i>	<ul style="list-style-type: none"> The detailed routing and profiling of the transmission line shall not interfere with any residential, commercial or public structures. 	During construction	RREA/ Contractors	Included in project planning and design cost
Land	Economic displacement <i>Avoid economic displacement as far as possible and compensate those affected so that they are not worse off than before where not possible</i>	<ul style="list-style-type: none"> Implement the Resettlement Action Plan which was developed prior to construction. 	During construction	RREA	Included in livelihood restoration cost (USD 455,000)
Public Infrastructure	Pressure on social services <i>Avoid deterioration of social services</i>	<ul style="list-style-type: none"> Provide adequate health care to project workers and their families so as to avoid adding additional pressure on the existing health facilities 	During construction	RREA/ Contractors	<u>Contractor:</u> Included in construction cost <u>RREA:</u> Included in community health, safety and

Resource or Receptor	Impact Objective	Mitigation Measures	Timeframes	Responsibility	Estimated Cost
Public Infrastructure	Security threats <i>Avoid increases in security threats and ensure project security does not itself become a threat</i>	<ul style="list-style-type: none"> Conduct preventive health campaigns for the communities with particular focus on water and sanitation related diseases Establish a community development programme. Consult with affected communities and, in partnership with them, identify community development initiatives, based on their development priorities. Include best practice health and safety provisions in the construction contracts and ensure strict compliance with national legislation and the World Bank EHS guidelines. Comply with the IFC/EBRD guidance on workers' accommodation for workers' camp standards in regard to quality, management and provision of basic social services. Establish a grievance mechanism for workers. Where local security systems exist, consider supporting these to strengthen community policing and crime-handling measures Institute strict access control measures for project property, including fencing. Ensure that the conduct of security personnel complies with good international practice 	During construction	RREA/ Contractors	security cost (USD 10,000)
					<u>Contractor:</u> Included in construction cost <u>RREA:</u> Included in community health, safety and security cost (USD 10,000)
Community Health and Safety	Disturbance from construction traffic <i>Avoid traffic becoming a nuisance or safety issue</i>	<ul style="list-style-type: none"> Disseminate traffic management plans in the project area, through campaigns in schools and communities. Ensure all project vehicle drivers are well trained and have a full and up to date license to operate their vehicles. Institute speed limits and traffic controls for project vehicles and equipment. Develop roads that cater exclusively for project purposes and place them in areas that 	During construction	RREA/ Contractor	<u>Contractor:</u> Included in construction cost <u>RREA:</u> Included in community health, safety and security cost (USD 10,000)

Resource or Receptor	Impact Objective	Mitigation Measures	Timeframes	Responsibility	Estimated Cost
Community Health and Safety	Population influx <i>Allow social/cultural process to continue as close to normal as possible</i>	<p>are low impact in terms of dust and noise generation and local traffic.</p> <ul style="list-style-type: none"> • Develop and implement an HIV/AIDS policy and information document for all workers directly related to the project. The information document will address factual health issues as well as behaviour change issues around the transmission and infection of HIV/AIDS. • Conduct public health campaigns addressing issues of behavioural change, water and sanitation, malaria, HIV/AIDS, Ebola, etc. • Implement a grievance procedure that is easily accessible to the local community, through which complaints related to contractor or employee behaviour can be lodged and responded to. The project will respond in a serious manner to any such complaints. Key steps include: <ul style="list-style-type: none"> ○ Circulation of contact details of 'grievance officer' or other key project contact. ○ Awareness raising among the local community regarding the grievance procedure and how it works. ○ Establishment of a grievance register to be updated and maintained by the project. ○ Stakeholders should be made aware of the key guiding principles of the mechanism, as well as how and where they can submit any grievances. • Develop an induction programme, including a Code of Conduct, for all workers directly related to the project. A copy of the Code of Conduct is to be presented to all workers and 	During construction	RREA/ Contractors	<u>Contractor:</u> Included in construction cost <u>RREA:</u> Included in community health, safety and security cost (USD 10,000)

Resource or Receptor	Impact Objective	Mitigation Measures	Timeframes	Responsibility	Estimated Cost
		<p>signed by each person. The Code of Conduct must address the following aspects:</p> <ul style="list-style-type: none"> ○ respect for local residents and customs; ○ zero tolerance of bribery or corruption; ○ zero tolerance of illegal activities by construction personnel including: unlicensed prostitution; sexual relations with minors under 18 years of age; illegal sale or purchase of alcohol; sale, purchase or consumption of drugs; illegal gambling or fighting; ○ no alcohol and drugs policy during working time or at times that will affect ability to work; ○ description of disciplinary measures for infringement of the Code and company rules. If workers are found to be in contravention of the Code of Conduct, which they signed at the commencement of their contract, they will face disciplinary procedures that could result in dismissal. 			
Worker Health and Safety	Health and safety risks <i>Limit health and safety risks to acceptable levels</i>	<ul style="list-style-type: none"> • Include best practice health and safety provisions in the construction contracts and ensure strict compliance with national legislation and the World Bank EHS guidelines • Comply with the IFC/EBRD guidance on workers' accommodation for workers' camp standards in regard to quality, management and provision of basic social services. • Ensure project sites are secured against unauthorized access 	During construction	RREA/ Contractors	<u>Contractor:</u> Included in construction cost <u>RREA:</u> Included in community health, safety and security cost (USD 10,000)

Resource or Receptor	Impact Objective	Mitigation Measures	Timeframes	Responsibility	Estimated Cost
Visual Amenity	Visual impact <i>Avoid unsightly project sites/components</i>	<ul style="list-style-type: none"> • Temporary construction facilities shall be demolished and the sites restored to the pre-construction state. • Excess material shall be disposed of in terms of the WMP. 	During construction	Contractors	Included in construction cost
Noise	Noise control <i>Avoid annoyances to the general public and protect the public and workers from noise. Keep noise emissions from Diesel Power Plant in line with national and international regulations</i>	<ul style="list-style-type: none"> • Locate noisy activities at an adequate distance from residential area to reduce the level of noise to an acceptable level, where possible. • Schedule noisy activities to daytime hours (07h00-18h00). • Install noise control devices in construction equipment if noise levels exceed the applicable guidelines. • Instruct the workforce to avoid unnecessary noise. • To maintain positive community relations, keep the public informed about the construction and operation plans and efforts to minimize noise, and establish procedures for prompt response and corrective action with regard to noise complaints. • Install a sound wall on the northern and western portion of the diesel power plant building. The sound wall should have a minimum surface density of 10 kg/m², no gaps, and be high enough to block the line-of-sight between the noise source and the NSRs. 	During construction	Contractors	Included in construction cost
Cultural Heritage	Loss of physical cultural resources <i>Avoid losses of cultural heritage or where this is not feasible limit impacts to levels</i>	<ul style="list-style-type: none"> • Follow the mitigation hierarchy that prioritizes avoiding impacts to cultural heritage resources. Where avoidance is determined technically and/or financially unfeasible, all efforts should be made to minimize project impacts. The removal or relocation of cultural heritage resources should be viewed as the last option to 	During construction	RREA/ Contractors	Included in project planning cost and contingency

Resource or Receptor	Impact Objective	Mitigation Measures	Timeframes	Responsibility	Estimated Cost
	<i>acceptable to stakeholders</i>	<p>mitigate impacts and, if necessary, be done using the best available techniques as determined by a technical expert and in consultation with cultural heritage stakeholders.</p> <ul style="list-style-type: none"> • Develop and implement a chance finds procedure (CFP). A CFP is a project-specific procedure that outlines the actions to be taken if previously unknown cultural heritage is encountered. The contents of the CFP are to include at minimum the following elements: <ul style="list-style-type: none"> ○ Record keeping and expert verification procedures; ○ Chain of custody instructions for movable finds; ○ Clear criteria for potential temporary work stoppages; and ○ Roles, responsibilities, and response times required from both project staff and any relevant heritage authority, as well as any agreed consultation procedures. • Pre-construction cultural heritage surveys to identify and document undiscovered cultural heritage resources within the proposed reservoir area, access road sections to be upgraded, along the transmission line and access road. If resources are found close to the access road or transmission line route develop construction plans to avoid or minimize direct impacts from vibration, dust, and exhaust. • Engage with stakeholders to schedule construction activities to avoid restricting user access or creating noise or visual disturbances during planned resource uses (i.e. religious services). 			

