Draft Report Environmental and Social Impact Assessment (ESIA)
Symbion Power Lake Kivu Ltd Project, Rwanda

Acronyms and Abbreviations

AIDS:	*Acquired Immune Deficiency Syndrome*
APELAC:	*Association des pécheurs du Lac*
API:	*American Petroleum Institute*
ASPR:	*Average Score per Taxon*
BELSPO:	*Belgium Science Policy*
BID:	*Background Information Document*
BP:	*Bank Procedures*
CESMP:	*Contractor Environmental and Social Management Plan*
CH_4:	*Methane gas*
CLO:	*Community Liaison Officer*
CO:	*Carbon Monoxide*
CO_2:	*Carbone Dioxide*
CSR:	*Corporate Social Responsibility*
DDP:	*District Development Plan*
DRC:	*Democratic Republic of Congo*
EA:	*Environmental Assessment*
EAS:	*East African Standards*
EAGLES:	*East African Great Lakes Ecosystem Sensitivity*
EAWAG:	*Swiss Federal Institute for Environmental Science and Technology*
ED&P:	*Green and Clean Solutions*
EDCL:	*Energy Development Corporation Ltd*
EDPRS:	*Economic Development and Poverty Reduction Strategy*
EIA:	*Environmental Impact Assessment*
EICV3:	*Integrated Households Living Conditions Survey*
EMMP:	*Environmental Mitigation and Monitoring Plan*
EMP:	*Environmental Management Plan*
ERP:	*Emergency Response Plan*
ESIA:	*Environmental and Social Impact Assessment*
ESMP:	*Environmental and Social Management Plan*
EU:	*European Union*
EUCL:	*Energy Utilities Corporation Ltd*
EWSA:	*Energy, Water and Sanitation Corporation*
FRSS:	*Free Standing Riser and Separator System*
GDP:	*Gross Domestic Product*
GEF:	*Gas Extraction Facility (GEF)*
GHGs:	*Green House Gases*
GNP:	*Gross National Product*
GoR:	*Government of Rwanda*
GSHAP:	*Global Seismic Hazard Assessment Program*
H_2S:	*Hydrogen Sulfide*
HDEP:	*High Density Polyethylene*
HFO:	*Heavy Fuel Oil*

HIV:	*Human Immune Deficiency Virus*
HV:	*High Voltage*
I&AP:	*Interested and Affected People*
IFC:	*International Finance Corporation*
IKS:	*Indigenous Knowledge System*
ISO:	*International Organization for Standardization*
IUCN:	*International Union for Conservation of Nature*
IZ:	*Intermediate Zone*
KP1:	*Kibuye Power 1*
LKMP:	*Lake Kivu Monitoring Programme*
LPG:	*Liquefied Petroleum Gas*
LRZ:	*Lower Resource Zone*
MINAGRI:	*Ministry of Agriculture*
MINECOFIN:	*Ministry of Planning and Finance*
MININFRA:	*Ministry of Infrastructure*
MINIRENA:	*Ministry of Lands, Environment, Forests, Water and Mines*
MPs:	*Management Prescriptions*
MTR:	*Mandatory Technical Requirement*
MW:	*Megawatts*
NAFA:	*National Forest Authority*
NGO:	*Non-governmental Organization*
NISR:	*National Institute of Statistics of Rwanda*
NO_2:	*Nitrogen Dioxide*
O&M:	*Operation and Maintenance*
O_2:	*Oxygen*
OP:	*Operational Policies*
OPGW:	*Optical Ground Wire*
OHSP:	*Occupational Health and Safety Program*
PCDP:	*Public Consultation and Disclosure Plan*
PFD:	*Process Flow Diagram*
PGA:	*Peak Ground Acceleration*
PLC:	*Programmable Logic Controller*
PPA:	*Power Purchase Agreement*
PPE:	*Personal Protective Equipment*
PRZ:	*Potential Resource Zone*
PS:	*Performance standards*
PVMTI:	*Photovoltaic Market Transformation Initiative*
RDB:	*Rwanda Development Board*
REC:	*Rwanda Energy Company*
REG:	*Rwanda Energy Group*
REMA:	*Rwanda Environment Management Authority*

rWFD:	*Revised Waste Framework Directive*
RNRA:	*Rwanda Natural Resources Authority*
RURA:	*Rwanda Utilities Regulatory Authority*
RWF:	*Rwandese Francs*
RZ:	*Resource Zone*
SEO:	*Site Environmental Officer*
SEP:	*Stakeholder Engagement Plan*
SINELAC:	*Société Internationale d'Electricité des Pays des Grands Lacs*
SO_2:	*Sulphur Dioxide*
SOCIGAZ:	*Société Commerciale et Industrielle du Gaz Méthane du Lac Kivu*
SPLKL:	*Symbion Power Lake Kivu Ltd*
STD:	*Sexually Transmitted Diseases*
TMP:	*Traffic Management Plan*
TSP:	*Total Suspended Particulate*
TSS:	*Total Suspended Solids*
UNCCD:	*United Nations Conventions to Combat Desrtification*
UNDP:	*United Nations Development Programme*
UNEP:	*United Nations Environment Programme*
US:	*United States*
USD:	*United States Dollars*
WASAC:	*Water and Sanitation Corporation*
WB:	*World Bank*
WHO:	*World Health Organization*

Units of Measurements

dB:	*Decibels*
GWh:	*Gig watt-hours*
kJ:	*Kilojoules*
KM^2:	*Square Kilometers*
kPa:	*Kilo Pascal*
kV:	*kilovolts*
KW:	*Kilowatts*
M^2:	*Square Meters*
M^3:	*Cubic Meters*
MJ:	*Mega joule*
NM^3:	*Normal Cubic Meters*
M:	*Meters*
MW:	*Megawatts*
RPM:	*Revolutions Per Minute*

Table of Contents

List of tables

List of figures

List of plates

Executive Summary

Introduction

Symbion Power a US Energy Company that has energy investments in various countries contracted Eco Design & Protection Ltd (ED&P) through Symbion Power Lake Kivu (SPLKL) Ltd, their wholly owned subsidiary to undertake an Environmental and Social Impact Assessment (ESIA) for the proposed project of ***Extraction of Gas and Electric Power Production Plant in the Rubavu District of the Western Province.***

Objective of the Study

The objective of this study was to evaluate the environmental and social impacts of all works related to extraction of gas and production of electric power from Lake Kivu, in the Rubavu District of the Western province. The study has considered the construction, operation and decommissioning phases of onshore and offshore project facilities.

Legal and Institutional Framework

Rwanda has recently taken significant steps towards promoting and developing the energy sector, under clear political commitment to three complementary sets of targets: The Economic Development and Poverty Reduction Strategy (2012), Millennium Development Goals (2015), and Vision 2020. In this context, significant strides have been made with respect to developing gas exploitation in Lake Kivu for power generation.

For instance, strong energy sector institutions with adequate capacity such as the Rwanda Energy Group (REG) have been established with a view to meeting ambitious growth targets. An effective energy information system has also been established and capacity building provided to all sector institutions to undertake implement their roles and responsibilities in the promotion of the water and energy sectors. The objective of Rwanda's electricity strategy is to increase access to modern energy and to meet the ever-increasing power demand for economic development of the nation.

In so achieving, the institutional and legal frameworks have been reinforced. Clear provisions and integrated mechanisms that foster the energy sector whilst avoiding environmental damage have been put in place. The new Constitution of the Republic of Rwanda of 25th December 2015, as amended to date constitutes the basis for the legal framework for the protection and safeguarding of the water, energy and agricultural sector in Rwanda. Moreover, in Rwanda, management of the energy sector is shared by several ministries, decentralized organs (Districts) as well as various public institutions.

The policy sets out institutional and legal reforms with a view to providing the country with a coherent and harmonious framework for coordination of sectoral and crosscutting policies. It calls for the establishment of the Rwanda Environment Management Authority (REMA) and the provincial, district and lower level committees responsible for environmental protection. The policy recognizes that the environment is a new concern in Rwanda, requiring awareness and coordination of actions at various levels.

The main institutions with responsibility for the environment are the Ministry of Natural Resources (MINIRENA) and the Rwanda Environmental Management Authority (REMA), the latter of which was established in 2005.

As the Project is to be implemented with support of International Finance Institutions, the requirements are such that IFC Performance Standards (PS) will need to be met. The IFC Performance Standards are the key documents through which the IFC manage the quality and level of assessment required for the Projects, which they finance. Four performance standards will be triggered by the project. We have mentioned and analysed:

Performance Standard 1 covers several types of Environmental Assessment instruments, including ESIAs

Performance Standard 3: Resource Efficiency and Pollution Prevention, aims to avoid or minimize adverse impacts on human health and the environment

Baseline Assessment

The Symbion Power Lake Kivu Ltd project facilities will be erected in Rubavu District while the barges will be operated at 5 to 7km from lakeshores. Rubavu has an equatorial climate, altitude average. Gas will be extracted from a lake with specific characteristics on water quality. The physicochemical parameters measured with the exception of TDS are within the range recommended for a normal aquatic habitat. Mean temperature readings recorded were in the range of 8 to 30oC to which fish in the tropics is adapted. Transparency tends to increase during the dry season as a consequence of different degrees of light penetration. Conductivity is higher in dry season. The mean seasonal total alkalinity recorded is high. Oxygen levels recorded is above the limit of 5mg/l recommended by WHO for fish. Important, the salinity level is not critical for fresh water fish species. Geologically, the site project is occupied by metasedimentary sequence of Mesoproterozoic age consisting of Gishwati complex comprising micaschists with muscovite and biotite and metaquartzites with chlorite and biotite, as well as small pegmatitic granitic inclusions and doleritic sills.

On seismic point of view, the project site is located in a seismically active zone with weak to medium seismic intensity (7).

It would be desirable to take into account all the seismic parameters required during the construction of project infrastructures.

Rubavu is one of the areas from which onshore and offshore facilities can be located for the exploitation of Lake Kivu gas.

In Kivu it's the methane, rather than the carbon dioxide, that's most likely to trigger a gas eruption. That adds urgency to the prospect of harnessing its energy potential, something Rwanda has long sought to do

Agriculture has for a long time been a core sector of economy in terms of its contribution to domestic income and employment. Even agriculture through its chare in total GDP, agriculture remains important because it provides the basis for growth in other sectors such as manufacturing and services. Being the largest employer, the majority of women in Rubavu district is employed in agriculture as primary producers and contributes 29.3percent of agriculture production against 45.7 at national level.

The primary sources of energy used for lighting by households were categorized as follows: electricity, oil, lamp, firewood, candle, lantern, battery, and other unspecified sources.

In Rubavu district, 21% of households use electricity as their main source of lighting, ranking the district first in Western Provence. Other infrastructures such as road, schools, health centres, water supply and sanitation are in poor condition and need improvement to sustain the livelihoods of the population.
Lake Kivu is a sensitive ecosystem that needs to be degassed, monitored and protected from any instability. As desirable as the project seems for both economic and safety reasons, however, it could pose environmental risks of its own—including the chance that the degassing operations could change the structure and properties of the lake.

Project Description

The Project consists of extracting gas dissolved within a deep layer of water in Lake Kivu and processing it to remove water and other gases so as to concentrate the methane content until it is suitable for supplying gas- fired generators to produce electricity. The Gas Plant will have both offshore and onshore installations, connected via submerged pipelines. The Power Plant will be comprised of generators as well as step-up transformers to transfer electricity to the Rwandan 220 kV grid.
The basic processes and technologies proposed for this Project are similar to those used elsewhere in the world on offshore gas processing and power generation projects. Symbion and its contractors have taken these basic concepts and optimized them for this specific and unique Lake Kivu gas deposit.

Project Area

Symbion Power Lake Kivu Ltd (SPLKL) was granted a concession to extract and process methane gas for power energy. The concession area marked concession area 2 is in Bwishura Sector, the south of Rubavu.
After comparing with some other sites, the peninsula near Busoro, was chosen as the preferred site for the gas plant and the power plant. The area is flat enough to construct the Onshore Gas Plant, the Power Plant and the Substation. The centre of the Onshore Gas Plant will be located at 1°45'31.95"S, 29°16'35.69"E, which is approximately 10 km south of Rubavu. The GoR has availed 4.08 hectares of land for the onshore installations after expropriation and compensation of 31households loosing land and properties among whom 4 will lose houses.
While the gas plant, gas power plant and substation will be constructed at the peninsula near Busoro, an existing jetty known, as Kitraco will be upgraded to facilitate barges construction. The site is about 2.5 km south of Rubavu.
Methane gas will be extracted from Lake Kivu and processed in project facilities surrounding the Lake. The Symbion Power Lake Kivu Ltd project facilities will include: a gas extraction and treating facility located on floating platforms (barges) in the deep waters of the lake, an onshore gas receiving facility, and a submerged, floating pipeline to transport the fuel gas ashore from each barge.

Project Alternatives

The study assessed potential project alternatives including:

- *Alternatives source of energy such as hydropower, solar power, wind power, and oil technology with capacity to achieve the same goal,*
- *Alternative technology based on physical arrangement, gas liquid separation process, CO2 content in fuel gas, number of barges, gas lift vs water jets and onshore and offshore split,*

- *Alternative site, and*
- *A "no project" alternative,*

In this study, the alternatives to developing Symbion Power Lake Kivu Ltd are analyzed. The considered alternatives would generate the (up to) 50 MW to be provided by Symbion Power Lake Kivu Ltd project in a comparable time frame and with equivalent economic benefits.
Other alternatives would have a long-term significant effect on the economy and the people of Rwanda. Rwanda's generation alternatives for the next 20 years include:

- *Wind-generated electricity;*
- *Geothermal electricity;*
- *Solar-generated electricity;*
- *Small scale hydroelectric development;*
- *Co-generation facilities;*
- *Biomass-generated electricity;*
- *Thermal power plants;*
- *Large scale hydroelectric development; and,*
- *Demand management measures which reduce the need for the above-noted types of projects and bring more efficiency to the national system.*

It should be noted that wind, solar, small-scale hydroelectric development, Co-generation facilities and demand management measures are not a practical alternative in terms of power plant generation capacity.

Project environmental and socal impacts

Positive Impacts

The Symbion Power Lake Kivu Ltd project would generate a number of economic and developmental benefits at both the national macroeconomic level and the local level. The GoR expects these benefits to majorly contribute to its goal of national poverty eradication. Specifically, the project is expected to benefit Rwanda's economy by:

- *Reducing electricity rationing and the associated costs of alternative self-generation;*
- *Creating conditions necessary to attract foreign direct investment to Rwanda;*
- *Increasing productivity and lowering operating costs of the Government, educational institutions, healthcare facilities, businesses and industry;*
- *Facilitating rural electrification; and,*
- *Minimizing the cost of electricity for consumers.*

The project is also expected to help reduce noise and air emissions generated by the numerous small generators that are currently used to provide electricity during blackout periods.
The local economic benefits of the project are those expected to accrue to employees and the wider community, including the indirect benefits expected from income-generating activities facilitated by the Symbion Power Lake Kivu Ltd project. These expected economic benefits include:

- *Direct employment of Rwandese during the construction and operations phases;*
- *Increased trade in service industries, particularly during the gas extraction and the power plant construction period; and,*
- *Benefits from indirect employment and trade from industries and commercial activities established as a result of the greater availability of electricity;*
- *Improved road access in the Rubavu District and towards onshore installations.*

Adverse Impacts

Adverse impacts to the biophysical and social environment may be experienced during the construction, operation and decommissioning phases of the project. The negative impacts identified include:

-Disturbance of geology and soil with the construction of the gas and power plant

-Groundwater and surface water contamination especially the Lake Kivu to be touched by the onshore and offshore installations.

-Noise emissions especially from the onshore site and affecting the communities in the surroundings

-Noise and vibrations affecting populations living in the surroundings of the project site and employees operating within the project premises

-Disturbance of flora and fauna including the aquatic ecosystem of Lake Kivu

-Displacement as the developer acquires the land and the access road to the site is constructed.

-Gas exploitation and depletion, requiring compliance with Management Prescription for Lake Kivu gas exploitation

-Handling storage and disposal of hazardous material, and

-Lake Kivu ecosystem and stability

Mitigation measures

In respect of potential impacts by technical equipment, working conditions, operation methods, handling of hazardous substances etc. on Lake Kivu stability and ecosystem, management of CO2, health, safety and environment, the contractor has to comply with different national regulations from his guest country as well as from the donating organizations. There is the necessity and it is within the scope of this report to deal with these regulations here again, which should be, by the way, always consistent. Therefore, the statements concerning these aspects present details.

In order the project to be implemented appropriate mitigation measures for each impact are proposed. It is indicated how the impacts are to be monitored, at which frequency and what are the responsibilities of each and every stakeholder. The mitigation measures include:

- *Landowners should be assisted in their efforts to retain their livelihoods and standards of living. It may therefore be necessary to offer landowners support in the event of displacement.*
- *Precautions should be taken to prevent spills, and all workers should be trained in the proper handling, storage, and disposal of hazardous or toxic materials;*

- *Preferred noise levels as per IFC Standards should be 70 decibels during and nighttime in order to reduce negative impacts on surroundings especially during sleeping hours.*
- *Symbion Power Lake Kivu Ltd should undertake a revegetation program to restore the vegetation felled during the project development*
- *SO2 emissions will be controlled by limiting the sulfur content of the fuel gas;*
- *NOx emissions will be controlled through burner management and water injection.*
- *The pipeline should not be situated on lakebed where such failure in the pipeline may trigger spontaneous water degassing at the lake surface.*
- *The management of the amount of carbon dioxide in the lake must balance the need to remove it for safety reasons with the need to maintain sufficient concentrations for sustaining lake stratification and gas lift forces for extraction operations.*
- *The degassed water must be re-injected and remain at the lower margin of the main density gradient (at -270 m in 2004). Meeting this objective will involve controlling the degassed water density through its CO_2 content (minimum 50 % removal), and sizing the plant to avoid short-circuiting between the re-injection and extraction points*
- *The developer will assure a very close follow up for monitoring of Lake Kivu stability*
- *For the monitoring of the risk, the absolute proportions of dissolved CH_4, CO_2 and H_2S per liter of water dissolved in the bottom layers will be periodically measured.*
- *Development of the gas resource needs to be carried out incrementally to test extraction locations, technologies and their ability to adapt to the structure and behavior of the resource.*

While insisting the project must be in conformity with the Management Prescriptions (MPs), the project must be implemented with the proposed measures in place to adequately mitigate impacts identified above.