Resource or Receptor	Impact Objective	Mitigation Measures	Timeframes	Responsibility	Estimated Cost
		<ul style="list-style-type: none"> Undertake stakeholder engagement to identify planned project components near Poro, Sande, and other secret society resources and to determine if resources are located within the power generating infrastructure and/or inundation footprints and to schedule construction activities to avoid construction in designated areas during planned use of society locations. Members should not be pressured to divulge location of resources. If society resources are located within power generation facilities construction footprint or reservoir inundation areas, Project should engage stakeholders to develop a plan to relocate society compounds, clearings, etc. 			
OPERATION PHASE					
All	All impacts	<ul style="list-style-type: none"> Where activities are required for new works, redoing works or rehabilitation works <u>apply all applicable measures from the construction phase,</u> 	During operation	Contractors	Included in operations cost
Surface Water	Soil erosion <i>Prevent erosion and sedimentation of watercourses</i>	<ul style="list-style-type: none"> Undertake regular road maintenance to limit erosion. Regularly remove topsoil (and other material) accumulated in side drains of roadways to keep these open and functional. Update and continue to implement Erosion Control Plan 	During operation	Contractors	Included in operations cost
Surface Water	Sediment trapping	<ul style="list-style-type: none"> Use the flushing gate or draw down the water level and using excavators to reduce reservoir sedimentation. 	During operation	RREA	Included in operations cost

Resource or Receptor	Impact Objective	Mitigation Measures	Timeframes	Responsibility	Estimated Cost
	<i>Limit sediment abrasion of turbines</i>	<ul style="list-style-type: none"> Promote development and dissemination of improved agricultural practices (both cultural and post-harvest) which enable farmers to obtain more economic benefit from the more intensive utilisation of the best agricultural soils, thereby reducing the pressure to cut and burn erosion-prone forest lands with steeper soils. 			
Surface Water	Surface (and soil) contamination <i>Prevent spillages and clean up accidental spills to avoid land and water contamination</i>	<ul style="list-style-type: none"> Equip all permanent facilities where fuel and hazardous materials are used or stored with secondary containment, oil traps, spill kits and absorbent materials. Storage and handling of fuel and hazardous materials shall be kept away from the river. Install and maintain sanitary water treatment facilities. Update and continue using the Water Quality Monitoring Plan. Update and continue using the Waste Management Plan. Update and continue using the HAZMAT Register and Hazardous Materials Management Plan. Continue use of the Pesticide Management Plan drawn up for construction. 	During operation	Contractors	Included in operations cost
Aquatic Ecology	Degradation of aquatic habitats <i>Maintain aquatic ecology diversity</i>	<ul style="list-style-type: none"> Release an environmental flow of at least 0.35 m³/s into the bypassed reach at all times. Once biomonitoring has been undertaken the environmental flow shall be amended to the flow volumes and regimes as required by an aquatic ecologist. Control energy dissipation of the water downstream of the dam through, for example, baffle blocks after the dam toe. Conduct biomonitoring of fish assemblage in the downstream reach of Kaiha River prior to 	During operation	RREA	Included in operation rules Included in monitoring costs (USD 20,000)

Resource or Receptor	Impact Objective	Mitigation Measures	Timeframes	Responsibility	Estimated Cost
		<p>and during operations. Fish monitoring will define flow requirements associated with spawning and the habitat maintenance over the dry reach. The results from the monitoring regime will: (i) inform any assumptions made regarding fish sensitivity in relation to peaking and (ii) monitor the impact of peaking on the receiving fish assemblages (iii) make recommendations where necessary to reduce any negative impacts.</p> <ul style="list-style-type: none"> • Install a fish screen (or reductions in trash rack openings) at the intake to reduce fish entrainment and mortality. The sizing of the fish screen should be the smallest that does not affect the flow of water. If monitoring shows this size to be insufficient the next step would be an electric current deterrent or a chute next to the intake (a chute would reduce the volume of water available to produce electricity). • Operate daily peaking in such a way to ensure smooth transitions between maximum and minimum discharge, thus avoiding rapid changes in downstream river flow and water levels. Typically this rate should not be more than 4 or 5 cm/hour as some drift is likely to occur if this rate increases but this rate should be confirmed by an aquatic ecologist performing monitoring at the site. • In the event of hydropower plant outage, provide a compensation flow by immediately opening the flushing gate outage when there is no spilling over the dam. The volume of compensation flow should be confirmed by an aquatic ecologist performing monitoring at the site. 			

Resource or Receptor	Impact Objective	Mitigation Measures	Timeframes	Responsibility	Estimated Cost
Aquatic Ecology	Habitat conversion Habitat degradation <i>Protect sensitive vegetation and fauna from future disturbances</i>	<ul style="list-style-type: none"> Establish a protected area upstream and downstream of the dam Support will be provided to the Department of Forest Conservation to raise their capacity and control the illegal bush meat trade and conduct anti-poaching operations in the surrounding areas. Restrict vehicle access to the transmission line servitude for maintenance work. 	During operation	RREA	Unknown, requires a participatory process (included in stakeholder engagement costs, USD 10,000)
Biodiversity	Establishment of invasive plant species <i>Avoid competition to indigenous vegetation from IAPS</i>	<ul style="list-style-type: none"> Update and continue to implement IAP Management Plan Remove invasive plant species during routine vegetation maintenance as per the IAP Management Plan. Restore disturbed areas immediately after maintenance works as per the Rehabilitation Plan. Avoid importation of exotic trees and soil from other places (e.g. for restoration or as ornamentals). 	During operation	RREA	Included in operations cost
Fauna	Electrocution and wire collision <i>Prevent avifauna and faunal mortality from transmission lines</i>	<ul style="list-style-type: none"> Monitor collision and electrocution of birds and animals for five years, whereafter the specialist undertaking the monitoring can determine the need for more monitoring. National birding institutions must be involved in this monitoring to contribute towards understanding of impacts in Liberia. Results of monitoring will determine the need for installation of additional visibility devices (bird flappers). Consider removal of an upper earth line in future as technology advances. 	During operation	RREA	Included in monitoring costs (USD 20,000)
Air Quality	Air emissions <i>Ensure air emissions meet national and</i>	<ul style="list-style-type: none"> Model emissions from any subsequent addition of capacity to the proposed diesel generators at the time of imminent operation 	During operation	RREA	TBD

Resource or Receptor	Impact Objective	Mitigation Measures	Timeframes	Responsibility	Estimated Cost
Greenhouse Gases	<i>international standards</i> GHG emissions <i>Limit project contributions to climate change</i>	<p>of the add-on. No mitigation is proposed for the 1.8 MW installation of diesel generators.</p> <ul style="list-style-type: none"> Minimise unnecessary land disturbance during the construction of the access road and hydropower plant, including avoiding unnecessary damage or destruction of existing vegetated forest and other biomass-rich areas. Assess opportunities for the productive use of biomass material (especially forest wood) subsequent to land clearance. Minimise fuel consumption by vehicles and machinery used for the earth and track work, by minimising idling, developing and implementing a regular equipment and vehicle maintenance plan to avoid a reduction in equipment efficiency over time; considering energy efficiency during the procurement of equipment; implementing driver training for mobile equipment operators to minimise fuel consumption; ensuring vehicles and equipment are used at their optimal / designed capacity (i.e. not overloaded); using energy efficient timetabling to minimise equipment idling and prevent unnecessary trips; and through a program to encourage awareness of energy efficiency amongst personnel Maximise the efficiency of the diesel generators for power generation through the following measures: procuring generators with a high inherent efficiency; deploying the correct sized diesel generators to match power requirements; minimising idling of generators; carrying out regular maintenance in accordance with operator specifications; and maximising fuel quality, procurement of 	During operation	Contractors	Included in operations cost

Resource or Receptor	Impact Objective	Mitigation Measures	Timeframes	Responsibility	Estimated Cost
Macroeconomy	Employment and business opportunities <i>Provide equal opportunities to all to participate in employment and procurement; promote development of local enterprises and women in employment</i>	<p>generators using alternative, or low carbon fuels / biofuels should also be considered.</p> <ul style="list-style-type: none"> The development and implementation of a GHG management plan is critical if the GHG emissions are to be managed over time. <p>Continue economic development activities begun in construction phase including the following:</p> <ul style="list-style-type: none"> Prioritises the employment of local residents (originating from towns in the project area), over foreigners. Set criteria for prioritising local residents and then other people from Liberia as part of the recruitment process. Women should receive preference in non-labour intensive positions to encourage and promote gender equality. Require all contractors to recruit in terms of the project's recruitment policy, where practical. Prevent child labour by not employing minors of less than 18 years of age Maintain the employment-seekers database for the area. This database is to be updated and made available to the contractors. Advertise job opportunities and criteria for skills and experience needed through local media, at least three months ahead of recruitment. This information should also be provided to all relevant authorities, community representatives and organisations on the interested and affected party database. No employment will take place at the entrance to the site. Only formal channels for employment will be used. 	During operations	RREA and Contractors	<p><u>Contractor</u>: Included in cost</p> <p><u>RREA</u>: Included in community health, safety and security cost (USD 10,000)</p>

Resource or Receptor	Impact Objective	Mitigation Measures	Timeframes	Responsibility	Estimated Cost
		<ul style="list-style-type: none"> • Maintain the local procurement policy to ensure that local procurement is maximized. The policy will include: <ul style="list-style-type: none"> ○ Reasonable targets for using local suppliers. ○ A clause of none discrimination on any grounds of gender, ethnicity, religion. ○ Criteria for monitoring local procurement and reporting on supplier performance management. ○ Clearly communicate the criteria and tendering process prior to the commencement of construction activities; and ○ The procurement policy and tendering requirements must be easily accessible to potential suppliers. • Maintain internal training 'certification' or reference letter provisions to those who receive internal training. • Maintain training plans according to each permanent employee' work agreement and relevant to their job description. • Break down procurement requirement to its smallest parts. This will allow numerous small businesses to benefit from the project. • Require all contractors to adhere to the procurement and employment policies and procedures of the project. Contractors will be discouraged from bringing in-migrant workers into the area unless the skills required cannot be found in the project area and project affected districts. • Ensure that the appointed project contractors and suppliers have access to Health, Safety, 			

Resource or Receptor	Impact Objective	Mitigation Measures	Timeframes	Responsibility	Estimated Cost
Public Safety	Dam failure <i>Avoid failures and where not possible prevent loss of life and reduce damage to property and infrastructure</i>	<p>Environmental and Quality training as required by the project. This will help to ensure that they have future opportunities to provide goods and services to the sectors.</p> <ul style="list-style-type: none"> Establish a grievance protocol and procedures, as described in the IFC Good Practice Note Addressing Grievances from Project-Affected Communities (2009) and other related or updated documents, whereby people can raise concerns and issues regarding all project-related activities. Monitor on-the-job performance and training through performance reviews. Training needs will be identified and provided by the project. Define an Emergency Preparedness and Response System in compliance with the IFC Good Practice Note Environmental, Health, and Safety Guidelines for Hydropower Projects (March 2018)(page 29) should the dam rupture/fail: <ul style="list-style-type: none"> Identification of areas where accidents and emergency situations may occur; Communities and individuals that may be impacted; Response procedures; Provision of equipment and resources; Designation of responsibilities; Communication, including that with potentially Affected Communities and periodic training to ensure effective response; and, The emergency preparedness and response activities to be periodically reviewed and revised, at least every 	During operation	RREA	Included in operation cost

Resource or Receptor	Impact Objective	Mitigation Measures	Timeframes	Responsibility	Estimated Cost
		<p>5 years, to reflect changing conditions.</p> <ul style="list-style-type: none"> Operate and maintain structures according to international specifications. Undertake ongoing monitoring of the physical structures during operation. Conduct a risk assessment (for example Failure Mode Effects and Criticality Analysis) to identify conceivable failures as well as their probabilities and consequences) in accordance with internationally accepted practices. Through this approach dam safety programs can identify the elements of the physical infrastructure and the operating procedures that need to be routinely inspected, monitored and adjusted to achieve the acceptable level of risk. Prepare and follow a dam safety and emergency response management plan that defines the operating procedures and specifications to protect the physical health and safety of people (residents, worker and visitors) and their socio-economic regime, the physical environment and its ecological habitats and the integrity of the hydropower dam and associated project components to ensure sustainable, safe optimal performance. 			
Noise	Noise control <i>Avoid annoyances to the general public and protect the public and workers from noise. Keep noise emissions from</i>	<ul style="list-style-type: none"> To maintain positive community relations, keep the public informed about the construction and operation plans and efforts to minimize noise, and establish procedures for prompt response and corrective action with regard to noise complaints. 	During construction	Contractors	Included in construction cost

Resource or Receptor	Impact Objective	Mitigation Measures	Timeframes	Responsibility	Estimated Cost
	<i>Diesel Power Plant in line with national and international regulations</i>				

9.4 MONITORING, CHECKING AND CORRECTIVE ACTION

9.4.1 Introduction

Checking includes inspections and monitoring as well as audit activities to confirm proper implementation of checking systems as well as effectiveness of mitigations. Corrective actions include response to out-of-control situations, non-compliances, and non-conformances. Actions also include those intended to improve performance.

The objective of the monitoring plan is to:

- Provide checks on the implementation of the mitigation measures (activity monitoring) and early indications of progress, or lack thereof, with respect to achievement of objectives (outcome monitoring); and
- Identify corrective measures or the redesign of mitigation measures (proactive action), if the originally planned mitigation measures are not sufficiently effective.

The overall responsibility of implementing the monitoring requirements rests with RREA. However, the various monitoring activities will be conducted by the institution implementing the respective management actions (combined with compliance monitoring by the RREA ECO or owner's engineer).

The total timeframe of the monitoring period is not time-bound and it should last until the project impacts have been mitigated or fully compensated. In practical terms, the implementation schedule and cost estimates have been set according to the expected time needed to achieve the performance targets.

9.4.2 Inspection

Inspections will be conducted by the Project weekly on an *ad hoc* basis and formally at least once every six months. The results of the inspection activities will be reported to RREA management to be addressed.

9.4.3 Monitoring

This ESMP provides a plan for environmental and social monitoring. The aim of the monitoring programme is to ensure that the negative environmental impacts identified in this ESIA are effectively mitigated in the construction, operations and decommissioning stages of the proposed Project.

The ESIA Consultant is responsible for developing the Monitoring Plan in the ESIA Report. The Employer (RREA) will be responsible for reviewing and approving the Monitoring Plan.

Monitoring methodologies or processes must be put in place in order to ensure the efficacy of the mitigation measures identified in the ESIA. Monitoring methodologies should be established to address the following:

- Alteration to the biological, chemical, physical, social and health characteristics of the recipient environment;
- Alterations in the interactions between project activities and environmental sensitivities, and interactions among the various sensitivities;
- Monitoring the effectiveness of the mitigation measures;
- Determination of long term and residual effects; and
- Identification of Project specific cumulative environmental effects.

Self-monitoring will be conducted to ensure compliance with regulatory requirements as well as to evaluate the effectiveness of operational controls and other measures intended to mitigate potential impacts. Monitoring parameters are included in the ESMP.

External monitoring will be conducted by the EPA and RREA. The frequency of monitoring of the project area will be determined by the Liberia EPA and the RREA. Other administrative matters related to monitoring will be specified by Liberia EPA and RREA.

Please see Table 9.2 for the responsible authority or party for each monitoring activity listed.