Environmental and Social Management Plan

In order to ensure successful implementation of proposed mitigation measures, parameter monitoring and subsequent audits, Environmental and Social Management Plan (ESMP) and Environmental and Social Monitoring Plan (ESMP) were prepared in the detailed Environmental and Social Impact Assessment (ESIA), under chapter 8 in this report. The environmental and Social Management Plan summarizes mitigation measures to be taken with respect to the different environmental issues raised during the scoping phase in addition to those identified by the EIA team of experts during the detailed EA and the responsibilities of key stakeholders at the various project phases are clarified in detail in the ESMP.

Overall, the project is environmentally feasible and sound with few potential negative impacts, which can be minimized or completely mitigated through incorporation of corrective, rehabilitation, restoration and instituting of appropriate mitigation measures. These have been integrated into the project decision-making level so as to ensure that the project designs take into consideration all the highlighted aspects of this study. The information presented in this environmental project report where approved will form basis for the final design stage of the project.

Key parameters to monitor during operation of the project are also included in this draft ESIA report submitted to the client, however, the following aspects are part of the issues to monitor during project implementation phase:

-Amount of CO2 discharged and extracted.
-Point of discharge (CO2 and H2O)
-Degassed water density through its CO_2
-Proportions of dissolved CH_4, CO_2 and H_2S per liter of water dissolved in the bottom layers periodically measured.
-Water Extraction and re-injection type.
-Continuous monitoring is required (number of fish catch per day)
-Noise levels emitted from different machines at plant and community
-Lake Kivu water quality (pH, To, Turbidity, DO, BOC, COD, Fecal coliforms, TSS,)
Roles and responsibilities for monitoring of the Project will be shared with the Rwandan governmental authorities and by the Project team. REMA, Lake Kivu Monitoring Programme (LKMP) and SPLK Ltd are responsible for environmental monitoring and auditing. It is expected that SPLK Ltd will undertake self-monitoring, record keeping and reporting and submit this information to REMA annually. REMA will be responsible for review and, on occasion, verification of reports and data submitted and for periodic inspections as needed.

Recommendations

This study has proposed a number of recommendations that the project needs to implement for mitigating adverse impacts and prevent the potential ones.
The recommendations for main environmental mitigation measures include relocation of populations affected by the project, the degassed water must be re-injected and remain at the lower margin of the main density gradient, the developer to ensure a very close follow up for monitoring of Lake Kivu stability, waste management and disposal planning, noise and air pollution abatement measures, emergency response planning as well as the purchase of necessary response equipment. These mitigation measures must be incorporated into the project's design and implementation.
In order to develop institutional capacity in implementing and enforcing the ESMP, training should be provided with adequate budgets to ensure satisfactory achievement of an environmentally sound performance. The training proposed here should include technical skills relating to environmental assessment, environmental mitigation plans, and environmental monitoring.

1.0 Introduction

1.1 Background

Rwanda has a landmass of 26,338km^2, and an estimated population of 8.128,553 million, of which 94% resides in the rural areas (MINECOFIN, 2003). Of the landmass, 34% is farmed, 15% is natural and planted forest, and 14.6% is protected area for game and other functions. The population density is above 500 persons per km^2 of arable land, one of the highest population densities in Sub-Saharan Africa. The distribution of arable land currently stands at one hectare for every 9 persons, a ration that is diminishing due to a relatively high birth rate. About 60% of the population is below 18 years of age, which implies that every adult person cares for 1.5 dependents. Life expectancy is 47 years. Population growth average 2.6% per annum. Average per capita GNP is US$ 210. Coffee and Tea are the main agricultural exports.

Energy is crucial to Rwanda's economic growth. In an effort to help end the power deficit in the country, the GoR is seeking ways of extracting methane gas from Lake Kivu to supplement the existing power supply. It is in this context that Symbion Power Lake Kivu Ltd has been contracted for a project that will generate 50 MW of electric power. The methane gas production facility will generate approximately 14MW of electricity for the local grid in Phase 1. Phase 2 will add an additional 42 MW.

In 1936 methane gas was discovered in the deep waters of Lake Kivu on the border between the Republic of Rwanda and the Democratic Republic of Congo while scientists trying to understand why there were relatively few fish in the lake. Whether the extraction of Lake Kivu gas on large scale will have a positive impact on number of fishes in the lake, this has to be confirmed during exploitation.

The Lake, which is located at an altitude of 1462 m, is 485 m deep and has a surface area of 2400 km^2. A number of studies of the lake and its potential resources have been carried out since the initial discovery of the methane reserves. The most comprehensive of these studies was that of Dr. Klaus Tietze issued in 1976. The studies have shown that there are some 300 km^3 of dissolved carbon dioxide and 55-60 km^3 of methane gas accumulated and trapped at a significant depth beneath the Lake's surface, and these quantities are increasing on a daily basis.

There is no dispute about the primarily magmatic origin of the carbon dioxide, but models of the genesis of the methane have been contradictory up to now. They have been based on too few and partly too inaccurate data.

On the basis of new measurements obtained from gas and sediment samples, some of the old concepts have been further developed to a new model. According to this model, the methane is generated mainly by bacteria from the organic carbon of the sediment. It probably also contains minor amounts of thermostatic methane (International Journal of Earth Sciences, Septembre 2005).

About 70% of the organic carbon of the upper sediment is derived from mainly magmatic carbon dioxide ("old" carbon), which enters the biozone of the lake from the deep water by

eddy diffusion and is assimilated there. The remaining 30% comes from atmospheric carbon dioxide ("young" carbon) assimilated in the biozone. But because methane also migrates into the lake from deeper sediment, the ^{14}C-content in the methane dissolved in the lake water is not 30% modern but only ca. 10% modern.
If nothing is done to counteract the accumulation of gas with extraction, the likelihood of a catastrophic eruption occurring within the next 100-200 years will continue to grow.

The Symbion Power Lake Kivu Ltd project could reduce or eliminate the risk of such an eruption by harnessing the gas in the Lake to fuel a power plant.
By extracting gas from four distinct points (with equal volumes being extracted from each), the project will limit the scale of extraction occurring at any single point. Carefully monitoring the stability of the Lake can reduce the risks associated with the extraction of its gas reserves, ensuring a durable and sustainable supply.
The objectives of the project's gas extraction monitoring will be to:

- Assure the safety of personnel and public as well as the environmental safety at the plants;
- Assure re-injection of the gas-depleted water (after methane extraction), according to the Mandatory Requirements and Guidelines and with periodic adjustments to the re-injection depth range;
- Follow the gas inventory in the lake for management, planning and concession purposes.

Hassan discussed in 2000 the economic feasibility of exploiting Lake Kivu methane gas. He concluded that it was both economically feasible to extract and sue the Lake Kivu gas and that the gas could be of considerable economic benefit to Rwanda. Hassan concluded that if Rwanda used the methane to generate electric energy, it could help to relieve the growing shortage of electric power and thereby boost the country's economic development.

1.2 Project context

The gas extraction process consists of abstraction of the gas rich water from the resource zone. The gases are separated from the water and the gas stream is 'washed' to remove CO2 and H_2S, purifying the methane, which is then compressed and pumped along submerged pipelines to the shore where it is burned in gas engines to produce electricity. The technical complexity of the process is heightened due to the volumes of water required, the need to use the lifting power of the gas laden water, the remote nature of the lake and the potential risks associated with the natural lake conditions.
While Symbion have been granted concessions 2, KP1/REC and Contour Global are operating from concessions 1 and 4, respectively. The barges will be located where the lake depth is approximately 380 m - 420 m. This will allow the risers to access the desired resource zone while avoiding interference from lake sediment.
The final positions will depend on a detailed bathymetry, which will be completed during the detailed design phase. These barge locations give an overall distance of approximately 5 km for the export pipeline.

While the gas plant, gas power plant and substation will be constructed at the peninsula near Busoro, an existing jetty known, as Kitraco will be upgraded to facilitate barges construction. The site is about 2.5 km south of Rubavu.

The project engineering design specifies several key infrastructure components to the proposed development:

- Four Gas Extraction Facilities (GEFs) offshore;
- A Power Plant site with marine maintenance facilities onshore; and
- A Marine Landing Site (onshore) to assemble and launch the Gas Extraction Facilities (GEFs).

The project will be implemented in two stages:
Phase I will produce 14MW of power from one GEF with connecting pipeline and three gas engines operating at the Power Plant.
Phase II will provide an additional 42MW of power to give a total of 56MW through the addition of three GEFs. Construction of Phase II is scheduled to begin towards the end of 2017 and full production capacity is programmed to be achieved in 2019. The project is designed in a modular way. This allows for design changes identified during the initial operation of the Phase I GEF.

1.3 Description of the developer

Symbion, leading private sector partners of the U.S. Government's Power Africa initiative, is one of the most active American power sector firms in the generation, transmission and distribution industry in Africa. As an IPP, Symbion's power plants supply electricity to some of the world's most critically underserved regions.
Since 2010, Symbion has owned and operated thermal power plants in Tanzania and is currently developing a new 400 MW gas power facility as a public-private partnership with the Tanzanian government-owned electricity utility. In addition, Symbion has signed a PPA to build, own, and operate a 35MW geothermal power plant in Kenya and is the lead technical partner and consortium member that owns a 972 MW power plant in Delta State, Nigeria, with plans for further expansion.
In 2013, Symbion completed over 2,000 kilometers of transmission and distribution line construction and 26 substations in Tanzania. Symbion is also one of the most successful wartime contractors in Iraq, where the company completed nine electrification projects, including the construction of a 300 km transmission line across Al Anbar province, Iraq's most dangerous area at the height of the insurgency.
Symbion is led by Chief Executive Officer Paul Hinks and is headquartered in Washington, DC.

1.4 Description of the consultant firm

Eco Design & Protection (ED&P) Ltd conducted this Environmental and Social Impact Assessment (ESIA).

ED&P Ltd is a local multi-disciplinary environmental consultancy firm headquartered in Kigali-Rwanda. The firm has been involved in providing institutional assessment, Training and Capacity Building in ESIA, socioeconomic assessment, waste water treatment design, environmental assessment and management services in sectors ranging from roads construction, renewable energy development, gas extraction and exploitation, hydropower development, mining exploitation, small and large scale manufacturing industries, erection of telecommunication towers, petrol station construction, agriculture, irrigation projects,..Etc.

The firm is a privately limited company that was established in 2008 and has grown steadily and intends to forge a solid reputation in the East African Region. The firm has an excellent and successful reputation of collaborative networking with local and international firms with worldwide experience. ED & P is dedicated to building relationships based on mutual trust in order to bring the best services possible to the clients.

The company consultants have been contracted by International organisations to provide technical backstopping to various projects in Rwanda. These include the African Development Bank, the World Bank, the one UN, the United Nations Environment Programme, the United Nations Economic Commission for Africa, the United Nations Industrial Development Programme, the United Nations Education, Scientific and Cultural Organization, the United Nations Development Programme,..etc. The consultants are closely working with the government institutions among them, the Ministry of Infrastructure, the Ministry of Agriculture, the Ministry of East African Community, the Ministry of Natural Resources, Rwanda Environment Management Authority and the Rwanda Development Board.

1.5 Environmental and Social Impact Assessment (ESIA)

The Environmental Organic Law (2005) recognizes the right of every citizen to a clean, safe and healthy environment, and the right of access to environmental resources for recreational, educational, health, spiritual, cultural and economic purposes.

In pursuance of the Environmental Organic Law, Symbion Power Lake Kivu (SPLKL) has commissioned Eco Design & Protection Ltd to undertake the Environmental and Social Impact Assessment for the 50MW water to gas power plant. The main objective of this ESIA is to determine how the proposed project could impact on the environment and the livelihoods of people. Specifically, this ESIA intends to achieve the following objectives:

- Establishment of a baseline on the actual state of the social and biophysical environment in the proposed project sites and the area of influence.
- Identification of impacts of the project onto the social and biophysical environment including identification of alternatives (including the no project alternative);
- Identification of project stakeholders and affected population and initiation of a public consultation process;

- Identification of measures to prevent, minimize, mitigate or compensate adverse environmental and social impacts;
- Elaboration of an environmental and social management plan (ESMP) that describes in detail necessary mitigation measures, costing, scheduling and responsibility for such measures as well as an environmental monitoring plan.

The proposed development will be an international finance institutions funded initiative. Therefore, this ESIA has also taken into account IFC Performance Standards and World Bank defined in their Operational Policies documents. These Operational Policies have been taken into consideration and addressed in as far as applicable; these include:

- Environmental Assessment (OP 4.01)
- Natural Habitats (OP 4.04)
- Water Resources Management (OP 4.07)
- Involuntary settlement (OP.4.12)
- Physical Cultural Resources (OP.4.12)

Further, this ESIA is responding to the Environmental Organic Law (2005); requires project proponents or developers to undertake an Environmental and Social Impact Assessment (ESIA) at their own cost prior to commencement or financing of a project or undertaking. Types of projects requiring mandatory EIA are listed, which includes the proposed development. The law prohibits any development to be initiated without an Environmental Impact Assessment (EIA) Certificate.
The ESIA findings are expected to inform the final design and form the basis for environmental permission and approval of the project.

The ESIA was undertaken by ED&P in order to develop the assessment in accordance with the international standards that may apply to the Project including those of the World Bank Group and the International Finance Corporation (IFC) Performance Standards (PS).

1.6 Study scope and methodology

1.6.1 Study Scope

The scope of the study was defined by the Symbion Power Lake Kivu Ltd project's potential impacts and by input from its stakeholders. The terms of reference also helped in shaping this study's scope and the methodology. The study was undertaken in the Bwishura Sector of the Rubavu District in the Western Province of the Republic of Rwanda.
A scoping study was undertaken at the beginning of this ESIA study. This scoping exercise involved consultation with the client (Symbion Power Lake Kivu Ltd), key stakeholders including REMA, RDB and REG and it helped the study team define the spatial and contextual scope of the ESMP.

The scoping process helped the team identify the issues that were likely to be of priority importance during the ESIA study and eliminated those that were of little concern. The rapid scoping exercise also enabled the consultants to identify the stakeholders and public concerns. The scoping exercise also helped in introducing the project to key stakeholders and involved them in determining the scope and focus of the ESMP study.

This ESIA was conducted by an independent contractor; ED&P Ltd. The ESIA study covered all issues pertaining to the physical, biological and socio-cultural environment of the project. ED&P has identified and assessed the project's potential impacts on the environment and possible mitigation measures. The ESIA process is an innovative management tool that is used to identify the potential environmental and social impacts of a project. The study is conducted early on the project cycle, allowing for mitigation to be built into projects' design. The challenge for this ESIA report remains gaining the effective participation of the communities that may be affected by the project.
Regarding the infrastructures to be erected for this project and the potential associated environmental and socio-economic impacts, the consultant had to address the following:

- Major hazards, including the stability of the lake and catastrophic risks posed by the presence of methane and carbon dioxide in the lake;
- Occupational, health and safety hazards;
- Project impacts on ambient air quality, groundwater, and surface water;
- Noise pollution impacts and handling of hazardous materials;
- Water quality;
- Soil erosion;
- Solid and liquid waste;
- Ponding;
- Traffic;
- Fire safety and increased accident;
- Labor force;
- Visual intrusion;
- Major grievances, all ecological, historical, archaeological, environmental, social issues of concern;
- The risk of communicable diseases including sexually transmitted diseases (STD) such as HIV/AIDS;
- Loss of habitat, Housing for workforce, if relevant;
- Lake limnology and stability;
- Flora and fauna;
- Major types of probable emergency situations, and;
- Possible effects to be identified on Land Owners.

1.6.2 Methodology

The ESIA provides a description of the Project site and the surrounding environment including specifying any information necessary to identify and assess the environmental and social effects of the Project. Baseline data collection used a combination of desk-based sources and surveys, depending on the topic.

It was applied in this assignment different techniques for data collection and these include; a comprehensive literature review, interview schedule for key informants, general interviews, focused group discussions, field visits, and surveys during the detailed impact assessment phase.

As part of ESIA Study process an air dispersion modelling study was conducted with aim of finding out the impact from the proposed stack emissions to the atmosphere the significance of the impacts and the areas being impacted. The objective of the assessment was to determine whether or not the operation of the plant would be in compliance with the East Africa Air Quality Standards (EAS 751:2010) and the World Bank Group Air Quality Guidelines (AQGs).
The AERMOD 9.2.0 Dispersion Model was used in the estimation of downwind ground level concentration of the Oxides of Nitrogen (NOx) and Carbon Monoxide; the main pollutants of concern as far as methane gas power plant is concerned.

To commence this assignment, we had a one-week period to mobilize the consultants with the key role players and commence the detailed planning of the project and compilation of the draft progress report.
Different meetings were held with the client to establish the following:
- Establish the study team;
- Review deliverables and schedule;
- Obtain all pertinent information from the client; and
- Establish communication lines and procedures.