In addition, lender requirements may include other forms of external monitoring as specified by the lending institution.

9.4.4 *Auditing*

Beyond the routine inspection and monitoring activities conducted, audits will be carried out internally by RREA to ensure compliance with regulatory requirements. Audits to be conducted will also cover the subcontractor self-reported monitoring and inspection activities. The audit shall be performed by qualified staff and the results shall be reported to RREA management to be addressed.

The audit will include a review of compliance with the requirements of the ESIA and ESMP and include, at a minimum, the following:

- Completeness of environmental and social management documentation, including planning documents and inspection records;

- Conformance with monitoring requirements;
- Efficacy of activities to address any non-conformance with monitoring requirements; and
- Training activities and record keeping.

There will also be a cycle of audits into specific areas or activities of the Project. The frequency of audits will be risk based and will vary with the stage of the Project and will depend on the results of previous audits.

9.4.5 *Corrective Action*

Impacts will be identified and associated risks addressed before an incident occurs. Investigating a 'near miss' or actual incident after it occurs can be used to obtain valuable lessons and information that can be used to prevent similar or more serious occurrences in the future.

RREA will implement a formal non-compliance and corrective action tracking procedure for investigating the causes of, and identifying corrective actions to, accidents or environmental or social non-compliances. This will ensure coordinated action between RREA and contractors. The ECO will be responsible for keeping records of corrective actions and for overseeing the modification of environmental or social protection procedures and/or training programs to avoid repetition of non-conformances and non-compliances.

9.4.6 *Reporting*

Throughout the Project, RREA will keep the regulatory authorities informed of the Project performance with respect to environmental and social matters by way of written status reports and face-to-face meetings. RREA will prepare a report on environmental and social performance and submit it to government authorities at a frequency agreed.

If required, RREA will provide appropriate documentation of environmental and social management related activities, including internal inspection records, training records, and reports to the relevant authorities.

Contractors are also required to provide performance reporting to RREA on a regular basis through weekly and monthly reports. These will be used as inputs to the above.

9.4.7 *Monitoring Methods*

Generally, the monitoring of construction practices and mitigation measures will be based on visual inspections at the construction sites. In addition, the contractors will be responsible for monitoring the outcome of their management actions on the physical, biological and human environment.

The performance indicators, the means of verification and the monitoring frequency are described in Table 9.2.

Table 9.2 *Monitoring During Construction*

Management Issue	Performance Indicators	Means of Verification	Monitoring Frequency	Responsible Authority/ Party
Landscape and vegetation management	<ul style="list-style-type: none"> Quantity and quality of vegetation clearing Quality of landscaping at restored sites Plant species used for re-vegetation Number and location of spoil heaps Cleanliness of construction site 	<ul style="list-style-type: none"> Visual inspections Photographic documentation Interviews 	Weekly inspections	EPA and RREA
Biodiversity Protection	<ul style="list-style-type: none"> Protection of the remaining upstream and downstream natural forest habitats. 	<ul style="list-style-type: none"> Presence of a diversity of species, with evidence of some endangered and/or critically endangered species recorded during baseline assessments. 	Bi-annual surveys (wet and dry season), for a period of five years	<ul style="list-style-type: none"> EPA
Biodiversity Protection	<ul style="list-style-type: none"> Preclearing checks by a competent forest ecologists with appropriate veterinary support when appropriate for: <ul style="list-style-type: none"> Mature trees that can be avoided Fauna needing to be translocated Ecologist presence on site just prior to and during vegetation clearing to safely translocate any animals not able to escape. 	<ul style="list-style-type: none"> Consulting contracts and payment schedules with competent ecologists Photographic evidence of results 	<p>Prior to and during vegetation clearing</p> <p>Prior to and during inundation</p>	<ul style="list-style-type: none"> EPA
Bird and Bat collisions with transmission lines	<ul style="list-style-type: none"> Monitoring of the collision and electrocution of birds, bats and presence of any other fauna involving national birding institutions. National birding institutions must be involved in this monitoring to contribute towards understanding of impacts in Liberia. Results of monitoring will determine the need for installation of additional visibility devices. 	<ul style="list-style-type: none"> Consulting contracts and payment schedules with competent ornithologists 	Monthly surveys, for a period of five years	<ul style="list-style-type: none"> EPA

Management Issue	Performance Indicators	Means of Verification	Monitoring Frequency	Responsible Authority/ Party
Invasive Alien Plant Control	<ul style="list-style-type: none"> Implementation records for alien plant control Log of control methods used, dates and locations Appropriate storage and dispensing of herbicides 	<ul style="list-style-type: none"> Occurrence of invasive alien plants in areas disturbed by construction. Records and audits of rehabilitation activities 	Bi-annual surveys	<ul style="list-style-type: none"> EPA
Soil erosion and sedimentation control	<ul style="list-style-type: none"> Number and location of silt trap fences / sedimentation ponds Timing and duration of in-stream works Water quality parameters Evidence of erosion in areas disturbed by construction Amount and intensity of rainfall No. of spills of hazardous materials 	<ul style="list-style-type: none"> Visual inspections <ul style="list-style-type: none"> Where active earthworks are taking place Topsoil stockpiles. Along established and new access roads to monitor compaction, pollution and erosion. At areas with high possibility of pollution like storage areas and parking areas and around temporary fuel depots At the edges of development footprints Where land rehabilitation was done Photographic documentation Interviews Water quality measurements in the main river downstream of the construction areas 	Daily inspections by ECO Weekly inspections Quarterly water quality measurements (weekly during in-stream works or when discharging water or as specified by an aquatic ecologist)	<ul style="list-style-type: none"> EPA and RREA
Waste and wastewater management	<ul style="list-style-type: none"> Amounts and types of waste generated, sorted, recycled/reused, treated and disposed Number, location and status of waste disposal sites Number and status of toilet facilities Wastewater quality parameters 	<ul style="list-style-type: none"> Visual inspections Photographic documentation Interviews Wastewater quality measurements at source (see Appendix 11) 	Weekly inspections monthly wastewater quality measurements	<ul style="list-style-type: none"> EPA and RREA

Management Issue	Performance Indicators	Means of Verification	Monitoring Frequency	Responsible Authority/ Party
	<ul style="list-style-type: none"> Quality of secondary containment structures Labelling of hazardous waste Evidence of pollution spill contingency plan No. of spills of hazardous material 			
Air pollution control	<ul style="list-style-type: none"> Frequency of water spraying on roads and stockpiles Evidence that trucks cover loose materials Location and timing of waste burning Ambient air quality (PM10) at site, schools and health facilities 	<ul style="list-style-type: none"> Visual inspections Photographic documentation Interviews PM10 measurements at construction sites and roadsides using standard air sampling equipment (conforming to EC Directive 89/336/EEC and ISO 12103-1) (see Appendix 12) 	<p>Weekly inspections</p> <p>Weekly air quality measurements</p>	<ul style="list-style-type: none"> EPA
Sedimentation of reservoir	<ul style="list-style-type: none"> Depth of reservoir Quantity of sediment in sampling 	<ul style="list-style-type: none"> Monitor water depth, in a boat from the dam upstream as far as possible, with the reservoir full, measuring water depth along the original (now flooded) river channel at intervals of approximately 100 m. Make measurements in the straight portion of the channel and not in river bends. The location of each measurement point can be recorded using a hand-held GPS unit (horizontal accuracy about 5m). It is recommended that the measurement points be pre-selected and recorded by GPS prior to filling the reservoir to avoid sites with rocks which will give an irregular bottom 	<p>Annual depth measurement</p> <p>bi-annual sediment sampling</p>	<ul style="list-style-type: none"> RREA and EPA