The scope of work broadly comprised of four main implementation phases namely;
- Stakeholder mobilization, consultation and data collection
- Scoping phase;
- Detailed EA study;
- Data evaluation and reporting

Stakeholder mobilization: The team Leader made arrangements to mobilize all team members needed at the commencement of the assignment. At this stage the Project Management and Quality Assurance procedures was established to ensure the correct and efficient methods for communication, document management procedures, were set up.

1.6.2.1 Baseline Assessment

Baseline data was first collected from secondary data; however, the team discovered that not much data had been collected in the area, and then primary data were collected from the site.

Data collected included information on: the terrestrial and aquatic physical environment (geology, topography, soils, climate and meteorology, ambient air quality, surface and ground water hydrology, existing water pollution discharges, and receiving water quality); the terrestrial and aquatic biological environment (flora, fauna, rare or endangered species, sensitive habitats – including significant natural sites etc., species of commercial importance, species with potential to become nuisances or dangers); and the socio-cultural environment: (population, land use, planned development activities, community structure, employment, distribution of income, goods and services, recreation, public health and safety, cultural aspects/properties, aspirations and attitudes).

1.6.2.2 Project Alternatives

The study team together with stakeholders analyzed various project alternatives available that would achieve this project's objectives with few adverse environmental consequences. The identified alternatives were evaluated based on their environmental impacts and associated costs. The project alternatives assessed during this process included:

- Alternative sources of energy – both renewable and non-renewable sources – including hydropower, diesel/fossil fuel, wind power, and solar energy, among others;
- Site/Location Alternatives for the proposed facilities, which were evaluated based on potential location-based impacts and land-use conflicts;
- Process alternatives, including evaluation of the construction alternatives for the building of the methane gas and electric power production facilities, which were assessed with a view to minimizing raw material use and generation of waste;
- Technology alternatives, including all possible alternatives in technology that could generate electricity from methane gas, assessed to determine the most affordable options, and finally;
- A" no project" alternative to determine the impact of a scenario where no such project was undertaken.

1.6.2.3 Public Consultation

Public Participation, Consultation and Disclosure

Public participation is an opportunity to present the baseline study, the identification of the potential impacts identified and importantly the mitigation measures.

Public participation and stakeholder engagement requirements will follow the IFC Good Practice Manual Doing Better Business through Effective Public Consultation and Disclosure (1998).

A Stakeholder Engagement Plan (SEP) has been prepared to record the methodology and outcomes of both the ESIA and wider project stakeholder engagement process. It will also set out proposals for future stakeholder engagement and participatory methods for communication and feedback.

During the scoping process, a stakeholder mapping exercise was undertaken to identify the Interested and Affected Parties (I&AP) of the project. In identifying the relevant stakeholders, the study team also determined those stakeholders who would not be significantly impacted by the proposed project.

Public consultation was critical in helping the team to understand the local conditions and the Indigenous Knowledge Systems (IKS) in the project area.

The stakeholders' consultation also helped in highlighting the serious socio-economic and environmental concerns associated with the project, and it was instrumental to pinpointing the necessary mitigation measures.

Stakeholders were sought from a variety of groups, including civil society, relevant governmental ministries, the client, provincial officials, educational institutions, and others.

I & AP were invited to a stakeholder consultative workshop to raise their issues and concerns with other stakeholders. During this workshop, a site visit was arranged for the public to allow stakeholders to review the project area and site.

Stakeholder contributions were captured in the Public Issues and Concerns Report. Issues, concerns and suggestions from stakeholders were then integrated to the study's agenda.

1.6.2.4 Impact Prediction and Evaluation

Various methods and techniques were applied in impact identification, prediction and evaluation. The ED&P team with the help of stakeholders identified and analysed the project's potential impacts, as associated with specific project activities and phases. First, ED&P considered both the potential positive and negative impacts of the project. In considering these impacts, the study examined them in light of several key characteristics, including their nature (positive or negative), extent (spatial scope), occurrence (one-off, intermittent or constant), magnitude, reversibility, directness or indirectness, probability of occurrence and significance with and without mitigation.

ED&P used a number of tools to identify and assess potential impacts. A simple structure checklist was used to identify environmental impacts, while a weighted matrix was used in analysing impacts. An impacts network was used to identify indirect and cumulative networks.

For each environmental and social topic, impacts will be identified and characterized.

Impacts can be defined as a physical or measurable change in the environment which results from the Project. Impacts for the purposes of the ESIA are defined as set out in the table below:

Table 1: Definition of potential impacts types

Term	Definition
Beneficial / Positive	An impact that is considered to represent an improvement on the baseline or introduces a positive change.
Adverse / Negative	An impact that is considered to represent an adverse change from the baseline, or introduces a new undesirable factor.
Direct	Impacts that arise directly from activities that form an integral part of the Project (e.g. new infrastructure).
Indirect	Impacts that arise indirectly from activities not explicitly forming part of the Project (e.g. noise changes due to changes in road traffic resulting from the operation of Project).
Secondary	Secondary or induced impacts caused by a change in the Project environment (e.g. employment opportunities created by the supply chain requirements).
Cumulative	Impacts arising from the combination of multiple impacts from existing projects, the Project and / or future projects.
Transboundary	Impacts that extend to multiple countries, but are not global in nature (e.g. air pollution extending to neighbour countries and use or pollution of international waterways).
Global	Impacts that, when taken together with impacts created by other human activities, can become nationally, regionally or globally significant.

A number of the potential effects identified as arising from the Project are likely to cut across the topic areas identified, either intrinsically or in terms of secondary or indirect impacts.

Cumulative Impacts

The IFC PS 1: Social and Environmental Assessment and its Guidance Note, define cumulative impacts as "the combination of multiple impacts from existing projects, the Project, and / or anticipated future projects may result in significant adverse and / or beneficial impacts that would not be expected in case of a stand-alone project". This guidance was applied during the assessment of cumulative impacts.

The ESIA considers cumulative impacts of the Project from existing and proposed developments. These are presented in the Cumulative Impacts sub-section of each topic chapter.

Transboundary Impacts

Transboundary impacts are defined by the IFC PS 1 as impacts that extend to multiple countries, but are not global in nature. It is not anticipated that the Project will give rise to any transboundary impacts.

Global Impacts

IFC PS 1 identifies that while individual project impacts on climate change, ozone layer, biodiversity or similar environmental issues may not be significant, when taken together with impacts created by other human activities, they can become nationally, regionally or globally significant.

An assessment of the global warming potential of the Project is included in Section 5 of this document. No other potential impact from the Project is considered to represent a 'global impact'.

Assessment of Impacts and Identification of Significant Effects

For each of the baseline topics covered, the significance of potential impacts will be assessed.

The determination and assessment of impacts will be based on the following criteria:

- Magnitude: to what extent environmental resources are going to be affected;
- Extent: how much area will be adversely or positively affected by the project;
- Significance: what value in terms of costs and benefits does society place on the resources and the different impacts affecting the resource(s); and
- Special sensitivity: which impacts are significant in the specific local economic, social and ecological setting.

Following international best practice, significant effects will be determined by consideration of the following:

- Sensitivity of the resource or receptor (rated as high, medium and low) by considering the importance of the receiving environment (international, national, regional, district and local), rarity of the receiving environment, benefits or services provided by the environmental resources and perception of the resource or receptor); and
- Severity of the impact, measured by the importance of the consequences of change (high, medium, low, negligible) by considering inter alia magnitude, duration, intensity, likelihood, frequency and reversibility of the change.

The following criteria are used to determine the sensitivity of the receptor / resource and severity of the impact. It should be noted that the definitions given are for guidance only, and not all the definitions will apply to all of the environmental/social receptors and resources being assessed. Therefore, the assessment will be further justified within each topic, referring to those tables where definitions are applicable.

Table 2: Determination of receptor sensitivity

	High	Medium	Low
Guideline definitions	Receptor is rare, legally protected, of international or national designation. Population rely on resource for health, subsistence or livelihood, or receptor is of high cultural value. Human receptors – vulnerable groups, Project Affected People (PAPs).	Receptor is of regional importance. Resource may benefit the local population, but they do not rely on it for health, subsistence or livelihood. Receptor is of some cultural value.	Receptor is common, or of local importance. Resource is not used or is of no value to the population.

Table 3: Determination of receptor sensitivity

	High	Medium	Low	Very low
Guideline definitions	Effect is trans-boundary or national. Effect exceeds a national or international standard, >75 per cent of receptor / resource is affected. Effect is long-term (>10 yrs), permanent and irreversible.	Effect is regional, 25-75 per cent of a receptor/ resource is affected. Effect is medium term (2-10 yrs) and reversible.	Effect is local, 10-25 per cent of a receptor/ resource is affected. Effect is short term (<2 yrs) and reversible.	Effect is too small to be measured. <10 per cent of a receptor/ resource is affected. Effect is confined to construction period, or is intermittent.

The sensitivity of the receptor and the severity of the effect are used to determine the significance of the impact. The determination of impact significance, for both positive and negative effects is set out in the table below.

Table 4: Illustrative determination of significance criteria

Effect		RECEPTOR/ RESOURCE SENSITIVITY		
		High	Medium	Low
IMPACT SEVERITY	High	Major	Major	Moderate
	Medium	Major	Moderate	Minor
	Low	Moderate	Minor	Minor
	Very low	Minor	Insignificant	Insignificant
	No change	None	None	None

Mitigation and Enhancement Measures

For any significant negative impacts identified as a result of the Project, mitigation measures are proposed to ensure compliance with applicable Rwandan laws and regulations, and meet the requirements of international standards, including the IFC PS 1 through 8. Mitigation is considered under the following classifications:

- Avoidance – avoiding environmental damage at source through design;
- Minimize – lessening the severity of an impact which cannot be avoided entirely;
- Mitigation and compensation – acknowledges that some negative consequences will stem from development, but provides means by which the conditions can be compensated for or improved; and
- Enhancement – increasing the effects of positive impacts.

1.6.2.5 Environmental and Social Management System

An ESMS comprises of an assessment of the environmental and social impacts, policies, an Environmental and Social Management Plan (ESMP) and specific management plans (as required). SPLKL has developed an ESMP, which will provide a framework from which the contractor will be tasked with producing a site-specific Contractor Environmental and Social Management Plan (CESMP) for their work.

SPLKL is committed to the principle of sustainability with regard to its management of the environment and the highest social, health and safety standards. SPLKL believes that workplace injuries and occupational diseases are preventable through good planning, careful oversight, training and staff responsibility in carrying out work in a safe manner. Notable issues such as job hazards, fire prevention, evacuation plans, emergency preparedness plans and health of employees as well as providing up to the task safety training for all staff will be included in the management system.

Four key elements guide the ESMS development and implementation and assist staff to achieve continual improvement in environmental performance as outlined below:

4 Environmental, Social, Health and Safety Planning
5 Checking and Corrective
6 Management Review and
7 Implementation and Operation.

The ESMS elements are cyclic in nature in the sense that the outcomes from the implementation and operation culminate in a continual review to further improve efficiency.

The ESMP will comply with IFC PS 1: Social and Environmental Assessment and Management Systems: Action Plan and Management System, with full accordance required by SPLKL in the CESMP that will be developed by the construction contractor.
The ESMP will also consider the operational environmental and health risks and hazards of the Project. An operations ESMP will be developed by SPLKL or its designated contractor in accordance with the principles and measures provided in the ESMP ahead of operations commencing. A decommission plan will also be drafted ahead of any decommissioning activities to the satisfaction of SPLKL.

Project Standards
Symbion Power Lake Kivu Ltd has adopted the following standards for the Project:

- National Laws of Rwanda;
- World Bank Group Environmental, Health and Safety (EHS) guidelines and standards, including;
    - i. IFC PS (January 2012);
    - ii. IFC General EHS Guidelines (April 2007);
    - iii. IFC EHS Guidelines for Thermal Power Plants (December 2008); and
    - iv. IFC EHS Guidelines for Construction Materials Extraction (April 2007).

All relevant international conventions for the individual technical specialties, which are identified in the appropriate sections of the report.

Project categorization
The IFC categorizes projects as a way of indicating the level of environmental and social concern of a proposed investment. Projects are assigned a Category of A, B or C, in descending order of environmental and social sensitivity. The project category governs how IFC's Disclosure Policy applies to the proposed investment. Different lending organizations may apply different specific criteria to categorization, but the principals are aligned.

For Category A Projects, these are expected to have significant adverse social and/or environmental impacts that are diverse, irreversible, or unprecedented. Category B Projects are expected to have limited adverse social and/or environmental impacts that can be readily addressed through mitigation measures. Category C Projects are expected to have minimal or no adverse impacts,

This ESIA process concluded that a thermal power project would most likely fall within Category A, and an ESIA report was prepared including an evaluation of the possible environmental and social impacts of the Project, measures designed to manage, mitigate and monitor those impacts and details of public consultations.

The study and assessment has confirmed the Project as Category A for the following reasons:

- The Project's greenhouse gas emissions will exceed 900,000 of carbon dioxide equivalent (CO_2eq) tones/year.

- The project and Lake Kivu stability if not appropriately monitored to make sure it complies with MPs, serious hazardous on the lake and its surroundings could occur.

Purpose of the Document
The purpose of this document is to present the findings and recommendations of the ESIA in line with the national guidelines and international standards adopted by SPLKL.

This ESIA document provides:
- Comprehensive details of the nature, scale, location and likely significant impacts of the Project;
- Comprehensive baseline of the existing environment of the site and its surroundings, both natural and social;
- Proposal of how negative impacts can be avoided, reduced or offset through further design or mitigation;
- Proposal for how positive impacts can be enhanced or maximized;
- Identification of any cumulative impacts and proposed mitigation; and
- Proposal of options as to how any significant residual impacts would be mitigated, managed or monitored.

2.0 Legislative, Policy and Institutional Framework

This Section presents the national legal framework and regulations for planning and environmental and social protection in Rwanda, as well as international standards of potential financiers to the Project, initially understood to comprise the IFC and the World Bank. Where national legal standards are not as stringent as international requirements or vice versa, the Project will be required to defer to the most stringent requirement except in cases where that would contravene national law.

This chapter reviews the relevant legal and institutional arrangements that would hinder or guide the development of the project in line with national and international laws. Being a signatory to various international conventions and laws, it is important that Rwanda's national projects are in line with these laws, and so some of the relevant international conventions are reviewed in this chapter.

2.1 Legal Framework

2.1.1 The Constitution of the Republic of Rwanda, 25 December 2015

It should be noted at the outset that, all laws and regulations in Rwanda must be aligned with principles in the Constitution. The Rwandan Constitution was approved in a national referendum and adopted in Parliament on 25th December 2015. It defines the principles and overall legal framework for the management of the water, energy and agricultural sector. According to the Constitution of the Republic of Rwanda in:

Article 3: Supremacy of the Constitution
The Constitution is the supreme law of the country.
Any law, decision or act contrary to this Constitution is without effect.
Article 21: Right to good health
All Rwandans have the right to good health.
Article 22: Right to a clean environment
Everyone has the right to live in a clean and healthy environment.
Article 23: Respect for privacy of a person and of family
Article 34: Everyone has the right to private property, whether individually or collectively owned.
Private property, whether owned individually or collectively, is inviolable.
The right to property shall not be encroached upon except in public interest and in accordance with the provisions of the law.
Article 35: Private ownership of land and other rights related to land are granted by the State.
A law determines modalities of concession, transfer and use of land.
<u>**Compliance aspects**</u>
The project must be implemented while considering:

- The provisions of the constitution are above any other law that will be used in reference

❖ The project will be implemented in a context of environmental sustainability, ensuring all environmental impacts are mitigated to ensure a clean environment to the parties supposed to be affected

❖ The parties that have land rights will be fairly compensated in consideration of the right to private property.

2.1.2 Environmental Organic Law No 04/2005

The most relevant legislation for this study is the Organic Law on Environmental Protection, Conservation and Management. This is the law that regulates the protection of environment in Rwanda. The law sets out the general legal framework for environmental protection and management in Rwanda. It also proclaims the environment one of the priority concerns of the Government of Rwanda. Under the fundamental principle on national environmental protection policy this law develops national strategies, plans and programs, aiming at ensuring the conservation and protection of environment and sustainable use of natural resources.
The law protects the right of every natural or legal person in Rwanda to live in a healthy and balanced environment and asserts that each has an obligation to contribute individually or collectively to safeguard the country's natural, historical and socio-cultural heritage.

The law on the protection and management of natural resources aims to avoid and reduce adverse impacts on the environment. It measures results from an environmental evaluation of policies, programs and projects, aimed at preventing the consequences of such activities.
The principle of sustainability of the environment and equity among generation places human beings at the core of sustainable development and asserts all humanity's right to a healthy and productive life in harmony with nature. To respect this human right, the Rwandan people must try to equitably meet the needs of both the present and future generation.
The law on environmental protection and management is currently registered in the environmental organic law, as published in the official Gazette on May 1, 2005.The National Environment Policy and the Organic Law N°16/2006 led to the creation of REMA in 2006, which raised the importance of environmental management in Rwanda. REMA is currently under the auspices of the Ministry of Natural Resources (MINIRENA) and is recognized as the key authority in environmental monitoring, regulation and enforcement

Rwanda's current Organic Law has the following objectives:

- To protect the human and natural environment;
- To establish fundamental principles for the management and protection of the environment from all forms of degradation so as to develop natural resources and fight all kinds of pollution;
- To improve the living conditions of the population, while preserving ecosystems and available resources;

- To ensure a sustainable environment and resources as well as rational and sustainable use of resources, taking into account the equality of present and future generations;
- To guarantee to all Rwandans an economically viable, ecologically sustainable and socially acceptable development;
- To establish precautionary principles in order to reduce negative effects on the environment and to ensure the rehabilitation of environmentally degraded areas.

Chapter IV of the Organic Law Article 65 mandates that all projects carry out an Environmental Impact Assessment. EIA guidelines stipulate what should be the EIA content (annex 1).
Article 3: States that every person has the duty to protect safeguard and promote the environment. The State shall protect, conserve and manage the environment.

Article 67: Further specifies that every project shall be subjected to an Environmental Impact Assessment prior to its commencement. It shall be the same for programs, plans and policies likely to affect the environment. Specific details of projects referred to in this Article shall be spelt out by the order of the Minister in charge of environment.
Article 68 states that Environmental Impact Assessment (EIA) shall include at least the following:

- A brief description of the project and its variants.
- Analysis of direct and indirect foreseeable consequences on the environment.
- Analysis of the initial state of the environment.
- Measures envisaged reducing, preventing or compensating for the consequences.
- Reasons for the choice.
- A summary of requisitions from clause1 to 5 of this article;
- A definition of the evaluation and monitoring methods used regularly and environmental indicators before (initial state), during and after implementation of the project or, as the case may be, at the final evaluation stage of the project;
- A financial evaluation of measures recommended preventing, reducing or compensating for the negative effects of the project on the environment and measures for regular monitoring and control of relevant environmental indicators.

Article 69 States that the analysis and approval of Environmental Impact Assessments is the responsibility of the Rwanda Environmental Protection Authority or any other person given a written authorisation. The project promoter shall pay a levy, which shall be assessed from the amount invested or to be invested, excluding the amount of operating cost. The assessment of this levy shall be fixed by law establishing the National Fund for the Environment. The impact study shall be done at the expense and under the responsibility of the promoter.

The Organic Law also puts in place the National Fund of the Environment in Rwanda (FONERWA). The composition, the working and the assignments of these various institutions will be determined by particular laws.

Title IV of Article 67 of the Organic Law requires that the execution of Policies, Plans and Projects be subject to mandatory EIA studies to identify the potential adverse impacts they could have on the environment.

Further to this Article, through a Ministerial Decree, a list of all the projects that must undertake an EIA has been put in place under article 68 of the Organic Law. Article 30 further stipulates that works of public or private construction as roads, dams etc must be subjected to EIA studies.

Article 69 of the Organic Law further specifies that the EIA studies undertaken must be submitted to REMA for approval and that the studies must be undertaken at the proponent's expense.

<u>**Compliance aspects**</u>

-SPLK is committed to construct and operate the proposed project facilities under green policies. It is in this context that SPLK has hired ED&P to undertake the ESIA to be submitted to Rwanda Development Board and shared with the lender for evaluation and conformity.

-The project will be implemented in conditions that ensure environmental sustainability and use of resources as well as rational and sustainable use of resources, taking into account the equality of present and future generations.

This applies in all aspects of the intervention project including among others;

❖ Waste management. Will apply on disposal of solid wastes into the environment without complying with the established standards and procedures. Requires all time compliance, considering:

❖ Aerial emissions,
❖ Effluent discharge practices
❖ Excessive noise and vibrations
❖ Social disruption control
❖ Excavations and soil loss
❖ Adverse interference with natural resources including wetlands and water resources
❖ The developer and the contractor on the ground will closely work with local authorities and environmental committees existing at different levels
❖ The ESIA report will be submitted to RDB for review and the developer will work closely with REMA, being the environmental authority
❖ The project cycle should ensure compliance with this statute all the time.

2.1.3 Expropriation Law No 32/2015 of 11/06/2015

The law determines the procedures relating to expropriation in the public interest.
Only Government can order expropriation in the public interest.
Article 4 stipulates that:
Every project, at any level, which intends to carry out acts of expropriation in the public interest, shall budget for valuation of the property of the person to be expropriated and for fair compensation.

Article 17 on value of activities developed after the publication of the decision of expropriation in the public interest stipulates that:
After the publication of the decision on expropriation in the public interest and the list of holders of rights registered on land titles and property incorporated on land, the landowner shall not develop any other long-term activities on the land. Otherwise, such activities shall not be compensable during expropriation.
Article 36 stipulates:
The approved fair compensation shall be paid within a period not exceeding one hundred and twenty (120) days from the day of its approval by the District or City of Kigali Council or the relevant Ministry.
If fair compensation is not paid within the period provided under Paragraph One of this Article, expropriation shall become null and void unless otherwise agreed upon between the expropriator and the person to be expropriated.
Subsequent to receiving fair compensation, the expropriated person shall have a period not exceeding one hundred and twenty (120) days to relocate.

Compliance aspects
The Government has committed to avail land for SPLKL project. The government has included the project in the public interest ones and expropriation process is ongoing. Fair compensation is provided in the expropriation law and people will relocate once the compensation is complete.

2.1.4 The Environmental Impact Assessment Regulations, 2007

REMA has developed the EIA regulations that provide a guideline and the requirements for an EIA in Rwanda. Under these new regulations Sub Article 1 makes it mandatory for all the projects listed under Schedule I to be subjected to a full scale EIA. The Sub Article further states that:

Sub Article 1) No environmental authorization shall be granted by the Authority for any project in Schedule I to these Regulations if no Environmental Impact Assessment has been submitted to the Authority in accordance with the provisions of these Regulations.

Sub Article 2) states that any project listed under Impact Level III of Schedule I to these Regulations shall require a full environmental impact assessment by the preparation of an environmental impact report, unless the Authority refuses permission. The construction of the gas extraction and electric power production facilities falls in this category and thus must be subjected to a full scale EIA.

Compliance aspects

-As per the project details and its screening, the project was classified category A as per the World Bank guidelines and IFC Performance standards. It was also classified category III in accordance with national EIA regulations (2007). Therefore, the ESIA will be undertaken through that consideration and submitted for approval.

2.1.4.1 Consultation with stakeholders

Once the stakeholders have been identified and properly categorized, the process of involving them in the EIA process should begin. For this category A project, consultations involve an exchange of vital information or facts and key issues between the developer, and the stakeholder community on the other. The consultation process should accord the stakeholder community every opportunity to comment on the merits, demerits and any other aspect of the proposed project. The process must be well planned and coordinated so that participation is convenient and cost-effective to all the parties involved. An effective consultation process should generally ensure that:

- The public have got a clear understanding of the proposed project;
- Feedback mechanisms are clearly laid out and known by parties involved.

Compliance aspects

-A public consultation was organized and the decision to hold that meeting will come from the environmental authority (REMA). In the same context a public consultation meeting will be organized when the draft ESIA report is available. The report will be uploaded on the project developer's platform and this communicated to the stakeholders. A reasonable time will be given to the stakeholders to review the draft report.

2.1.5 Law n°62/2008 of 10/09/2008 putting in place the use, conservation, protection and management of water resources regulations

Law regulating the use, conservation, protection and management of water resources[1] defines the rules to the use, conservation, protection and management of water resources. It determines provisions for public water domain, the institutions in charge of water domain, planning in water domain and regime of water use, sanitation of water used, particular provisions for domestic and animals' purposes, easement, public works related to water and

[1] See Law No 62/2008 of 10/09/2008.

sanitation, international cooperation on shared waters as well as penal provisions. According to this law, water is a good belonging to state public domain. Its use constitutes a recognized right in force to all in the scope of laws and regulation in use. Also, protecting and using water resources in Rwanda in the natural balance respect are of general interest and constitutes an imperative duty for all , notably the state the local communities , private sector , civil society and citizens.

The 2008 Water Law provides that water is a public good, and responsibility for its proper use and protection is the responsibility of the state, the private sector, civil society and the citizens.[2] The water law recognizes principles such as: protecting water resources from pollution, requiring water users and water polluters to pay, using water user associations, and providing for the public distribution of water. The priorities for water distribution are: (1) the population; (2) livestock; and (3) hydroelectric energy production. It should be noted that the above mentioned 2005 Organic Land Law also provides that the country's lakes, rivers, and groundwater are in the public domain, and the use of water resources is shared by all.

Compliance aspects

The project was designed so that the water consumption and use is minimized. –The gas extraction and processing will be done in a way that avoids pollution of Lake Kivu and other surface waters in the catchment.

2.1.6 Land Law N° 43/2013 of 16/06/2013

Land in Rwanda is one of the primary livelihood assets of rural citizens. Yet, with Rwanda's population density the highest in Africa land is extremely precious for communities there and oftentimes a source of conflict. As such, land in Rwanda has emerged as one of the most pressing issues facing the government of Rwanda and Rwandan citizens, heralding a need for broad information sharing about land matters coupled with solid research on land issues that can feed an adaptive policy environment.

In Recent years with the principal of Good Governance that the government has made a priority, law determines modalities of allocating, acquisition, transfer, use and management of land in Rwanda as land is being scarce since Land resources are not increasing while the population growth remains high. In this back ground that the government of Rwanda through the Ministry of Natural Resources has found imperative to ensure both rational use and prudent management of land.

To achieve this noble objective, the Government of Rwanda has reviewed the Organic Law n° 08/2005 of 14/07/2005 determining the use and management of land in Rwanda. The revision was mainly transform the Organic Land Law into ordinary law in order to comply with the provisions of the constitution of the Republic of Rwanda. In addition, various weaknesses in the Organic Land Law which made its application difficult, have been addressed. Actually, the new Law N° 43/2013 of 16/06/2013 Law governing land in Rwanda

[2] Ibid.

has been gazetted in the *Official Gazette no Special of 16/06/2013*.
The new Land law is found as a long-term solution as it takes into consideration all aspects of the Land policy, which has been adopted by the government of Rwanda in 2004.

The section 2, article 11 of the law on individual ownership of land stipulates that Individual land is composed of the land acquired through custom, written law which excludes public land or district, town, municipality and the City of Kigali land, the one acquired from competent authorities, purchased land, gift, exchange and sharing.
The section 3, article 12 of the law on State Land Sub-section one stipulates that State land which makes up the public domain consists of all the land meant to be used by public or land reserved for organs of state services as well as national land reserved for environmental protection. This is to say:
1° Land containing lakes and rivers as listed by an order of the Minister having water in his or her attributions;
2° Shores of lakes and rivers up to the length determined by an order of the Minister having environment in his or her attributions starting from the furthest line reached by water depending on successive floods. This is not concerned with exceptional floods;
3° Land occupied by springs and wells determined in accordance with an order of the Minister having water in his or her attributions;
4° National land reserved for environmental conservation composed of natural forests, national parks, reserved swamps, public gardens and tourist sites;
5° State roads and their boundaries which were listed by the order of the Minister having infrastructure in his or her attributions;
6° Land and buildings the administration reserved for public activities or the land used by public administration organs.
Article 13:
Lake and river waters and underground water are public domain. Notwithstanding provisions of regulations relating to the use of such waters, as well as particular agreements the state may enter with interested persons who may take over the management of such water, the powers to use the water is common to all persons.
Whatsoever, no person is allowed to pollute water and no one is allowed to change its course without permission from the competent authorities.
<u>**Compliance aspects**</u>
-The land necessary for the project will be acquired in a respect of land law provisions and in accordance with the term of the concession agreement.
- The project will encroach in the lake buffer zone which is actually not a dry area. Mitigation measures are to be proposed to optimise the plant power generation, protect and conserve the lake Kivu water resources. Construction activities are susceptible to pollute the lake water with waste including hazardous waste.

2.1.7 Ministerial Order N°007/16.01 determining the length of land and shores of lakes and rivers

Pursuant to Organic Law nº 08/2005 of 08/04/2005 determining the modalities of protection, conservation and promotion of the environment in Rwanda, the article 2 of this order stipulates that stipulates the land within a distance of fifty (50) meters from the lakeshore is public property. The length mentioned in this article shall be calculated beginning from the furthest line reached by water depending on successive floods. And according to article 4 No activities or buildings are authorized on the said land except activities aiming at protecting big rivers, shores or activities authorized by the Minister in charge of environment and when such activities are deemed not destructive to the environment on condition that a prior environmental impact assessment study has been done. As per the article 5, the land within a distance of ten (50) meters from the lakeshore and the land on the river shore within the distance referred to in article 3 are reserved as natural vegetation. Artificial vegetation can be grown on this land in case of restoring the damaged land or if that vegetation is responsible for protecting the environment by stopping soil erosion, being habitats for living organisms. Article 6 stipulates within the distance provided for in Articles 2 and 3 of this Order, the following are prohibited:
1. Dumping solid wastes;
2. Dumping liquid wastes.

<u>Compliance aspects</u>

This applies in all aspects of the intervention project including among others;

- Encroachment into the 50m lakeshores only if permitted by the designated authority. With the planned construction of onshore facilities, some installations will be within the 50meters buffer zone. An ESIA has been conducted and has proposed recommendations to mitigate related impact to the lake Kivu valuable ecosystem.
-No liquid or solid waste will be dumped within the 50 meters' buffer zone throughout all project phases.
-Except the authorized installations in the buffer zone, the remaining area will be green with a pleasant environment that protects the lake.

2.1.8 Law No 37/2008 of 11/08/2008 on mining and quarry exploitation

The Law carters for activities relating to prospecting, search, exploitation, purchase, stocking, handling, transport and commercialization of transferable substances other than hydrocarbon as well as quarry products within the Republic of Rwanda.
Some of the general principles of the law are the following:
Quarry exploitation activities, exploiting related products shall comply with all professional and environmental requirements;
Quarry exploitation activities and exploiting related products shall comply with Laws and regulations on land, environment, trade, labour, security, culture and public health;

Importing, manufacturing, transporting, trading and using dynamites in quarry exploitation shall be carried out upon authorization by the Minister in charge of security on request by the Minister. A Ministerial Order shall determine the requirements for grant of authorization.

<u>Compliance aspects</u>

- ❖ For each quarry to be exploited, an EIA study will be undertaken
- ❖ Compliance for all sites with direct or indirect implications on the health of the workers or the neighboring communities.
- ❖ All health and safety measures should be in place to ensure the workers and the neighboring communities are not exposed to risks.

2.1.9 Management Prescriptions (MPs)

For any gas plant to be operated from the Lake Kivu onshore and offshore sites and for development of the gas resources, there are established Management Prescriptions and mandatory requirements that have to be adhered to.

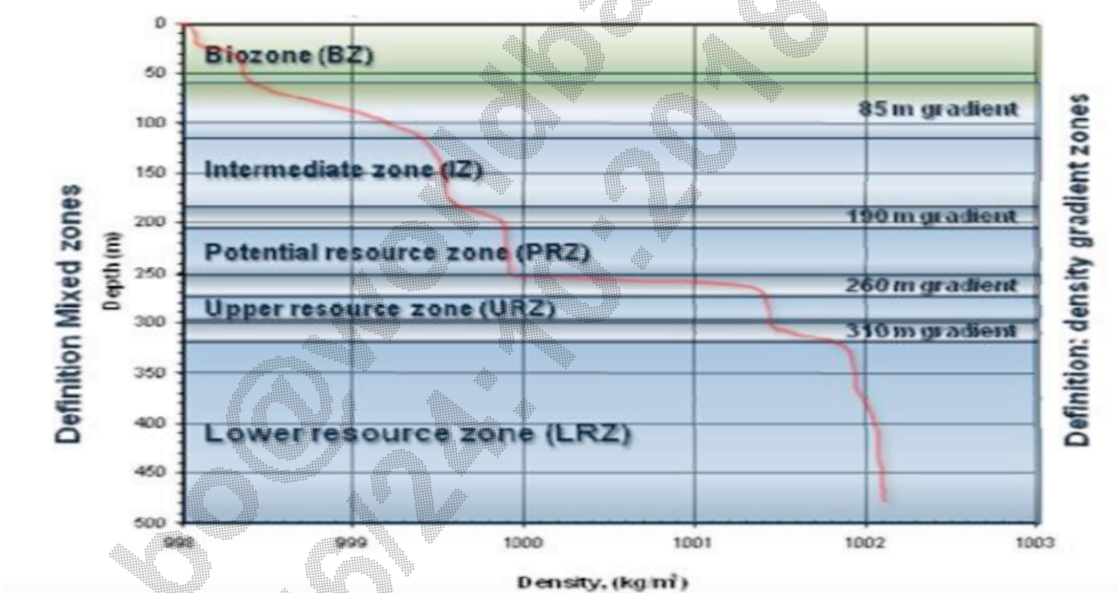


Figure 1: Vertical density profile in Lake Kivu

Table 5: Project compliance with Mandatory Technical Requirements

Requirement	*Met*	*Compliance note*
Water extraction and re-injection must be done horizontally. *Equipment must be designed to reliably prevent, for the design lifetime of a facility, the accidental deviation of re-injection flows away from the horizontal, and/or their redirection into vertical flows, at the point of reinjection.*	*Yes*	*The water extraction and re-injection of the lake water is carried out horizontally through large diameter, horizontally directing nozzles. The design of the diffuser nozzles is shown in Figure 11.* *Modelling shows that the discharge*