Management Issue	Performance Indicators	Means of Verification	Monitoring Frequency	Responsible Authority/ Party
		depth, and to revisit these same sites at each subsequent sediment survey. These survey sites should be areas with relatively flat bottoms and devoid of large stones, in straight reaches of the river between meander bends. <ul style="list-style-type: none"> • Sampling of sediment on water exiting dam 	Daily sediment sampling once delta within 500 m of turbines	
GHG	<ul style="list-style-type: none"> • % land disturbance during the construction of the access road and hydropower plant • Number of opportunities created for the productive use of biomass material subsequent to land clearance. • Fuel consumption by vehicles and machinery • Compliance with the maintenance schedule • Number of energy efficiency initiatives during the procurement of equipment; • Driver training inspections • Number of vehicles and equipment inspections; • Efficiency of the diesel generators for power generation 	<ul style="list-style-type: none"> • Evaluate the % land disturbance during the construction of the access road and hydropower plant • Check the number of opportunities created for the productive use of biomass material (especially forest wood) subsequent to land clearance. • Evaluation the fuel consumption by vehicles and machinery used for the earth and track work • Regular equipment and vehicle maintenance plan to avoid a reduction in equipment efficiency over time; • Audits to evaluate if energy efficiency during the procurement of equipment; • Inspection of driver training for mobile equipment operators to minimise fuel consumption; 	Biannual (seasonal) monitoring	<ul style="list-style-type: none"> • EPA

Management Issue	Performance Indicators	Means of Verification	Monitoring Frequency	Responsible Authority/ Party
		<ul style="list-style-type: none"> Vehicles and equipment inspection to check if are used at their optimal / designed capacity (i.e. not overloaded); Assessment of the use energy efficient timetabling to minimise equipment idling and prevent unnecessary trips; and through a program to encourage awareness of energy efficiency amongst personnel. Evaluation of the efficiency of the diesel generators for power generation 		
Hydropeaking	<ul style="list-style-type: none"> A change in fish assemblages within the downstream reach affected by peaking 	<ul style="list-style-type: none"> Fish community assessment for a period of three years during operations 	Biannual (seasonal) monitoring	<ul style="list-style-type: none"> EPA and RREA
Water quality	<ul style="list-style-type: none"> Total Suspended Solids (TSS) or turbidity and any other measures required by aquatic ecologist. TSS or turbidity levels upstream and downstream of instream construction should not vary with more than 20% at any time. 	<ul style="list-style-type: none"> <i>In situ</i> measurement with a turbidity meter, or a TSS analyses from samples analyzed by a laboratory 	Daily measurements during periods of instream construction or during releases of discharge into/near watercourses Monthly measurements above and below the dam during operation	<ul style="list-style-type: none"> EPA
Fish migration and spawning	<ul style="list-style-type: none"> A decrease in the frequency of occurrence of observed species with migration and spawning requirements and a decrease in juvenile fish of migratory species in relation to a control reach or baseline data. 	<ul style="list-style-type: none"> Fish community assessment for a period of three years during operations, at locations upstream of the inundation zone and downstream of the Hydropower Plant release point. The instream habitat at upstream and downstream locations should be similar. The fish assessment should 	Biannual (seasonal) monitoring	<ul style="list-style-type: none"> EPA and RREA

Management Issue	Performance Indicators	Means of Verification	Monitoring Frequency	Responsible Authority/ Party
		determine the ratio between adults and juveniles		
Fish injuries and mortalities	<ul style="list-style-type: none"> The number observed fish with injured or dead immediately downstream of the tailrace 	<ul style="list-style-type: none"> Visual inspection 	Daily during operation for the first year of operations.	<ul style="list-style-type: none"> EPA
Noise management	<ul style="list-style-type: none"> Timing of blasting construction Blasting practices Evidence of hearing protection used by workers Evidence of noise control devices Noise levels (dB) at site, schools and health facilities 	<ul style="list-style-type: none"> Visual and auditory inspections Interviews Blasting records Noise level measurements (Leq, dBA) at construction and blasting sites, as well as receptor, using a standard sound level meter (conforming to class 2 according to IEC 61672-1:2002) (see Appendix 13) 	Weekly inspections monthly noise measurements, or daily in case of non-compliance with World Bank Group Noise Level Guidelines	<ul style="list-style-type: none"> EPA and RREA
Physical cultural resources	<ul style="list-style-type: none"> Number of chance finds Evidence of chance finds procedures 	<ul style="list-style-type: none"> Visual inspections Photographic documentation Interviews 	Weekly inspections	<ul style="list-style-type: none"> EPA and RREA
Occupational health and safety	<ul style="list-style-type: none"> Number of workers trained in safety procedures Percentage of workers using Personal Protective Equipment (PPE) Structural integrity of workers' accommodation and sanitary facilities Access to health services by workers Malaria prevalence rate in workforce HIV/ AIDS prevalence rate in workforce Evidence of emergency preparedness and response plan 	<ul style="list-style-type: none"> Visual inspections Interviews Photographic documentation Incident reports 	Daily monitoring	<ul style="list-style-type: none"> EPA and RREA

Management Issue	Performance Indicators	Means of Verification	Monitoring Frequency	Responsible Authority/ Party
	<ul style="list-style-type: none"> Incident statistics (Total Recordable Injuries, Fatalities, Lost Time Injuries, Restricted Work Case, Medical Treatment Case, First Aid Case, Near Miss, Reports on Unwanted Occurrences) 			
Traffic and transportation safety	<ul style="list-style-type: none"> Evidence of traffic and transportation safety plan Traffic incident rate (including workers, community and livestock) Observed speed of construction vehicles Number of drivers trained and equipped with license Evidence of signing, warnings and controls 	<ul style="list-style-type: none"> Visual inspections Speed checks Photographic documentation Interviews 	Monthly inspections and checks	<ul style="list-style-type: none"> RREA
Security	<ul style="list-style-type: none"> Compliance with Voluntary Principles on Security and Human Rights Evidence of training of security personnel in the use of force and arms Number of security related grievances raised by the communities and workers 	<ul style="list-style-type: none"> Visual inspections Photographic documentation Interviews 	Weekly inspections	<ul style="list-style-type: none"> RREA
Resettlement/Economic displacement	<ul style="list-style-type: none"> Performance indicators to be as identified in the Resettlement Action Plan or Livelihoods Restoration Plan 	<ul style="list-style-type: none"> Verification means to be as identified in the Resettlement Action Plan or Livelihoods Restoration 	To be determined Resettlement Action Plan or Livelihoods Restoration	<ul style="list-style-type: none"> RREA
Labour management	<ul style="list-style-type: none"> Proportion of local population on overall project workforce Proportion of women employees on overall project workforce Evidence of written contracts Number of worker grievances Age of workers 	<ul style="list-style-type: none"> Visual inspections Interviews Employment contracts 	Weekly inspections	<ul style="list-style-type: none"> RREA and Labour Min.

Management Issue	Performance Indicators	Means of Verification	Monitoring Frequency	Responsible Authority/ Party
	<ul style="list-style-type: none"> Quality of workers accommodation Proportion of unskilled workforce that have had their skills upgraded 			
Local procurement	<ul style="list-style-type: none"> Proportion of local suppliers 	<ul style="list-style-type: none"> Supplier contracts 		
On-the-job performance	<ul style="list-style-type: none"> Evidence of operating at expected levels 	<ul style="list-style-type: none"> Performance reviews Training needs assessments Records of training 	Annual review	<ul style="list-style-type: none"> RREA

10

STAKEHOLDER ENGAGEMENT

10.1

INTRODUCTION

This Chapter describes:

- Stakeholder engagement and public consultation conducted prior to and during the ESIA;
- Plan for stakeholder engagement to complete the regulated ESIA process; and
- Plan for stakeholder engagement during project implementation (including the grievance mechanism).

10.2

CONSULTATION OBJECTIVES

Stakeholder consultations to support the ESIA process aims to achieve the following objectives:

- Provide information about the project and its potential impacts to those interested in or affected by the project, and solicit their opinion in this regard;
- Identify additional impacts/issues and possible mitigation measures;
- Verify the significance of the identified environmental, social and health impacts;
- Provide opportunities for stakeholders to discuss their opinions and concerns;
- Better understand the people's practices, perceptions and conditions in the project area;
- Manage expectations and misconceptions regarding the project;
- Inform the process of developing appropriate mitigation measures;
- Provide stakeholders an opportunity to contribute towards identification of mitigation measures and the environmental and social management plan (ESMP); and
- Analyse identified gaps.