The design as well as the choice of materials must ensure that corrosion or fatigue cannot cause premature failure of any parts of these points of re- injection. The design lifetime (materials as well as workmanship) must be 50 years. Fabrication of the re-injection pipe must be made to the highest standards.		*plume initially descends slightly then rises to the stratification depth. This will thicken the secondary gradient between the URZ and LRZ by pressing the bottom boundary downwards and leaving the upper boundary at its current depth.* *Further plume modelling will be done in detailed design to further verify that the design achieves the lake management objectives.*
The exit velocity at reinjection shall be so small that vertical displacement of the isopycnals (surfaces of equal density) shall be significantly smaller than the re-injection lens thickness. The design must be such as to prevent any accidental deviations from this throughout the lifetime of the facility.	*Yes*	*The net cross sectional area of the diffuser nozzles is a minimum of three times the cross sectional area of the riser pipe, which has effect of reducing the flow velocities to a minimum (~ 1 knot velocity).*
MTR2		
Using dilution water to adjust the density of degassed water before reinjection will normally be prohibited if taken from another zone. If required, dilution water must be taken from the zone into which the degassed water is re-injected	*N/A*	*No dilution system used.*
MTR3 (PlanA1)	*N/A*	*Not applicable*
When extracting gas-rich water from the LRZ, and re-injecting degassed water back into the same zone, the goal is to optimize performance under Plan A1 while allowing additional gas harvesting from the LRZ. Thus, the degassed water must be re-injected to restratify at the lower margin of the secondary density gradient separating the URZ and LRZ (at 325 m depth in 2004).	*Partially*	*All references to Plan A1 have not been taken into consideration.*
Meeting this objective will involve controlling the degassed water density through its CO_2 content (about 45% removal). *Plan A2 (this MTR4) must only be implemented if Plan A1 (MTR3) operations are working, and then only at about 50% of the total water extraction rate of Plan A1 operations.*	*No*	*To remove up to 45% of CO_2 by sending it to the Power Plant is technically possible but would result in increased capex, decreased generation capacity and hence increased electricity tariff. This is discussed further in Section 5.2.3* *It would, however, be possible to remove more CO_2 from the LRV and reinject*

		it either via the FRSS into the URZ/LRZ boundary or from the wash water discharge to beneath the biozone (in both cases, matching densities). This will be studied during detailed design in collaboration with the Lake Kivu Monitoring Program.
MTR5	*NA*	
MTR6		
When extracting gas-rich water from the Potential Resource Zone ….	*NA*	*Gas will be extracted from the LRZ.*
MTR7		
Methane gas produced offshore must not be transported to the shore in a way that might affect the surface use of the lake, or risk a gas outburst below the Biozone. *Any pipeline must be designed and equipped to prevent, under any circumstances, an uncontrolled flow of gas through the pipeline, and the release of gas below the Biozone.*	*Yes*	*Symbion is confident that the design and construction methods set out in export pipelines will limit the likelihood and hence the risk of a gas outburst below the Biozone to acceptable levels.* *In addition, there is no possibility of "gas creep" up the risers.*
Gas export pipelines must be located below -10 m depth. The Bilateral Regulatory Authority may approve shallower pipelines in special circumstances).	*Yes*	*The gas export pipelines will be located at a depth of - 20 m.*
MTR8		
The design of deep-water extraction systems must Yes prevent any self-sustaining gas-lift effect should a pipe-break or rupture occur (e.g. in a riser pipe or return water line) and result in the following *dangerous combination: An open-ended pipe length remaining suspended or standing:* *a) with the lower end in the Resource Zone; and* *b) the upper end close enough to the surface to sustain gas-lift.* *Gas concessionaires and their designers must make a convincing case that their underwater piping design will meet the objective of preventing this eventuality with sufficient reliability to ensure a fail-safe design.* *The designer must demonstrate that either the flow in the pipe will be completely arrested or that the pipe will naturally come to rest in an*	*Yes*	*The risers have a clump weight mounted just above the diffuser which will cause the riser to descend vertically into the very soft lake-bed mud (estimated to be 5-10 m deep). When the riser enters the mud the auto-siphon action will naturally be cut off.* *For any rupture that does not separate the riser from the separator, the changing pressure and flow readings from the Offshore Gas Plant will trigger automatic shutdown of the system via the shutdown valves.*

orientation that no longer connects the Resource Zone with the upper ~ 70 m of the lake in a manner that would support gas-lift.		
MTR9		
Gas extraction plant designs must ensure zero gaseous emissions during normal operations. Extraction facilities shall, as a minimum, be designed and operated to comply with the following regarding CH_4, CO_2 and H_2S releases during upset situations: *a)Offshore facilities: The amount of any gas released into the atmosphere must not be such as to result in atmospheric concentrations that would harm any person within the facility or nearby.* *b)Onshore facilities: The amount of any gas released into the atmosphere must not be such as to result in atmospheric concentrations that would harm any person within the facility, or harm or cause a nuisance to any person nearby.*	*Yes*	*The venting and flaring systems are described in Section 3.7.4.4*
MTR10		
Optimal use of the gas deposit while minimizing environmental impact requires that plant designs must be such as to minimize the loss of methane dissolved in the washing water.	*Yes*	*Negligible methane is dissolved in the wash water.*
MTR11		
Washing water containing hydrogen sulphide and discharged into the Biozone must be injected below depths inhabited by fish to prevent fish-kill in the biozone (now down to about 60 m depth) and so as to restratify above the centre of the density gradient below (now at about 70 m depth).	*Yes*	*All discharges are in depths below the biozone.*
MTR12		
Gas production systems must be demonstrably designed to yield the maximum useful energy while minimizing the unrecoverable losses.	*Yes*	*Symbion believes that its design provides the most efficient use of the methane resource. In particular, the use of very high efficiency gas engines to convert the methane to electricity provides for high overall efficiency.* *During detailed design, Symbion and its contractors will continue to optimise the*

		overall process to reduce energy losses.
MTR13		
In order to be able to react to changes, the concessionaire must include in the design the capability to be able to adjust their extraction and re-injection levels from time to time, or to be able to re-inject at multiple levels, simultaneously if required.	Conditional	*The free-standing risers makes their adjustment relatively straight-forward (although there will be some costs involved). Having 8 FRSS geographically spread over 4 barges also means that they can set to extract and reinject at different levels simultaneously if required.* *In undertaking its financial analysis, Symbion has assumed that this readjustment will be required twice during the 25-year post-COD term of the concession agreement and not more.*
The location of gas extraction platforms and associated satellite facilities shall all be located at least 500 m inside the specific concession boundary. This margin shall allow sufficient distance for all anchor systems to remain fully within the concession boundaries.	Conditional	*The barges have been provisionally located within the required boundaries, assuming that the necessary depths can be obtained without increasing the export pipe lengths (and hence capex).* *This will be further reviewed during detailed design following detailed bathymetry.*

2.2. Policy Framework

The national policy framework is based on a number of policies, plans and programs that ensure the conservation and use of natural resources. Among those policies are:

2.2.1 Rwanda Environmental Policy

The overall objective of the Environmental Policy is the improvement of man's well-being, the judicious utilization of natural resources and the protection and rational management of ecosystems for a sustainable and fair development.
The Policy seeks to achieve this through the following objectives.

(i) To improve the health and the quality of life for every citizen and promote sustainable socio-economic development through a rational management and utilization of resources and environment;
(ii) To integrate environmental aspects into all the development policies, planning and in all activities carried out at the national, provincial and local level, with the full participation of the population;
(iii) To conserve, preserve and restore ecosystems and maintain ecological and systems functioning, which are life supports, particularly the conservation of national biological diversity;

(iv) Optimum utilization of resources and attain a sustainable level of consumption of resources;
(v) to create awareness among the public about the relationship between the environment and development;
(vi) to ensure the participation of individuals and the community in the activities for the improvement of the environment with special attention to women and youth;
(vii) to ensure the fulfilment of basic needs of today's population and those of future generations.

2.2.2 Energy Policy

The national policy goal is to meet the energy challenges and needs of the Rwandan population for economic and social development in an environmentally sound and sustainable manner.

Since 1994, the energy sector as well as Rwanda's overall economy has gone through structural modifications, through which the role of the Government has changed, markets have been liberalized and private sector initiatives encouraged. Hence, the energy policy document has to take into account structural changes in the economy and political transformations at the national and international levels.

The national policy objective regarding the development of the energy sector is to provide an environmentally sound input in the energy development process by establishing an efficient energy production, procurement, transportation, distribution, and end-user system.

The Energy Policy, therefore, focuses on market mechanisms in aiming to realize this objective and achieve an efficient energy sector with a balance between national and commercial interests.

An interactive and participatory process between the Government, other stakeholders and relevant groups has been necessary as part of the formulation process in order to incorporate views of market actors and energy consumers to address the complex nature of the sector.

Specifically, the energy policy takes into consideration the need to:
(a) Have affordable and reliable energy supplies country wide;
(b) Reform the market for energy services and establish an adequate institutional framework, which facilitates investment, expansion of services, efficient pricing mechanisms and other financial incentives;
(c) Enhance the development and utilisation of indigenous and renewable energy sources and technologies,
(d) Adequately take into account environmental considerations for all energy activities,
(e) Increase energy efficiency and conservation in all sectors; and

(f) Increase energy education and build gender-balanced capacity in energy planning, implementation and monitoring.

Domestic energy demand has grown rapidly due to population growth and the increase in economic activities, especially during the last twelve years.

Biomass based fuels dominate the energy scenario, with an estimated 94 of the total energy supply made up of firewood, charcoal, and agricultural residues. This is likely to remain so in the near or even medium term future, unless income levels substantially increase. Lack of investment for about 20 years in electricity generation capacity has resulted in severe capacity deficits in electricity supply in Rwanda. At the same time, overuse of existing hydropower capacity has added a deficit in energy resources that not only deteriorates electricity but also the water supply because of its effect on water pumping stations.

It has been clear for some time that Rwanda's current energy deficit is critical, resulting in the over exploitation of hydropower water resources in preceding years. However, despite identifying multiple longer-term investment opportunities, including developing Lake Kivu's methane gas, Rusomo Falls, Nyaborongo and Rusizi 3, only limited progress has been made in securing funding for enhanced generation capacity.

Given that Rwanda is a land characterized by many hills and small rivers, there is also significant potential for the exploitation of micro-hydro power. Studies by the Ministry of Infrastructure have identified more than 160 sites with capacity potentials ranging from 20 KW to over 600 KW. Wind generated electricity has a little potential. Moreover, the transmission costs associated with transmitting small amounts of electricity over larger distances will remain a barrier to connecting wind turbines and micro-hydro plants to the grid. Without greater disposable incomes, it will be some time before electricity based on these resources will be affordable to rural communities.

Rwanda continues to rely on imported petroleum products. While electricity generation is mainly hydro-based, thermal plants provide 15 MW. Lake Kivu's methane gas reserves could enable Rwanda to greatly increase its energy independence. Discussions on ways of developing the methane gas to generate electricity are on-going. To date, the dissemination of renewable energy technologies has been limited to the promotion of improved stoves, improved charcoal production techniques, solar power, and biogas developments and to lesser extent photovoltaic cells.

The objective of the energy sector's development is to effectively contribute to the growth of the national economy and thereby improve the nation's average standard of living in a sustainable and environmentally sound manner.

The energy sector aims to create conditions for the provision of safe, reliable, efficient, cost-effective and environmentally conscious energy services to all sectors on a sustainable basis.

By fulfilling this mission, the energy sector will contribute to economic development and in the long-term poverty reduction.

Short and Medium Term Policy Priority Actions

The priorities for Rwanda's energy policy are to implement projects now so as to overcome the current electricity deficit, to pre-empt a future electricity shortage, to tackle proactively the wood crisis, to provide greater access to modern energy and to reduce reliance on imported petroleum products. Without efforts at these objectives, further capacity building and studies will have no value.

Rwanda's management and institutional capacity has to continue to progress if these projects are to be delivered effectively and efficiently. This will require further external support and guidance.

Several policy actions will be implemented in order to achieve the broad and specific objectives of this energy policy.

Priority Policy Actions

1. Meet the crisis of blackouts caused by delayed investment and drought
2. Provide economic power by developing the use of Lake Kivu methane, and by bringing on line more hydropower.
3. Enhance overall electrical infrastructure to meet demand growth and supply quality needs – generation, transmission and major distribution construction and rehabilitation.
4. Deliver a program of rural electrification on the basis of enhanced distribution networks, micro hydro, and solar power.
5. Implement a wood and charcoal efficiency and substitution strategy to counter the deforestation crisis.
6. Continue steady progress to a viable electricity and gas sector, consistent with meeting social needs.
7. Commence utilization of Lake Kivu's gas for projects other than immediate power generation.
8. Determine options for responding to oil prices and petroleum products costs, and their impact on the Rwandan economy. Reduce reliance on petroleum products.

2.2.3 The National Water Policy

The National Policy for Water and Sanitation aims to achieve in the short, medium and long term economically and environmentally sustainable benefits for the well being of the Rwandan population, and ensuring access to water in an equitable and sustainable manner.

6. The National Policy for the Habitat: grouping the perspective of the population, a pillar of the policy of the current habitat is among other things the release of agricultural land and reducing the pressure on the natural forest areas, marginal lands and wetlands.

7. National Strategy and Action Plan for the Environment: The strategy and environmental action plan date back to 1991. It aimed to achieve sustainable development by integrating environmental aspects.

2.2.4 Land Policy

Despite the fact that land has long been the most important economic, social and cultural asset of Rwandans, and has been the thrust of governance challenges for decades, the first comprehensive land policy was elaborated only in 2004. This policy has formed the basis of on-going land tenure reforms. The overall objective of the national land policy is to establish a land administration and land use management system that guarantees secure tenure for all users, promotes productive and sustainable use of rural and urban land resources and ensures protection of the environment. More specifically, the land policy seeks to:

- Put in place mechanisms which promote security of land tenure for the promotion of investments in land;
- Promote proper allocation of land, and proper use of land resources, according to their potential;
- Discourage land fragmentation and promote consolidated use in order to optimize production, by establishing appropriate mechanisms and incentive systems;
- Orient land management towards a more profitable and sustainable production, by making good choices among methods of land development;
- Promote techniques that protect land resources from all forms of land degradation.
- Establish institutional frameworks which enable land to become more valuable in the economy, or at the market;
- Promote research and public education on all aspects concerning land tenure, management, and transactions;
- Streamline and put in place orderly and equitable allocation of land, as well as in land transactions in order to control the pressure on land, inappropriate development and speculation in land markets;
- Sensitize the public and promote their active participation at all levels in decision making in order to ensure environmental protection and good practices in land management;
- Ensure the sustainable use of wetlands;

The policy objectives have been pursued through two broad areas: land tenure reforms, which include registration and titling, and improving land use through comprehensive land resources mapping and suitability assessment. The land policy is important for the sustainable management of environment and natural resources, and indeed the realization of the EDPRS and Vision 2020 aspirations because, because it is the resource base on which all economic, social and environmental development activities are anchored.

2.3 Institutional framework

2.3.1 Improving institutional capacity

Institutional coordination is still constrained by capacity limitations and knowledge gaps. For instance, there is not much awareness of the renewable energy alternatives and technology is very low in the country. Also the country is failing to benefit from the clean development mechanism because of a lack of knowledge on how to exploit the opportunities. There is also need for effective institutional coordination that promotes synergistic efforts towards a coherent national energy strategy particularly in favour of environmental protection.

The low consumption of commercial energy has had adverse impacts on economic growth, which is manifested in low levels of agricultural mechanization and industrialization. In the recent past Government has encouraged private sector in power generation. There is also need put in place effective strategies to build capacity, particularly for the private sector in conducting Environmental Impact Assessment (EIA). This has become evident with the development of the sector guidelines for environmental regulation, which has in all likelihood come with technical challenges to national environmental management.

The country's institutional architecture for promoting environmental sustainability has also improved. The establishment of REMA in 2006 provided the country with the institutional machinery for supporting the implementation of the environmental policies and laws. The post genocide political dispensation, especially the principles associated with decentralization and democratization, has helped to ensure the engagement of the population in development of Rwanda's environmental policies and laws. Globally, poor people who are largely dependent on natural resources continue to have precarious livelihoods

2.3.2 Ministry of Natural Resources

The Ministry is responsible for:
- The development and land use;
- The development of environmental policies and procedures;
- The protection of natural resources (water, land, flora and fauna)
- The environmental legislation,
- The biodiversity and other environmental aspects.

MINIRENA has an Environmental Department that coordinates and monitor the environmental related actions as well as the coordination of actions of the various conventions on the environment. He oversees the Office of the Rwanda Environment Management Authority (REMA), which is the implementing agency of policies and laws related to the environment.
Analysis of the forestry sector shows some weaknesses vis-à-vis institutional capacity. There is need for institutional development at the central administration level - the ministry and the National Forest Authority (NAFA) and at the local level - district and sector. Provision of

adequate resources and qualified staff to NAFA, districts and sectors is of paramount importance to ensure sustainable management of forest resources.

In line with this, it will be necessary to improve coordination mechanisms for different actors in the forestry sector. These will include the ministries, authorities, research institutions and non-governmental organizations. Information flow will also have to be improved. Forestry extension at national level, research and documentation of best practice are among some of the strategies that can be used.

The development of human capacity in forestry is an area that has been identified for attention. It involves the education of foresters at technical and professional levels to address the needs of the public and private sectors. In this regards, the National University of Rwanda has started a master's degree in agro-forestry. There are also other capacity building programmes being implemented through regional and international cooperation.

2.3.3 Ministry of Agriculture and Animal Resources

The Ministry of Agriculture and Livestock is responsible for the implementation of sectoral policy to monetize the ground heritage, particularly through soil conservation practices, integrated watershed management and wise use of marshland.

2.3.4 Ministry of Education

It is through the curriculum integrating environmental component at all levels that the ministry contributes to the formation of responsible citizens aware of the environmental problems of the country and the conservation of biological diversity.

2.3.5 Ministry of Local Government

The Ministry of Local Government, Community Development and Social Affairs is responsible for territorial administration, supervision of decentralized entities operations and capacity building. In terms of environment, it is involved in outreach and environmental awareness of the population in decentralized administrative entities.

2.3.6 Ministry of Infrastructure

The ministry has as specific mission in energy sector, to initiate, develop and maintain sustainable power generation facilities to supply clean, cost-effective and uninterrupted energy for the country and the region. Its other mission is also to orient and supervise the functioning and management of public institutions, agencies and companies under the Ministry of Infrastructure including existing agencies such as Rwanda Civil Aviation Authority (RCAA), Rwanda Energy Group (Energy Development Company Ltd, Energy Utility Company Ltd), RwandAir and other agencies to be formed under its sub-sectors.

2.3.6.1 REG/EDCL

The law repealing EWSA Law of 97/2013 of January 31, 2014 paved the way for the creation of two corporate entities, which were subsequently incorporated in July 2014 with 100% government shareholding. The Rwanda Energy Group Limited (REG Limited) and its two subsidiaries; The Energy Utility Corporation Limited (EUCL) and The Energy Development Corporation Limited (EDCL) entrusted with energy development and utility service delivery while the Water and Sanitation Corporation (WASAC) has the mandate to develop and operate water and sanitation infrastructure and deliver related services in the country.

The Rwanda Energy Group Limited was incorporated to expand, maintain and operate the energy infrastructure in the Country through its two subsidiaries the Energy Utility Corporation Limited (EUCL) and the Energy Development Corporation Limited (EDCL). The objective of creating these subsidiaries amongst others was to ensure focused attention to enhancing efficiency in utility operations on one hand and ensure more timely and cost efficient implementation of development projects on the other. Moreover, the REG holding structure provides the overall coordination and ensures effective development of energy and investment plans.

Overall the group structure is aimed to ensure the autonomy and efficiency of the EDCL and EUCL
EDCL vision and mission are the following:

Vision:
"To be the most efficient and customer centric utility company in the region"
Mission:
"To provide sufficient and quality of electricity to our customers at affordable and sustainable rates that support the socio-economic development of the country."

2.3.6.1 REMA

REMA is non-sectorial institution mandated to facilitate coordination and oversight of the implementation of national environmental policy and the subsequent legislation. REMA operates under the Ministry of Natural Resources (MINIRENA). **REMA Regulations** under the organic law on environmental protection and management provide the requirements for an EIA study and report as well as provide a list of projects eligible for a full EIA and those subject to Limited EIA. This project falls in the category for which a full EIA is required and therefore was undertaken.
REMA as the Environmental Authority has the mandate to conduct environmental monitoring to make sure the recommendations of the Environment and Social Impact Assessment study and proposed mitigation measures.

Institutional Capacity for Safeguard Policies

The Rwandan National Environment Policy (October 2003) sets out overall and specific objectives as well as fundamental principles for improved management of the environment, both at central and local levels, in accordance with the current policy of decentralization and good governance in Rwanda. The policy sets out institutional and legal reforms with a view to providing the country with a coherent and harmonious framework for coordination of sectoral and crosscutting policies. It calls for the establishment of the Rwanda Environment Management Authority (REMA) and the provincial, district and lower level committees responsible for environmental protection. The policy recognizes that the environment is a new concern in Rwanda, requiring awareness and coordination of actions at various levels.
The main institutions with responsibility for the environment are the Ministry of Lands, Environment, Forestry, Water and Mines (MINIRENA) and the Rwanda Environmental Management Authority (REMA), the latter of which was established in 2005. Within the MINIRENA the Directorate of Environment is broadly responsible for policy issues, the budget and for monitoring policy implementation; whereas REMA is the technical arm of the MINIRENA and is responsible for implementing the environment policy.

2.3.7 Rwanda Development Board (RDB):

During a cabinet meeting in 2009, it was decided the environmental unit seating in REMA and in charge of review of EIA reports and issuance of Environmental Certificates be deployed to RBD to enhance assistance to the private sector.

2.3.8 RURA (Rwanda Utilities Regulatory Agency), an independent multi-sector regulatory body, currently regulates both the electricity and gas sectors.

2.3.9 Rwanda Natural Resources Authority

RNRA is an authority that leads the management of promotion of natural resources, which is composed of land, water, forests, mines and geology. It shall be entrusted with supervision, monitoring and to ensure the implementation of issues relating to the promotion and protection of natural resources in programs and activities of all national institutions. Particularly, RNRA is responsible among others for:
1° implementing national policies, laws, strategies, regulations and government resolutions in matters relating to the promotion and protection of natural resources;
2° making a follow up and implementing international conventions Rwanda ratified on matters relating to the conservation of natural resources;
3° advising the Government on appropriate mechanisms for conservation of natural resources and investments opportunities;
4° registering land, issuing and keeping land authentic deeds and any other information relating to land of Rwanda;
5° ensuring proper geological data and their respective maps;
6° providing technical advice on the proper use of natural resources;
7° making follow up and supervising activities relating to proper management, promotion and

valuation of natural resources; and
8° rehabilitating and conserving where natural resources are damaged in the country.

2.4 Transboundary resources management

2.4.1 Agreements between the Republic of Rwanda and the Democratic Republic of Congo

Rwanda and DRC signed the Bukavu Agreement in 1975, whereby they declared Lake Kivu's gas to be a joint resource and agreed to create a jointly owned company: the SOCIGAZ.

Further, in 1988 another Agreement was signed by the two countries stipulating that the Democratic Republic of Congo and the Republic of Rwanda may approach, negotiate and select the concessionaires operating on their respective territories, and may independently determine the financial conditions of concessions; these conditions should be in accordance with the provisions of the Resources Management Agreement[3].

2.5 International Legislations

2.5.1 Introduction

The Project is required to meet the international standards of the IFC, which is part of the World Bank Group. The international environmental and social safeguard policies of these organizations are outlined below, as are the main international conventions that Rwanda is a signatory.

2.5.2 Conventions signed or ratified

Rwanda is a signatory to a number of conventions on sustainable development and is a member of various bilateral and multilateral organizations.
In addition to the national regulations of the environmental management in Rwanda has ratified several international conventions including:
• United Nations Framework Convention on Climate Change.
• United Nations Convention on Biological Diversity.
• United Nations Convention to Combat against Desertification (UNCCD).
• Stockholm Convention on Persistent Organic Pollutants.
• Vienna Convention for the Protection of the Ozone Layer, the Montreal Protocol on Substances that Deplete the Ozone Layer and the Amendments to the Montreal Protocol.
• Rotterdam Convention on the Prior Informed Consent Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade.
• Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal.

[3] Hassan 2000

• Ramsar Convention on Wetlands of International Importance especially as Waterfowl Habitat.
• Convention on the Conservation of Migratory animals wildlife and the Convention on International Trade in Endangered Species of wild flora and fauna threatened with extinction.
• Phytosanitary Convention for Africa.
• African Convention on the Conservation of Nature and Natural Resources.

2.5.3 World Bank Group EHS Guidelines

The EHS Guidelines produced by the World Bank Group are technical reference documents on cross-cutting environmental, health, and safety issues applicable to all industry sectors. They cover general and industry-specific examples of Good International Industry Practice, as defined in IFC's Performance Standard 3 on Pollution Prevention and Abatement.

The General EHS Guidelines (April 2007) contain the performance levels and measures that are normally acceptable to the IFC and are generally considered to be achievable in new facilities at reasonable costs by existing technology.

When host country regulations differ from the levels and measures presented in the EHS Guidelines, projects are expected to achieve whichever is more stringent. If less stringent levels or measures are appropriate in view of specific project circumstances, a full and detailed justification for any proposed alternatives is needed as part of the site-specific environmental assessment. This justification should demonstrate that the choice for any alternate performance levels is protective of human health and the environment.

Specific Industry EHS Sector Guidelines relevant to the project are:

1. Thermal Power Plants

2. Natural Gas Processing

3. Gas Development

2.5.4 IFC Performance standards

To manage the social and environmental risks and impacts of IFC projects, the IFC has developed a number of environmental and social PS. The IFC PS, updated in 2012, and the accompanying Guidance Notes have been adopted for this Project.
IFC PS indicate that the party responsible for implementing and operating the project must comply with the applicable national laws, including those laws implementing host country obligations under international law. The project operator is also required to meet the

requirements of the standards throughout the life of an investment by IFC or other relevant financial institution. These are as follows:

- Performance Standard 1: Assessment and Management of Environmental and Social Risks and Impacts
- Performance Standard 2: Labour and Working Conditions
- Performance Standard 3: Resource Efficiency and Pollution Prevention
- Performance Standard 4: Community Health, Safety, and Security
- Performance Standard 5: Land Acquisition and Involuntary Resettlement
- Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources
- Performance Standard 7: Indigenous Peoples
- Performance Standard 8: Cultural Heritage

The following PS are triggered by the project:

Performance Standard 1 covers several types of Environmental Assessment instruments, including ESIAs. These standards require that the Environmental Assessment is undertaken to a high standard and compliant with International Best Practice. Specifically, the objectives of PS1 are:

- To identify and evaluate environmental and social risks and impacts of the project;
- To adopt a mitigation hierarchy to anticipate and avoid, or where avoidance is not possible, minimize, and, where residual impacts remain, compensate/offset for risks and impacts to workers, Affected Communities, and the environment;
- To promote improved environmental and social performance of clients through the effective use of management systems;
- To ensure that grievances from Affected Communities and external communications from other stakeholders are responded to and managed appropriately;
- To promote and provide means for adequate engagement with Affected Communities throughout the project cycle on issues that could potentially affect them and to ensure that relevant environmental and social information is disclosed and disseminated. This scoping report is the initial step for the full Environmental and Social Impact Assessment and for the design of an Environmental and Social Management System for the project that will function throughout the construction, operational and decommissioning phases of the projects.

Performance Standard 2: Labour and Working Conditions aims to promote the fair treatment, non-discrimination, and equal opportunity of workers; to establish, maintain, and improve the worker-management relationship; to promote compliance with national employment and labour laws; to protect workers, including vulnerable categories of workers such as children, migrant workers, workers engaged by third parties, and workers in the client's supply chain; to promote safe and healthy working conditions, and the health of workers and to avoid the use of forced labour. Compliance with this performance standard is addressed in this scoping report in section 9.2.5 Worker Welfare and will be further considered in the ESIA.

The PS2 Recognizes that the pursuit of economic growth through employment creation and income generation should be accompanied by protection of the fundamental rights of workers. For any business, the workforce is a valuable asset, and a sound worker-management relationship is a key ingredient in the sustainability of a company.

Performance Standard 3: Resource Efficiency and Pollution Prevention, aims to avoid or minimize adverse impacts on human health and the environment by avoiding or minimizing pollution from project activities, to promote more sustainable use of resources, including energy and water and to reduce project-related GHG emissions.

Compliance with this PS is considered as a result of the information gathered during the scoping exercise (review of the project information, initial site investigations, stakeholder engagement and identification of potential impacts) a list of preliminary mitigation measures has been compiled for consideration in the ESIA. This preliminary mitigation measures will be reviewed in light of the additional information gathered as part of the ESIA preparation, including the additional baseline surveys and consultations and the systematic assessment of impacts.

Performance Standard 4: Community Health, Safety, and Security aims to anticipate and avoid adverse impacts on the health and safety of the Affected Community during the project life from both routine and non-routine circumstances and to ensure that the safeguarding of personnel and property is carried out in accordance with relevant human rights principles and in a manner that avoids or minimizes risks to the Affected Communities. Compliance with this PS in relation to environmental impacts to the affected communities is considered in sections 9.2.5 for Air Quality, Geology, Soil, Groundwater and water resources, Noise and Vibration, Wastewater Management and Solid and Hazardous Waste. The safeguarding of personnel is considered in 9.2.5 Worker Welfare and emergency preparedness is considered in the draft ESMS.

Performance Standard 5: Land Acquisition and Involuntary Resettlement. Land acquisition for the land has been undertaken on a voluntary basis. The agreement was voluntary and no expropriation process would have been triggered if a voluntary agreement had not been reached. Even though there is no involuntary resettlement, a Livelihood Restoration Plan has been prepared to anticipate and avoid, or where avoidance is not possible, minimize adverse social and economic impacts from land acquisition or restrictions on land use by (i) providing compensation for loss of assets at replacement cost and (ii) ensuring that resettlement activities are implemented with appropriate disclosure of information, consultation, and the informed participation of those affected; and to ensure that there is a restoration and improvement of the livelihoods and standards of living of the economically displaced persons;

Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources. The project is not expected to impact critical ecosystems, but the objectives of this PS will be taken into consideration. This standard aims to:

- Protect and conserve Lake Kivu biodiversity;
- Maintain the benefits from ecosystem services; and
- Promote the sustainable management of living natural resources through the adoption of practices that integrate conservation needs and development priorities.

Performance Standard 7: Indigenous People. This is one of the IFC Performance Standards that are not triggered as the proposed project lies within an area where there are no tribes that comply with the required characteristics in terms of internal organization and cultural and historical attachment to the land to be classified as indigenous peoples. However, this PS includes requirements in terms of establishing and maintaining an on-going relationship based on Informed Consultation and Participation (ICP) with the local communities affected by a project throughout the project's life-cycle that will be complied with.

Performance Standard 8: Cultural Heritage. The PS aims to Protect cultural heritage from the adverse impacts of project activities and support its preservation and to promote the equitable sharing of benefits from the use of cultural heritage The project is not expected to affect any cultural heritage.

Project Categorisation and standards

The Project is assessed against IFC Performance Standards and national EIA guidelines. It should be noted that the IFC has recently completed a review of its 2006 Performance Standards; these revised standards came into effect on the 1st January 2012.

The Symbion Power project is categorised according to the IFC categorisation and standards.

Similar to the ADB, the IFC standards uses a system of project categorising to determine the level of assessment and mitigation required. Projects are categorised, A, B or C based on the magnitude of their potential environmental and social effects. With reference to these standards, the Project is considered to be a 'Category A' project for the purpose of this assessment. IFC standards defines a 'Category A' project as one that is likely to have significant adverse environmental impacts that are irreversible, diverse, or unprecedented.

An environment and social assessment for a Category A project is required to examine the project's potential positive and negative impacts, compare them with those of feasible alternatives (including the "without project" scenario) and recommend any measures needed to prevent, minimize, mitigate, or compensate for adverse impacts and to improve performance.

Table 6: IFC Project categorisation

Category	Description
Category A	Business activities with potential significant adverse environmental or social risks and/or impacts that are diverse, irreversible, or unprecedented.
Category B	Business activities with potential limited adverse environmental or social risks and/or impacts that are few in number, generally site-specific, largely reversible, and readily addressed through mitigation measures.
Category C	Business activities with minimal or no adverse environmental or social risks and/or impacts.
Category F1	Business activities involving investments in FIs or through delivery mechanisms involving financial intermediation. This category is not applicable to the Project being considered here.

The Project has the potential to cause adverse impacts on the community and on the environment. The Project has the susceptibility to impact the lake stability and lake gas stratification; it may impact the lake as a sensitive area and has the potential to have diverse types of impacts. Therefore, this Project is considered to be a Category A project. However, it is considered feasible to mitigate and manage the majority of impacts associated with the Project through appropriate environmental and social management together with the monitoring to be specified in the ESMP and related plans that will be the outcome of this ESIA process.

3.0 Project Description

3.1 Introduction

This chapter defines the project characteristics including its location, type, design layout and components as mostly extracted from the current project feasibility study. It also describes the various activities that will be undertaken during its development.

3.2 Background

Rwanda is a dynamic country, which is trying to speed up development after the events of 1994. Unfortunately, this attempt is made difficult by serious deficiencies in the availability of energy resources. Energy consumption in Rwanda is greatly inferior to that needed for industrialization. The required minimum is generally thought to be 0.6 tep (ton equivalent petroleum) per person per year, whereas at the moment available energy is of the order of 0.16 tep per person per year. Today 80% of electricity consumed is by the capital city, Kigali, where only 5% of the population lives.

The Government of Rwanda (GoR) has decided to increase the energy production with diversification of energy resources. One of these resources is the methane gas trapped in the deep waters of Lake Kivu. The Government of Rwanda (GoR) has called upon Independent Power Producers (IPPs) to use this resource to build Rwanda's power generation capacity, which promises to be one of the most cost-effective sources of electricity available to the country.

On August 7, 2014, after a competitive bidding process, Rwanda's Energy, Water and Sanitation Authority (EWSA, now REG) awarded Symbion Power a concession to finance, design, build, own, and operate a 50 MW methane gas fuelled power plant on Lake Kivu. Symbion was one of six pre-qualified bidders and submitted the only bid to satisfy the technical requirements.
Following the successful bid, Symbion entered into an MoU with GoR outlining expectations and next steps. This MoU was signed and dated on November 3, 2014

3.3 Project Overview

The Project consists of extracting gas dissolved within a deep layer of water in Lake Kivu and processing it to remove water and other gases so as to concentrate the methane content until it is suitable for supplying gas- fired generators to produce electricity. The Gas Plant will have both an offshore and an onshore component, connected via submerged pipelines. The Power Plant will be comprised of generators as well as step-up transformers to transfer electricity to the Rwandan 220 kV grid.
The basic processes and technologies proposed for this Project are similar to those used elsewhere in the world on offshore gas processing and power generation projects. Symbion and its contractors have taken these basic concepts and optimized them for this Lake Kivu application.

3.4 Project objectives

The Symbion Lake Kivu project has the following objectives:

-Increase substantially Rwanda's available electricity generation at a much lower cost that existing diesel and heavy fuel oil based generation;
-Provide a major boost to Rwanda's economic development
-Support all other industries, small and medium sized enterprises and residents with a reliable and cost effective source of electricity.
-Invest in Power generation and realize economic benefit while maximizing financial return on the project.

3.5 Project justification

Symbion power Lake Kivu Ltd project presents an opportunity for generation of 50MW of low cost electricity that compares favorably with generation from other sources.

Lake Kivu is currently estimated to contain 255 billion cubic meters of carbon dioxide and 55 billion cubic meters of methane in its lower density layers. Without intervention, the gas concentrations are estimated to approach saturation and produce a cataclysmic gas release within a range of 50 to 200 years.

Gas extraction will be conducted in compliance with the "Lake Kivu Gas Extraction: Basic Principles, Mandatory Requirements and Guidelines for the concessionary Design and Operation of Gas Extraction Plants[4]. These guidelines were produced jointly by the governments of Rwanda and the Democratic Republic of Congo and were established by a panel of international experts that determined the restrictions that should apply to KP1 and any project that is to extract and exploit Lake Kivu Gas in the future.