10.3**STAKEHOLDER IDENTIFICATION**

The following list of stakeholders was identified for this project:

- Superintendent of Lofa County;
- Commissioners of the districts of Kolahun (including the two newly formed districts of Wanhasse and Lukambeh), Foya and Voinjama;
- Community members of Mbaloma town (the town from which the access road to the Kaiha 2 site will start);
- Community members of all the towns along the transmission line route; and
- Community members of all the towns that will benefit from the power supply and have a transformer installed.

10.4**STAKEHOLDER ENGAGEMENT CONDUCTED****10.4.1*****During Project Development***

Prior to the ESIA, national and international stakeholders were engaged by RREA under the auspices of the Scaling-up Renewable Energy Program (SREP). Stakeholder consultations have been conducted as part of the Environmental and Social Management Framework (ESMF) and Resettlement Policy Framework (RPF) process for the SREP. The minutes from those meetings are included in the respective reports (Earthtime 2015, Multiconsult 2015d).

10.4.2***During the ESIA***

During the ESIA views from stakeholders at all levels (national, local government and residents in the project area), were sought through interviews, group discussions and a number of public meetings. Feedback from these consultations is taken into account in this ESIA. A summary of issues discussed is included in *Section 10.5*.

Mobilisation Strategies

Prior to the site visit, a mobilisation letter was sent from the projects' proponent (RREA) to the Honourable George Dunor (superintendent of Lofa county) to inform him of the Project site visit and request his support and facilitation of the teams' work (Appendix 4). In addition, a Notice of Intent (NoI) was published in two newspapers (The Inquirer and The Observer) for three days between 21 and 25 March 2016, to inform the public of the project (Appendix 5).

Consultation Schedule

In order to include the maximum number of stakeholders within the time of the site visit, group meetings were conducted, where several towns' officials (town chiefs, clan chiefs, chair ladies, youth chiefs) were invited to meet in one location for a common meeting. In addition, a number of public meetings were conducted in a number of towns to get a better idea of the public opinion and concerns regarding the project.

A total of 14 meetings were performed between 15 and 19 March 2016 covering the main stakeholders and local officials of the districts of Kolahun (including the districts of Wanhasse and Lukambeh), Foya and Voinjama and included consultations in 26 towns *Table 9.3* (Table 9.3). An additional 5 meetings were held on 23 and 24 November 2017 to update the district officials on the status of the project. Details of the participants and stakeholders consulted are attached in Appendix 6.

Table 9.3 *Schedule of the Consultation Activities*

Date	Location	Description
15 March 2016	House of the superintendent of Lofa county – Voinjama city	Kick off meeting with the superintendent of Lofa county
15 March 2016	Yandisu – LPMC Camp	Public meeting with the community members of Yandisu – LPMC Camp
15 March 2016	Velezala	Public meeting with the community members and chiefs of Velezala town
15 March 2016	House of commissioner of Kolahun district – Kolba city	Stakeholder meeting with the commissioner and local authorities of Kolahun district
16 March 2016	Bolahun town	Group meeting with the local authorities of the towns of Bolahun, Honayohun, Fangonda, Korworhun, Sosomolahun, Ngahama, Twingihewa, Toingihewa Kimbolahun, and Massambolahun and some community members of Bolahun town.
16 March 2016	Lehuma town	Group meeting with the local authorities of the towns of Bondowalahun #1, Bondowalahun #2, Kimbalahun #2, Kpengbelahun, Lehuma, Lukasu, Manena, Mbaloma, Pasolahun and some community members of Lehuma Town and the elder chiefs of the newly created Wanhasse and Lukambeh districts.
16 March 2016	Lukasu town	Public meeting with the community members and local authorities of Lukasu town
17 March 2016	City Hall of Foya city	Group meeting with the commissioner of Foya district and chiefs of several towns and quarts in Foya district
17 March 2016	Mbabahun town	Public meeting with the community members and local authorities of Mbabahun town
17 March 2016	Porlowu town	Public meeting with the community members of Porlowu Town
17 March 2016	Kambolahun town	Public meeting with the community members and local authorities of Kambolahun town

Date	Location	Description
18 March 2016	Mbaloma town	Public meeting with the community members and local authorities of Mbaloma town
18 March 2016	Johnny's Town	Public meeting with the community members and local authorities of Johnny's Town
19 March 2016	Superintendent Head Quarters	Stakeholder meeting with the commissioner and local authorities of Voinjama district
23 November 2017	Superintendent Head Quarters	Stakeholder meeting with the local authorities of Voinjama district
23 November 2017	Kolahun City Corporation	Stakeholder meeting with the Acting Commissioner of Kolahun District and Mayor and Local Authorities of Kolahun City
23 November 2017	Foya Commissioner House	Stakeholder meeting with the Commissioner and Local Authorities of Foya District
24 November 2017	Mbaloma Town	Public meeting with the community members and local authorities of Mbaloma town
24 November 2017	Bondowalahun #1 Town	Public meeting with the community members and local authorities of Bondowalahun #1 Town

Participation and Consultation Methods

Each consultation meeting included a presentation by the ESIA team to introduce the project and provide a brief description of the project component and location, the steps undertaken to assess and finalise the location, the towns that might benefit from the power supply and the probable environmental and social impacts arising from project activities. A brochure (Appendix 8) was also distributed during the meetings to provide the attendees with a better understanding of the project. The presentation was followed by an open discussion to note the opinions and concerns that the communities may have regarding the project. All communication at the meetings was translated into local dialects to ensure that all the attendees were well informed. Minutes of the meetings held are attached in Appendix 7.

10.4.3 *Summary of Issues Raised*

The main issues raised during the consultation meetings are summarised in Table 9.4.

In general, the main reaction of the stakeholders was positive in terms of the development that can take place in these areas, if implemented. Specific issues are included in the meeting minutes in Appendix 7.

Table 9.4 *Main Issues Raised during Stakeholder Engagement*

Stakeholder Concerns and Questions	Summary of Discussion
Political setup and district divisions	<ul style="list-style-type: none"> The new political setup of splitting Kolahun district into 3 districts (Kohalun, Lukambeh and Wanhasse) changes the host of the Kaiha 2 location from Kolahun district to Lukambeh district.

Procedures and compensation of structures, crops and cultural sites along the transmission line route	<ul style="list-style-type: none"> • Several requests were raised regarding the connection of the centre of Lukambah district (Pasolahun town) and a few other towns to the transmission grid. • The transmission line will be routed along the road right of way (RoW) to reduce and avoid resettlement costs that will increase the cost of the project and reduce its feasibility. • Structures or crops within the RoW are entitled for compensation within the framework of the requirements of the Project's funders.. • The transmission line route will be carefully selected to avoid crossing existing structures. • If structures are within the RoW and in close proximity to the main road, the transmission line route will be diverted as much as possible by bypassing the towns to avoid crossing structures, thus avoiding resettlement. • With the absence of a formal local compensation system that can be applied to all the towns, discussions and agreements with the communities will take place to provide a fair compensation in cases where the transmission line crosses a cocoa/coffee garden or other permanent crops. • If the transmission line crosses a temporary crop, the towns will be notified ahead of time and the project will wait for the crops to be harvested before using the land. • The transmission line routing will aim to avoid any traditional and cultural sites. However, if any project component is required to cross through any such sites, negotiations with local communities will take place to reach an agreement. • In general, communities expressed their willingness to negotiate and even to provide some land without compensation for the benefit of the project and the development it will bring to the area.
Employment opportunities and gender equality during project phases	<ul style="list-style-type: none"> • Skilled and semi-skilled workers from the local community will be hired where and when possible during the construction phase. Gender equality will be promoted where the skills required are available. • Requests were made for the project to train local labour to be able to work on the project during the operational phase as well. • Another suggestion was made requesting the local authorities to implement a capacity building program for students from the communities to increase the potential for employment during the operations phase.
On what basis was the location and the beneficiaries of the power project chosen	<ul style="list-style-type: none"> • The location of the hydropower plant was chosen based on a pre- feasibility study that favoured Kaiha 2 over the other two potential sites. • The transmission line route was chosen to ensure the feasibility of the project by supplying the three major towns/cities in the area (Kolahun, Foya and Voinjama). The design also attempts to benefit as many towns along the route as possible. • Supplying power to additional towns which are further away from the will increase the cost of the project and the cost of the supplied electricity and reduce the project feasibility.
What is the cost of the power and who will pay for it?	<ul style="list-style-type: none"> • The power will not be supplied for free and the receivers will be paying for the electricity they will use. • The cost of the power is not determined yet but will be lower than the cost of electricity from diesel generators.
Expected timeline of the project	<ul style="list-style-type: none"> • The feasibility study and environmental assessment is currently being conducted and will need approximately three months to be concluded.

	<ul style="list-style-type: none"> • Once completed, the project owner will be looking for donors to fund the implementation. A few donors expressed interest in funding the project. • Once funding is secured, the project will start with the construction phase taking approximately two years. During this period, power will not be available but there would be some other benefits such as employment opportunities. • After the construction phase is completed, the operation phase will start and power will be generated and distributed. • The operation phase does not have a specific timeline and the hydropower plant will be operating as long as it is maintained properly.
Location of the Base Camp and other construction camps during the project construction Phase	<ul style="list-style-type: none"> • This had not been finalised at the time of engagement. • This will be decided during the design phase and communicated to communities prior to commencement of project.

10.5 *PLANNED STAKEHOLDER ENGAGEMENT*

This section presents the stakeholder engagement plan for the Project to be used during the execution of the proposed Project to ensure that all stakeholders are meaningfully involved and informed about the project activities, stakeholder opinions are received, incorporated and feedback is given promptly.

Objectives of the stakeholder engagement plan are as follows:

- To offer opportunities for stakeholders to raise their concerns and submit their opinions;
- To create avenues for complaints handling and grievance management;
- To create opportunities for information sharing and disclosure;
- To create a mechanism for giving feedback to the stakeholders;
- To create an avenue for participatory project impacts monitoring;
- To foster strong project community relationships; and
- To promote social acceptability of the project.

10.5.1 *Project Stakeholders*

The key stakeholders for this project were identified during the preparation of the ESIA.

10.5.2 *Stakeholder Engagement Strategies*

Regular Reporting

RREA will submit periodic reports to the relevant government agencies at central and local level. The reporting schedule will be defined by the regulatory bodies.

Public Consultations

In addition to the consultation meetings conducted as part of the ESIA process, the company will carry out another round of public consultations when the project has been approved and ready for implementation. The purpose of these meetings will be information sharing and participatory planning.

Community Mobilisation

Communities will be mobilised prior to commencement of construction activities for purposes of preparing them for the construction phase and its associated impacts. Communities will also be mobilised prior to commissioning for purposes of creating awareness about the safety precautions particularly for those in close proximity to the Project infrastructure.

Targeted Consultations

RREA's Environmental and Social Management Team will organise in-depth interviews, focus group discussions with key informants, socio-economic surveys and planning meetings with the relevant stakeholders.

The frequency of the consultations will depend on the demand for stakeholder input or on regulated feedback schedules. One of the groups that will be consulted prior to, and during the construction period, are the fishermen who occasionally set fish traps near the waterfall and other parts of the river.

Feedback

As and when found necessary, all stakeholders including the affected communities will be given feedback directly by the company's Environmental and Social Management Team. Such circumstances will include complaints handling and mitigation management planning.

Incorporation of Proceedings into Management Decisions

The results from the consultation and information sharing meetings will be used as input into management decisions. The views of the target groups will be used as basis upon which interventions will be designed and implemented. The views and opinions expressed by women and other special interest groups will be incorporated in the design of intervention strategies targeting them.

The detailed schedule of the stakeholder engagement activities shall be developed by the company's Environmental and Social Management Unit when the project has been approved and the organisation has been staffed and equipped with resources.

10.5.3

Grievance Mechanism

The Project-induced risks and impacts need to be carefully managed to avoid unnecessary tensions and conflicts. A grievance mechanism in line with lender requirements will therefore be established to ensure that complaints are recorded and resolved. The scope of the grievance mechanism includes project-related issues affecting the community and other external stakeholders, as well as cases involving workers and occupational health and safety where workers feel that the internal procedures of the contractors are not sufficient. It will be the responsibility of RREA to ensure that the grievance mechanism functions properly and is respected by all parties including contractors and any other project service providers.

The communities already have their own community-based systems for grievance redress. It is therefore proposed that, wherever possible, the project related grievances should be resolved through the existing community-based systems for grievance resolution. However, not all cases will be resolved within the traditional system, so other higher authorities have been proposed to follow up on the unresolved cases. The judicial system will be used as a last resort.

People with grievances will be expected to submit their grievances formally, either in writing on standard forms to the company's Environmental and Social Management Team, or through their town chief, city mayor, clan chief, or sub-clan chief, as appropriate. The received complaints will be registered in the company's database and then forwarded to the relevant office/officer.

The case will be investigated and a fact-finding mission may be organised together with the complainant and/or with the concerned chiefs as witnesses. Proposals on how the grievance can be resolved will be discussed, and the complainant will be advised accordingly. Once accepted by the complainant and the actual implementation of the remedy actions, the complaint will be signed off as resolved.

REFERENCES

The key documents referenced in the ESIA are the following:

- Multiconsult. 2016. Pre-feasibility studies of selected mini hydropower projects in Liberia: Kaiha 2 Hydropower Plant feasibility report. Norwegian Water Resources and Energy Directorate. 1 September 2016.
- Earthtime. 2015. Environment and Social Management Framework for Scaling-up Renewable Energy Program (SREP). Final Report, October 2015. RREA, Monrovia, Liberia.
- Multiconsult and Earthtime, 2016, Kaiha 2 Hydropower Plant and Transmission Grid, Environmental and Social Impact Assessment, Final Report, 25 October 2016

The following are other references:

Bain, M.B. 2007. Hydropower Operations and Environmental Conservation: St. Marys River, Ontario and Michigan. Project Report. International Lake Superior Board of Control.

BirdLife International. 2015. IUCN Red List for Birds. www.birdlife.org.
Cooper, G.P. and Record, S.J. 1931. The evergreen forests of Liberia. Yale University School of Forestry Bull. 31.

Creighton G., Borden, R. and White, S. 1974. "Preliminary Report on an Archaeological Survey of Liberia". *Liberian Studies Journal* 5(2): 87-105.

Creighton, G. 1976. "Microlithic Occurrences in the Republic of Liberia." *West African Journal of Archaeology* 6: 21-35.

Demey, R. 2007. Rapid survey of the birds of North Lorma, Gola and Grebo National Forests. In: Hoke, P., Demey, R. and Peal, A. (eds.). 2007. A rapid biological assessment of North Lorma, Gola and Grebo National Forests, Liberia. RAP Bulletin of Biological Assessment 44. Conservation International, Arlington, VA, USA.

EIA (US Energy Information Administration). 2015. How much carbon dioxide is produced per kilowatthour when generating electricity with fossil fuels? <https://www.eia.gov/tools/faqs/faq.cfm?id=74&t=11>. Downloaded on March 30, 2015.

EPA (Environmental Protection Agency). 2006. Environmental Impact Assessment Procedural Guidelines.

Fermon Y. and Gsegner, C. 2006. A Guide of the Freshwater Fishes of the Bong County, St Paul and St John rivers, Liberia.

Gatter, W. 1997. Birds of Liberia. Pica Press. Robertsbridge.

Gatter, W. 1984. For Future Natural Forests and Plantation Management in Liberia. Observation – Considerations – Results. German Forestry Mission Papers. 55 pp. Forestry Development Authority, Monrovia.