The proposed project will meet those elements pertaining to lake stability and the environment in both documents.
Rwanda suffers from a serious energy deficit, which is constraining economic development. As of 2008 only 6% of the population had access to electricity. By the year 2020, Rwanda Energy Group/Energy Development Corportaion (REG/EDCL), intends to extend coverage to 36 or 40 percent of the country's households and the SPLKL project will play an important part in meeting that target.

3.6 Project location

Symbion Power Lake Kivu Ltd (SPLKL) through tender was granted a concession to extract and process methane gas for power energy. The concession area marked concession area 2 is in the south of Rubavu and is depicted in the figure below.
After comparing with some other sites, the peninsula near Busoro, was chosen as the preferred site for the gas and power plants. The area is flat enough to construct the Onshore Gas Plant, the Power Plant and the Substation.

[4] Management Prescriptions, 2008

3.6.1 Onshore site Demarcation

- The centre of the Onshore Gas Plant shall be located at 1°45'34.23"S, 29°16'34.95"E, which is approximately 10 km south of Rubavu.
- The Site consists of all land within the boundaries of the polygon formed by connecting each of the boundary points set out in table below using straight lines. This polygon is illustrated by the figure below.
- The Site has an area of approximately 11.2 hectares.
- The entrance point to the Site (“**Site Entrance**”) shall be located at approximately 1°45'33.31"S, 29°16'33.03"E, and is marked as an orange circle in the figure below
- All latitude and longitude coordinates given in this Paragraph use the World Geodetic System of 1984 (WGS84) datum.

Figure 2: Site boundaries outlined by the white shaded polygon and Site Entrance marked in orange

Table 7: GPS Coordinates for Site Boundary Points

Boundary Point Number	Longitude	Latitude
1	29.27895967921116	-1.758158078076137
2	29.27884443524934	-1.757922797198462
3	29.2786942063858	-1.757663844968647
4	29.27852176880086	-1.757461629844598
5	29.27413585524495	-1.75798416531948

Boundary Point Number	Longitude	Latitude
6	29.27399005942381	-1.758308910187056
7	29.27388589280356	-1.758662148063319
8	29.27382931990252	-1.759020690432303
9	29.2738258517691	-1.759496888894441
10	29.27388545580385	-1.759896372441893
11	29.27535434448831	-1.760142586534029
12	29.27753452897629	-1.76177511090353
13	29.2777066903923	-1.76169333932912
14	29.27769575359567	-1.761491313922302
15	29.27776162327091	-1.761329064030831
16	29.27781757591498	-1.761213210622143
17	29.27779816694381	-1.760927088968095
18	29.277709873298	-1.76062837490641
19	29.27772309735655	-1.760329685086006
20	29.27779606195421	-1.759792250888652
21	29.27781010495883	-1.759311795926453
22	29.27788186548931	-1.759036936413729
23	29.27814292000978	-1.758703170260651
24	29.27851959815192	-1.758392903510914
25	29.2787727586364	-1.75819259082783
26	29.27895967921116	-1.758158078076137

Onshore easement

The Site shall include an easement from the landing site of the offshore gas pipeline, to be located at approximately 1°45'35.11"S, 29°16'29.95"E, to the main area of the Site.

3.6.2 Offshore site Demarcation

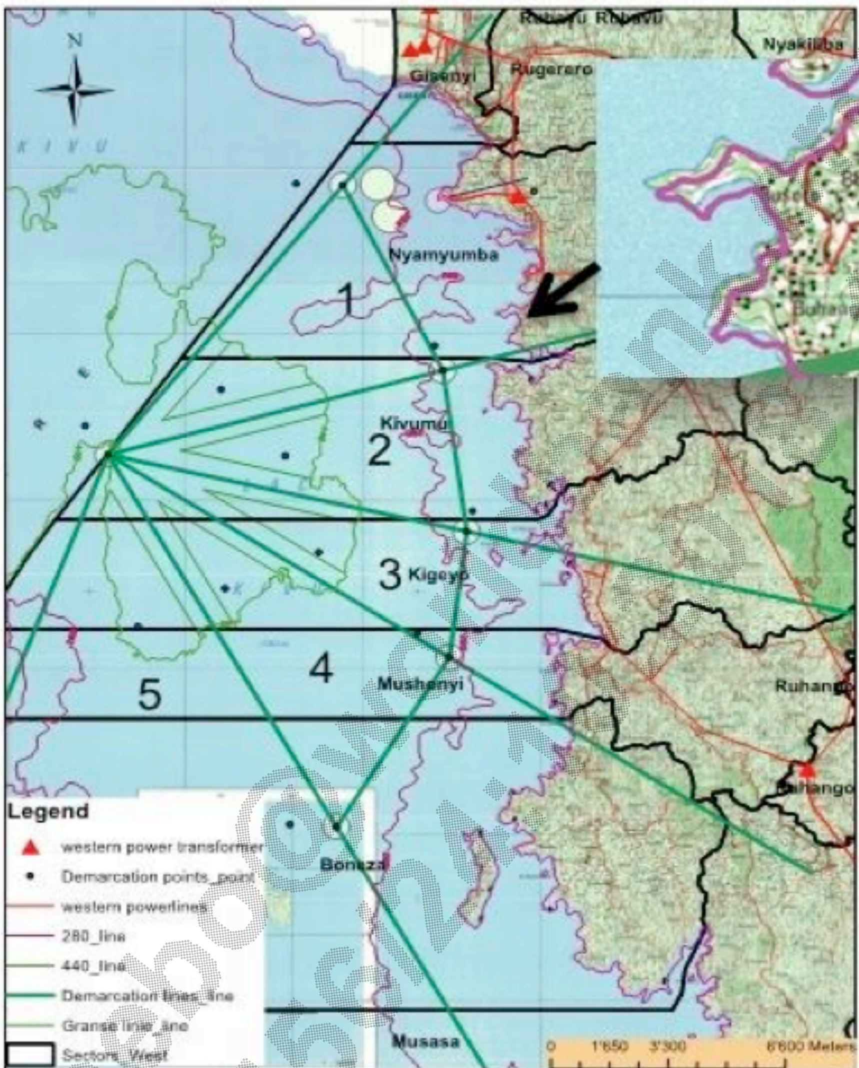


Figure 3: Concession boundaries of Symbion Power Lake Kivu Ltd

The concessions 1 and 4 have been granted to KP1/REC and Contour Global, respectively. The barges will be located where the lake depth is approximately 380 m - 420 m. This will allow the risers to access the desired resource zone while avoiding interference from lake sediment.

The final positions will depend on a detailed bathymetry, which will be completed during the detailed design phase. A preliminary layout is shown by the figure 2.

These barge locations give an overall distance of approximately 5 km for the export pipeline.

While the gas plant, gas power plant and substation will be constructed at the peninsula near Busoro, an existing jetty known, as Kitraco will be upgraded to facilitate barges construction. The site is about 2.5 km south of Rubavu. It was used to construct the KP1 facility. Kitraco appears to be available for this project, although the landowners have not yet been contacted and there is some ongoing, limited use of the site.

Offshore easement

The Site shall include an easement extending not less than 1,000m from the lakeshore adjacent to the Site and having a width of not less than 100m from which the project shall have the right to extract water for use in, and to reinject water resulting from, the onshore component of its Gas Plant, but not to extract any Gas.

The Site shall include an easement sufficient to install gas pipelines from the Extraction Area to the Site.

Extraction Area

The Extraction Area is the area of Lake Kivu within Rwanda delineated by the polygon numbered 2 in the figure 3, formed by linking the points set out in **Error! Reference source not found.** using straight lines.

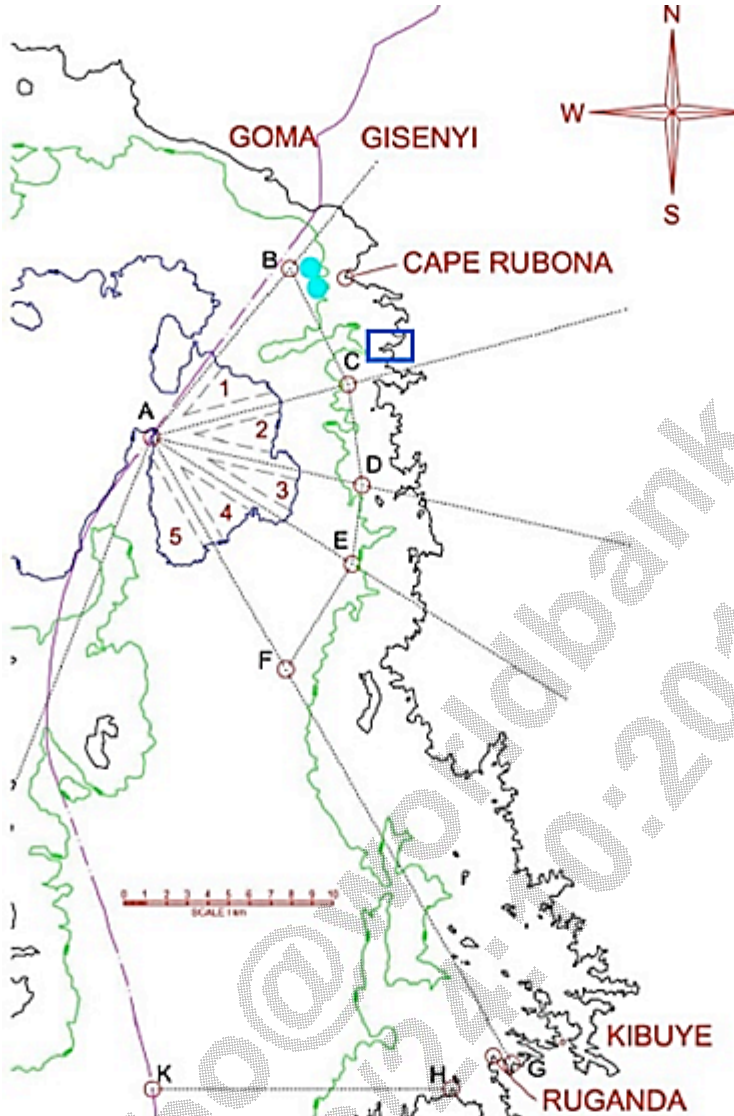


Figure 4: Map of Lake Kivu and surrounding shore showing the Extraction Area (Area 2) and the onshore component of the Site (demarcated in blue)

Table 8: GPS coordinates of the boundary points of the Extraction Area

Point	Longitude	Latitude
A	29.171800	-1.798650
C	29.256600	-1.775830
D	29.262700	-1.819450

ProjectCo shall extract Gas from the Lower Resource Zone (as that term is defined in the Management Prescriptions), unless otherwise agreed between the Parties.

3.7 Description of project activities

The project will be developed in three different phases:
Phase 1: Construction of off shore and onshore facilities including the construction of the gas plant and power plant (detailed above).
Phase 2: The operation of the onshore and off-shore facilities (detailed above) involving the extraction of the gas, its processing and power generation. It will start with a single offshore gas extraction system and barge supplying a modular onshore gas processing plant and power plant, followed by the remaining 3 barges to ramp up to 50MW. This modular, phased approach will reduce overall risk by ensuring that any unforeseen problems can be identified and rectified in the first stage.
Phase 3: The decommissioning of the offshore and onshore facilities. The design life of the Plant is 25 years in accordance with the term of the concession agreement.

At the end of the useful life of the project onshore and offshore installations, the plant will be decommissioned in accordance with legislative guidelines current at that time. Alternatively, if market conditions and / or electricity supply constraints at that time indicate that it would be appropriate to extend the life of the project, then decommissioning may be deferred to a later date. In order to ensure continuing adequate condition and environmental performance, the project would be re-engineered and re-permitted as required, dependent on the legislative requirements at that time.

Independently validated plant closure/ demolition methodologies must be developed for the specific gas to power facilities that are at the end of their useful life. The methodologies cover demolition of the equipment and buildings and removal of any contaminated and hazardous material from the site. When demolishing the project, it will be a matter of policy to ensure that the sites are left with no environmental risks.

In order to facilitate decommissioning much of the plant on sites will be made of materials suitable for recycling. In addition, a large proportion of the buildings will be constructed of pre-fabricated steel and will therefore also be of interest to a scrap metal merchant. After the removal of the main items of plant and steel buildings the remaining buildings will be demolished to ground level. All underground structures will either be removed or made safe. All debris to be removed offsite will be sent to a licensed disposal facility.

The results of the pre-construction contaminated land survey will be used as a basis for a further contaminated land and water survey to be performed when the plant is closed to assess whether or not any contamination of the sites has taken place during the lifetime of the plant. The sites will be returned to a condition suitable for reuse.
During decommissioning, all reasonable measures required to prevent any future pollution of the site will be carried out. This will include measures such as:

a) the emptying / cleaning and removal of storage tanks; and

b) the removal from site of all materials / liquids liable to cause contamination.

The surface water drainage system for plant will continue to operate through the decommissioning phase. Any areas where oil spillage could occur will continue to drain to an oil interceptor, which will continue to be maintained.

The decommissioning phase is likely to take place over several months.

The site's subsequent use would be discussed with the relevant authorities as part of the decommissioning process.

The schedule summary of activities is given in appendices (appendix 1)

3.7.1 Design concept and requirements

Initial gas extraction operations and total gas production rate are some of mandatory technical requirements provided through the Management Prescriptions (MPs). This is the context within which the gas plant was designed. Symbion has considered each prescription in the design.

3.7.2 Proposed construction activities and methodology

3.7.2.1 Offshore

Offshore construction activities will be coordinated from the Kitraco site. The existing jetty at Kitraco will be upgraded to accommodate the offshore construction activities, which will be basically assembling of barges, separator and risers. The barges themselves will be constructed from that site, as will the separator vessels and all risers. A construction barge and two Meercat (or similar) support vessels will carry out the actual offshore installation, with the construction barge being converted into the fourth barge after the installation of the third.

Barges assembly

The barges to support the Offshore Gas Plant will be constructed out of 40 ft. DnV standard containers with interlocking connectors. All internal stiffening will be completed prior to over-boarding the containers by the crawler crane. The floating containers will be manoeuvred and assembled with the assistance of the support vessels.

Barges topsides erection

The completed barge will be brought alongside the quay wall for installation of the topsides equipment. The equipment will be lift installed by the crawler crane. Given the limited quay wall length, equipment will be installed on one end of the vessel first. A support vessel will then rotate the barge 180 degrees to complete the installation.

Risers and separators fabrication and installation

The first step in the FRSS installation is installing the anchors to the lakebed. The separator and risers are then assembled and upended with the assistance of the installation barge and a support vessel. The separator is then moved between the anchors by the installation vessel and tethered.

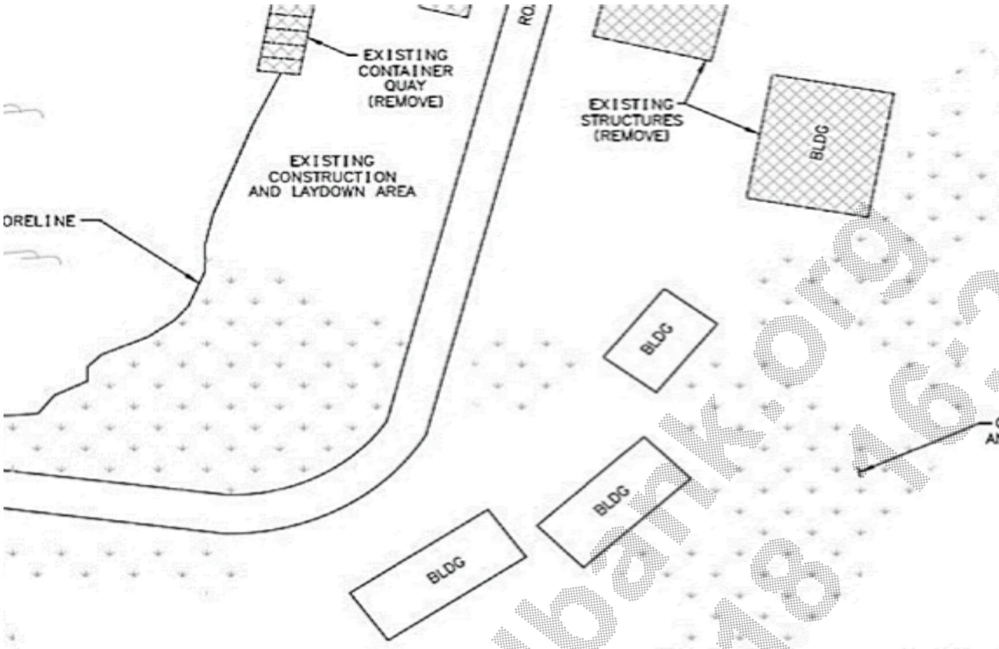


Figure 5: Present layout of Kitraco Jetty

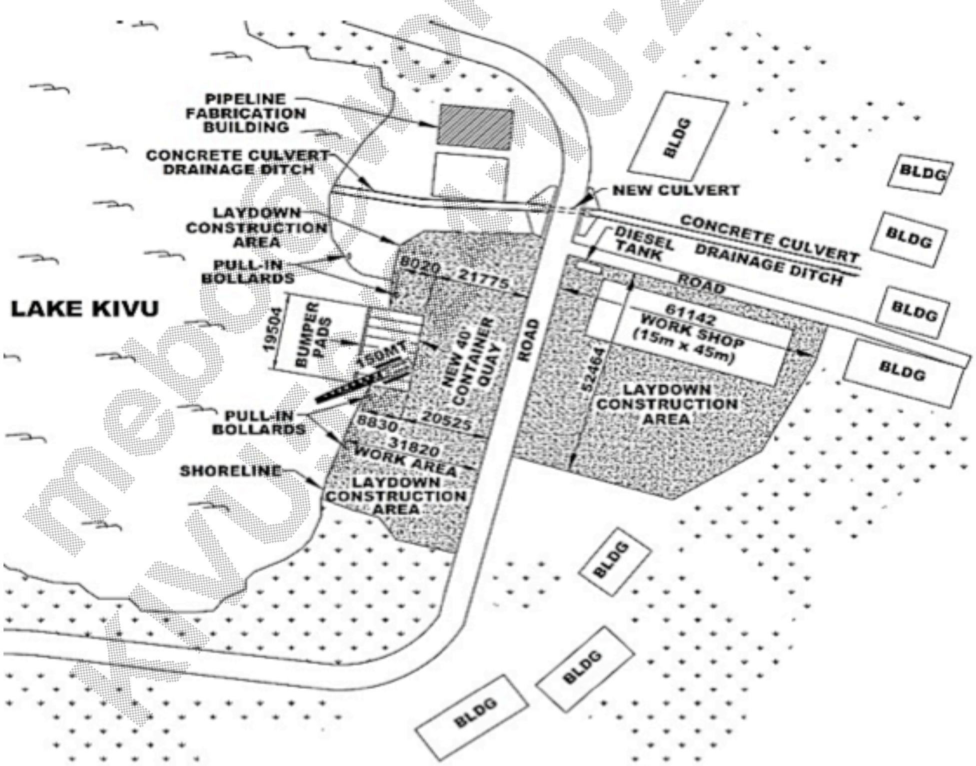


Figure 6: Proposed modification of Kitraco Jetty

3.7.2.2 Onshore gas plant

The installation of the onshore equipment will commence once the foundations have been laid, with the aid of a small, mobile crane. The wash water towers will require two 150 t cranes to lift and upright them over the foundations (one of which will be shared with the Kitraco site). Most of the piping spools and secondary steel will be preassembled offsite, reducing fabrication costs and schedule.