GLM Engineering. 2017. Sediment management at the Proposed Kaiha 2 Hydropower Project, Mano River Basin, Liberia. Project ID P149683. RREA, Monrovia, Liberia.

GoL (Government of Liberia). 2014. Water, Sanitation & Hygiene (WASH) Sector Performance Report 2013.

Grunthal, G., Bosse, C., Sellami, S. and Mayer-Rosa, D. 1992. Compilation of the GSHAP Regional Seismic Hazard for Europe, Africa and Middle East. GSHAP (Global Seismic Hazard Assessment Program).

Hillers, A. and Rödel, M-O. 2007. The amphibians of three national forests in Liberia, West Africa.

Historical Preservation Society of Liberia (HPSOL). 2018. “Architectural History of Liberia”. *Historical Preservation Society of Liberia*. Online article accessed on 2 May 2018 at <http://www.hpsol-liberia.net/>

Hoke, P., Demey, R. and Peal, A. (eds.). 2007. A rapid biological assessment of North Lorma, Gola and Grebo National Forests, Liberia. RAP Bulletin of Biological Assessment 44. Conservation International, Arlington, VA, USA.

Hugueny, B. 1989. West African rivers as biogeographic islands: species richness of fish communities.

Oecologia 79: 236-243.

IED. 2016a. Pre-feasibility Study of MW-Sized Hybrid Isolated Minigrids in Lofa County, Liberia Including Preliminary Design of Generation Facilities and Mini-Grids. Task 1 Report: Demand Estimates. Revised Version. February 2016. RREA, Monrovia, Liberia.

IED. 2016b. Pre-feasibility Study of MW-Sized Hybrid Isolated Minigrids in Lofa County, Liberia Including Preliminary Design of Generation Facilities and Mini-Grids. Task 4 Report: Analysis of Feasibility (at Prefeasibility Level). March 2016. RREA, Monrovia, Liberia.

IED. 2016c. Pre-feasibility study of MW-sized hybrid isolated mini-grids in Lofa County, Liberia. Task 3 Report: Engineering design and capital cost estimate March 2016. IED internal ref. IED: 2015/014/LIBERIA MINI-GRID. RREA, Monrovia, Liberia.

IPCC 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan.

IRD, Paris, MRAC, Tervuren. 2 vols., 1272 pp.

IUCN Red List of Threatened Species. 2015. Version 2015-4.

www.iucnredlist.org. Downloaded on May 2, 2016.

LEC. 2016. Addendum to the Resettlement Action Plan for Mt. Coffee – Paynesville Transmission Line Route. January 2016.

LISGRIS. 2009. 2008 Population and Housing Census: Final Results. Liberia Institute of Statistics and Geo- Information System, Republic of Liberia, 2009. LISGIS, Ministry of Health and Social Welfare, National AIDS Control Program and ICF International. 2014. Liberia Demographic and Health Survey 2013. Liberia Institute of Statistics and Geo-Information Services (LISGIS) and ICF International. Monrovia, Liberia.

Little, K.L. 1949. "The Role of the Secret Society in Cultural Specialization". *American Anthropologist* 51: 199-212.

Luiselli, L., Politano, E. and Lea, J. 2006. *Kinixys homeana*. The IUCN Red List of Threatened Species 2006: e.T11003A3238276. <http://dx.doi.org/10.2305/IUCN.UK.2006.RLTS.T11003A3238276.en>.

Multiconsult. 2015a. Pre-feasibility studies of selected mini hydropower projects in Liberia: Kaiha 2 Hydropower Plant prefeasibility report. Norwegian Water Resources and Energy Directorate. 20 July 2015.

Multiconsult. 2015b. Pre-feasibility studies of selected mini hydropower projects in Liberia: Kaiha 1 Hydropower Plant prefeasibility report. Norwegian Water Resources and Energy Directorate. 20 July 2015.

Multiconsult. 2015c. Pre-feasibility studies of selected mini hydropower projects in Liberia: Makona reconnaissance study report. Norwegian Water Resources and Energy Directorate. 20 July 2015.

Multiconsult. 2015d. Resettlement Policy Framework for Scaling-up Renewable Energy Program (SREP).

- Namubiru-Mwaura, E. L., Knox A. and Hughes, A. 2011. Customary Land Tenure in Liberia: Findings and Implications Drawn From 11 Case Studies. Liberia Land Policy & Institutional Support (LPIS) Project. November 2011. USAID Liberia.
- NRECA international. 2017. Kaiha 2 Diesel Power Plant. Proposed location at Old LEC s/s in Voinjama, Lofa County. Presentation.
- Olukoju, Ayodeji. 2006. *Culture and Customs of Liberia*. Greenwood Publishing Group. Westport, Connecticut, USA.
- Orr, K.G. 1972. "An Introduction to the Archaeology of Liberia". *Liberian Studies Journal*. 4(1): 55-79
- Osborne , P.L. 2012. Rivers, Flood plains and Estuaries: The River Continuum and Flood Pulse Concept.
- Owadi, B., Kendle, A. and Koiwu, T. 2010. The State of Food and Nutrition Security. October 2010. Ministry of Agriculture and World Food Programme, VAM Food Security Analysis. Monrovia, Liberia.
- Paugy, D., Leveque, C. and Teugels, G.G. 2004. Poissons d’eaux douces et saumâtres de l’Afrique de l’Ouest.
- Payne, A.I., Wakeford, R. and Ndomahina, E.T. 2006. Bumbuna Hydroelectric Project Baseline Biodiversity Surveys. Final Draft Baseline Fish Survey. Nippon Koel U.K.
- Robbins, Stephen P. and Judge, Timothy A. and Millett, Bruce and Waters-Marsh, Terry Published by Pearson Education Australia (2008)
- RREA. 2015. Resettlement Policy Framework for Scaling-Up Renewable Energy Program. LEC/Multiconsult, October 2015.
- Robertson, P. 2001. Liberia. In: Fishpool, L.C.D. and Evans, M.I. (eds). Important Bird Areas in Africa and Associated Islands: Priority Sites for Conservation. Pisces Publications and Birdlife International, Newbury and Cambridge, UK. Pp. 473-480.
- Rödel, M.O. and Ernst, R. 2004. Measuring and monitoring amphibian diversity in tropical forests. I. An evaluation of methods with recommendations for standardization. *Ecotropica* 10: 1-14.
- RoL (Republic of Liberia). 2007. Liberia Market Review (LMR). Conducted December 2006–February 2007.

Ministry of Agriculture, WFP, FAO, University of Liberia. Monrovia, July 2007
Schjøtz, A. 1999. *The Treefrogs of Africa*. Chimaira, Frankfurt.

Shirley, M.H. 2014. *Mecistops cataphractus*. The IUCN Red List of Threatened Species 2014: e.T5660A3044332. <http://dx.doi.org/10.2305/IUCN.UK.2014-1.RLTS.T5660A3044332.en>.
Downloaded on May 8, 2016.

Scerri, E. 2017. "The Stone Age Archaeology of West Africa." *Oxford Research Encyclopedia of African History*. Online article accessed on 27 April 2018 at <http://www.africanhistory.oxfordre.com>

Stattersfield, A.L., Crosby, M.J., Long, J.A. and Wege, D.C. 1998. *Endemic Bird Areas of the World: Priorities for Biodiversity Conservation*. BirdLife International Publication No. 7. 1998.

Taylor, E.H. and Weyer, D. 1958. Report on a Collection of Amphibians and Reptiles from Harbel, Republic of Liberia in "The University of Kansas Science Bulletin - Vol. XXXVIII, Part II, No. 14".

Tysdal, R.G. and Thorman, C.H. 1983, *Geological Map of Liberia*. Scale 1:1,000,000. U.S. Geological Survey and Liberian Geological Survey.

UNDP (United Nations Development Program). 2006. *First State of the Environment Report for Liberia*.
Monrovia, Liberia.

White, F. 1983. *The Vegetation of Africa*. UNESCO, Paris