The Onshore Gas Plant construction will be carefully coordinated with the Power Plant construction, which will be taking place at the same time.

3.7.3 Proposed gas processing activities and methodology

The project design has considered combining offshore and onshore facilities. Constructability and operability has been improved by placing as much as possible the gas process onshore, and splitting the offshore components into reasonably small, easily constructible sections.

The offshore component comprises four barges supporting topsides process equipment, each drawing gas from two Free-standing Riser and Separator Systems (FRSS).

There will be a total of 4 barges, each with a capacity of supplying 2 x 14 MW of methane gas to shore with a total interconnected capacity of 56 MW.

Figure 7: Locations of the 4 offshore gas barges and the route of the export pipelines

Each FRSS consists of a separator and two risers that are tethered to the lakebed. Water from the depths of the lake is drawn up through the first riser and separated under hydrostatic pressure in the separator. The degassed water is the rejected through the second riser.

The liberated gas is fed into the Offshore Gas Plant via flexible risers where it is scrubbed of water and compressed. The process equipment on each barge consists simply of two compression trains, utilities, and an emergency generator system to provide power to the utilities in case of a shut down.

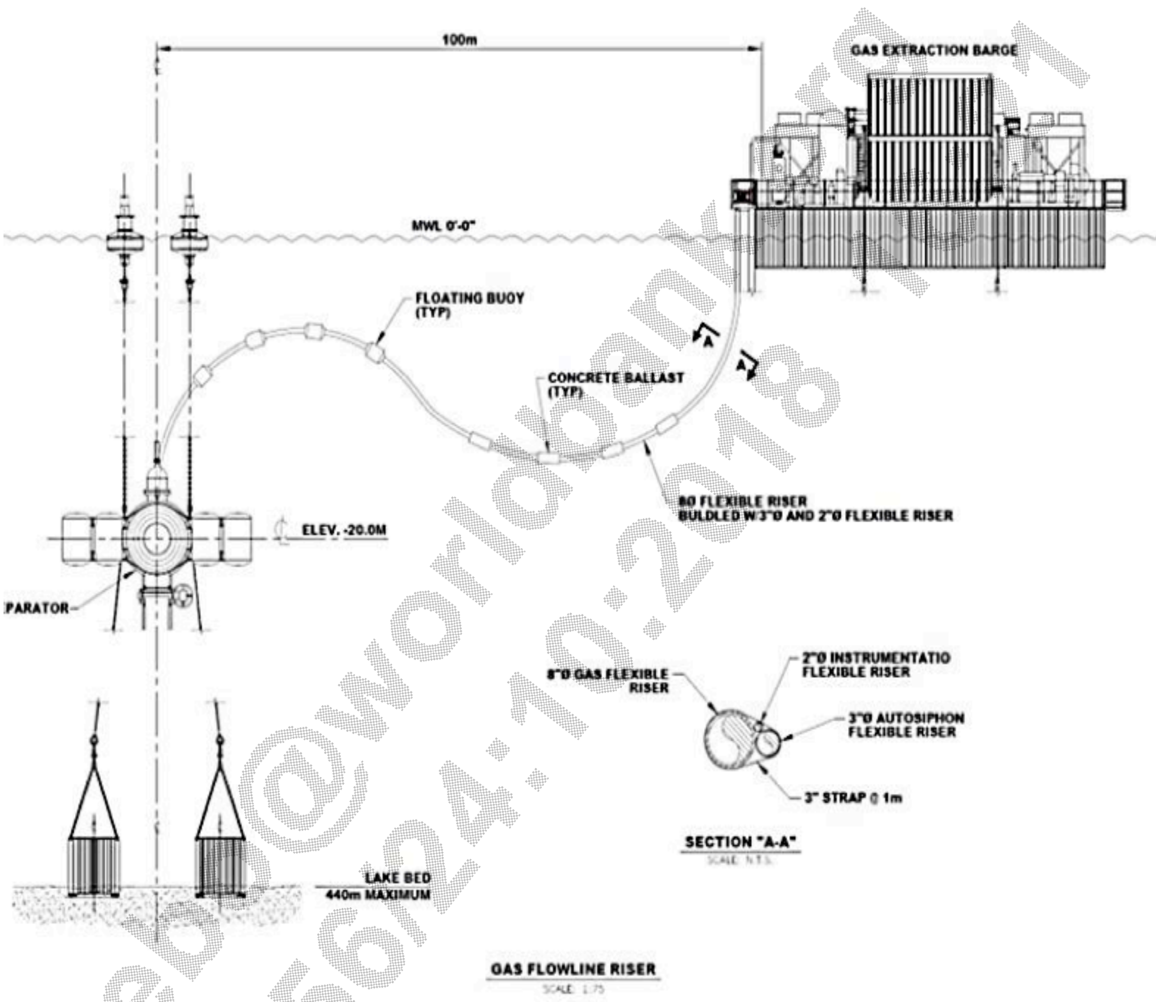


Figure 8: Offshore process: view of an FRSS and Offshore Gas Plant mounted on a barge

After compression, the export pipeline transports the pressurized gas to the Onshore Gas Plant where the methane is concentrated ("sweetened") in wash water towers through the reabsorption of CO_2 and H_2S back into the wash water, which is then discharged back into the lake. The sweetened gas is then heated slightly to avoid any condensate problems and fed via gas metering skids to a fuel gas header supplying the Power Plant.

3.7.4 Project components and functions

3.7.4.1 Onshore gas plant

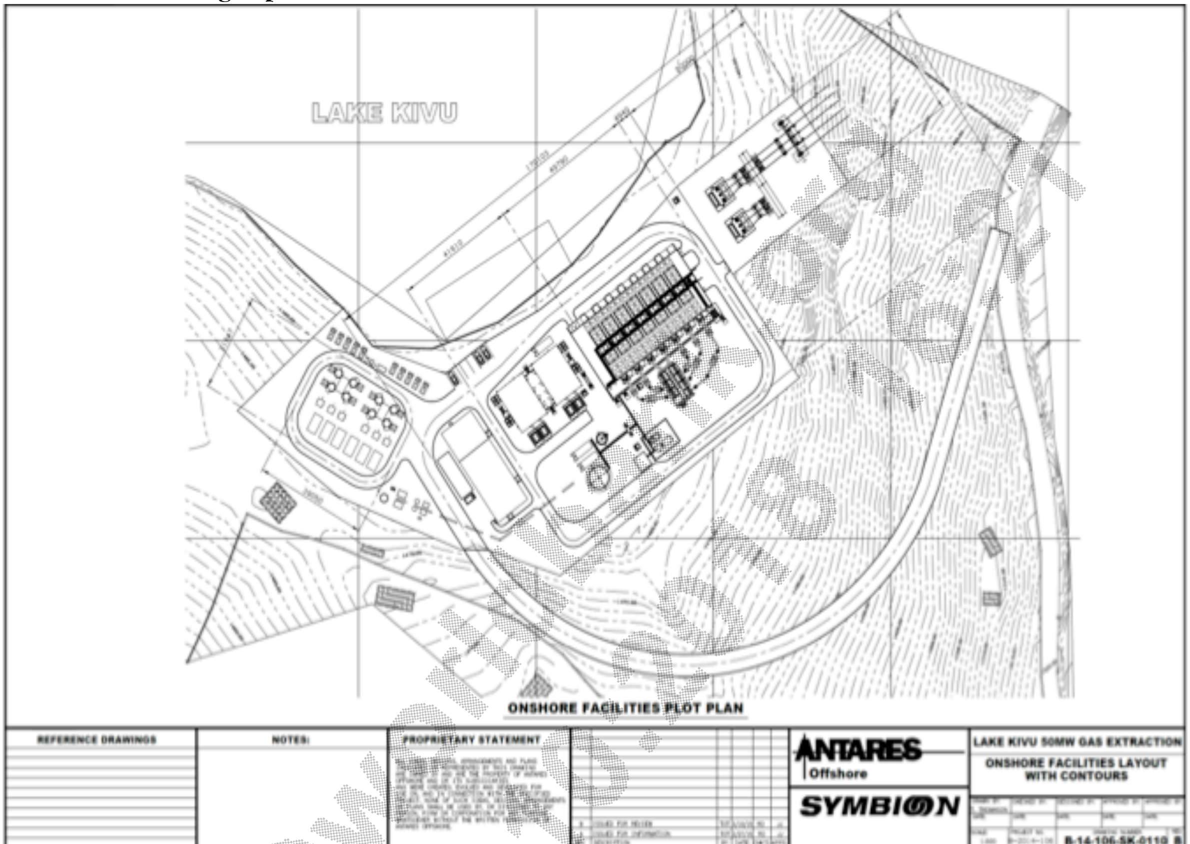


Figure 9: Layout gas plant, power plant and substation

Free standing riser and separator system

The extraction method is based upon a well-established technology in the oil and gas industry known as "gas lift". Gas lift was used on Lake Kivu from the mid-1960s through 2004 to extract methane for use in the boilers at the Bralirwa Brewery.

Each FRSS is comprised of a separator, a raw gas riser and a degassed riser. The gas riser draws water from the Lower Resource Zone (see Figure 5-21) to a separator tethered at a depth of -20 m and returns the degassed water to the top of the Upper Resource Zone. The extraction and reinjection depths, and hence compliance with the Lake Management Prescriptions, are discussed in more detail in Section 6.

The water is lifted by an auto-siphon process in which the break-out gas evolved (come out of solution) from the deep water creates a gas lifting effect. Eight FRSS modules will produce sufficient raw gas (to be converted into fuel gas) to operate the Power Plant at full load.

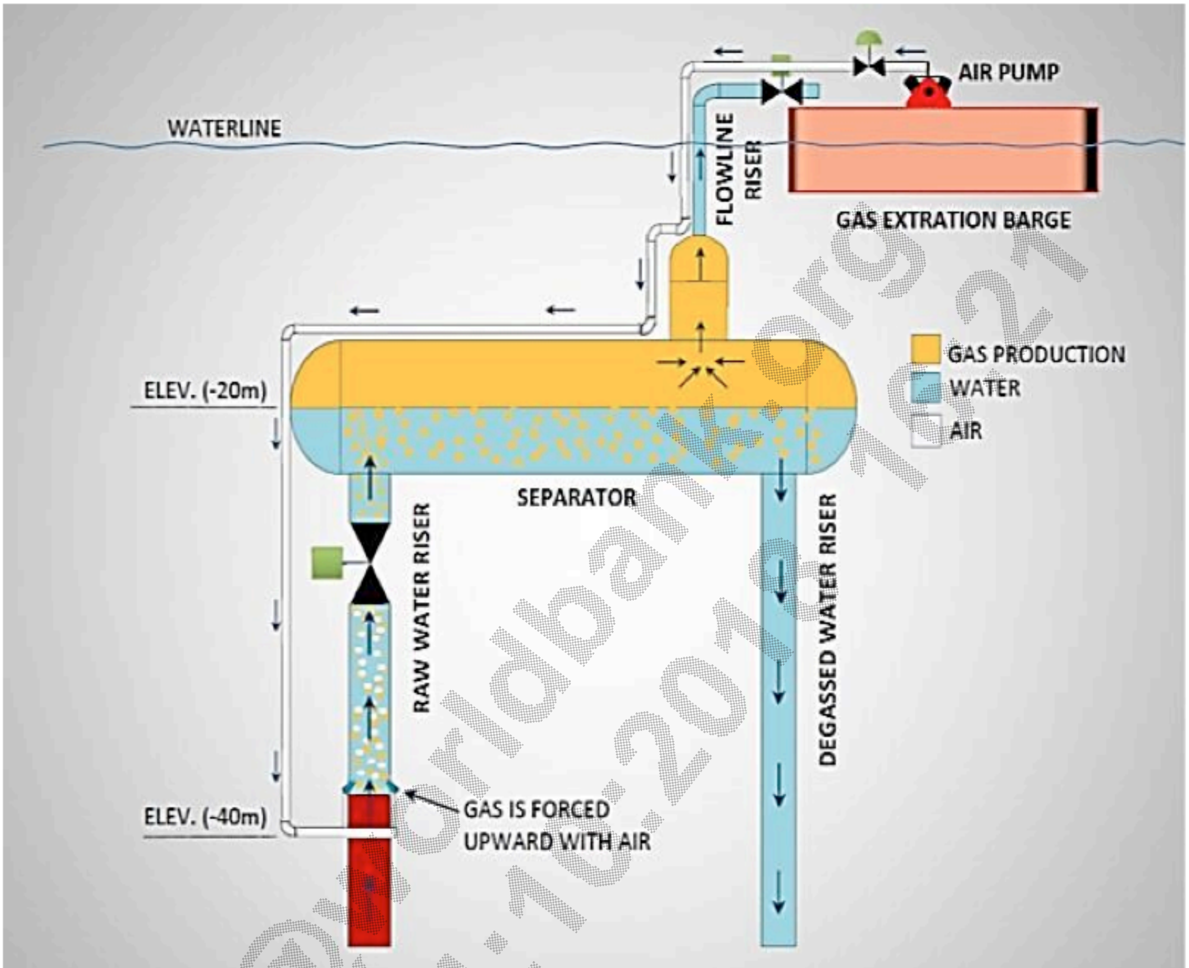


Figure 10: Simplified FRSS schematic

Raw water riser

The water is auto-lifted from the lake through a 48" diameter inlet riser to the production separator for natural separation of the gas from the water. The arrangement of the risers is provided in Figure 5-5.

The FRSS must be located where the water depth sufficient to provide a clearance of at least 15 m between the inlet filter and the lakebed. In the deep lake, fluidized soil is expected to rise 10 m above the lakebed. By keeping the inlet at least 15 m above the lakebed, suspended solids should not be drawn into the riser. Nonetheless, maintenance manholes are designed in the separator to provide access for cleaning and maintenance purposes.

In order to draw the water horizontally without mixing water between the different density layers, the design incorporates a **diffuser** with horizontal directing nozzles.

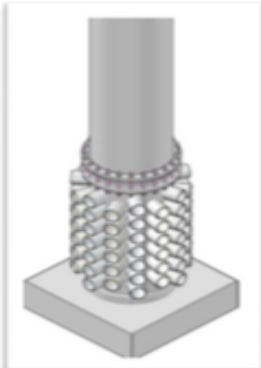


Figure 11: Diffuser

Auto siphon

The FRSS is equipped with an auto-siphon pump that injects air into the inlet riser at approximately - 40 m to initiate the gas lift process. This pump is only needed to initiate the lift. Once running, the lift is self-sustaining. Subsequently, the process can be shut down easily by increasing the backpressure on the gas riser in case of emergency.

Separator

The separator consists of a horizontal cylinder with two elliptical caps on both ends. Its function is to create a large horizontal water/gas interface surface area and shorter vertical route for gas bubbles to travel. This design allows the shortest solution resident time necessary to liberate the gas from the water.

The separators are tethered at a depth of - 20 m. They will be operated at ambient temperature and the hydrostatic pressure at that depth, approximately 2 bars (g). Simulations of the FRSS show that this is the optimum pressure to maximize methane liberation while constraining carbon dioxide liberation, thus forming the first step in achieving the required fuel gas specification.

The produced gas evolved from the water is routed via a flexible gas riser to the support barge for compression and export to the Onshore Gas Plant. The gas composition at the outlet of this riser is described in the table below:

Table 9: Gas composition post separator

Parameters	Unit	Value
Physical properties		
Pressure	kPa	297
Temperature	°C	25
Gas Flowrate	Nm^3/h	7305
Liquid Flowrate	m^3/h	-
Composition		
Methane	%-mole	30.3
CO2	%-mole	67.2
H2S	%-mole	0.14
Nitrogen	%-mole	1.32
Oxygen	%-mole	0.00
H2O	%-mole	1.06

Degassed riser

The degassed riser returns water from the separator to the upper resource zone through a 42" diameter outlet riser. In order to ensure a horizontal re-injection plume with constant density, the same diffuser nozzle used on the raw water riser is used on the degassed riser. The arrangement of the risers is shown in Figure below:

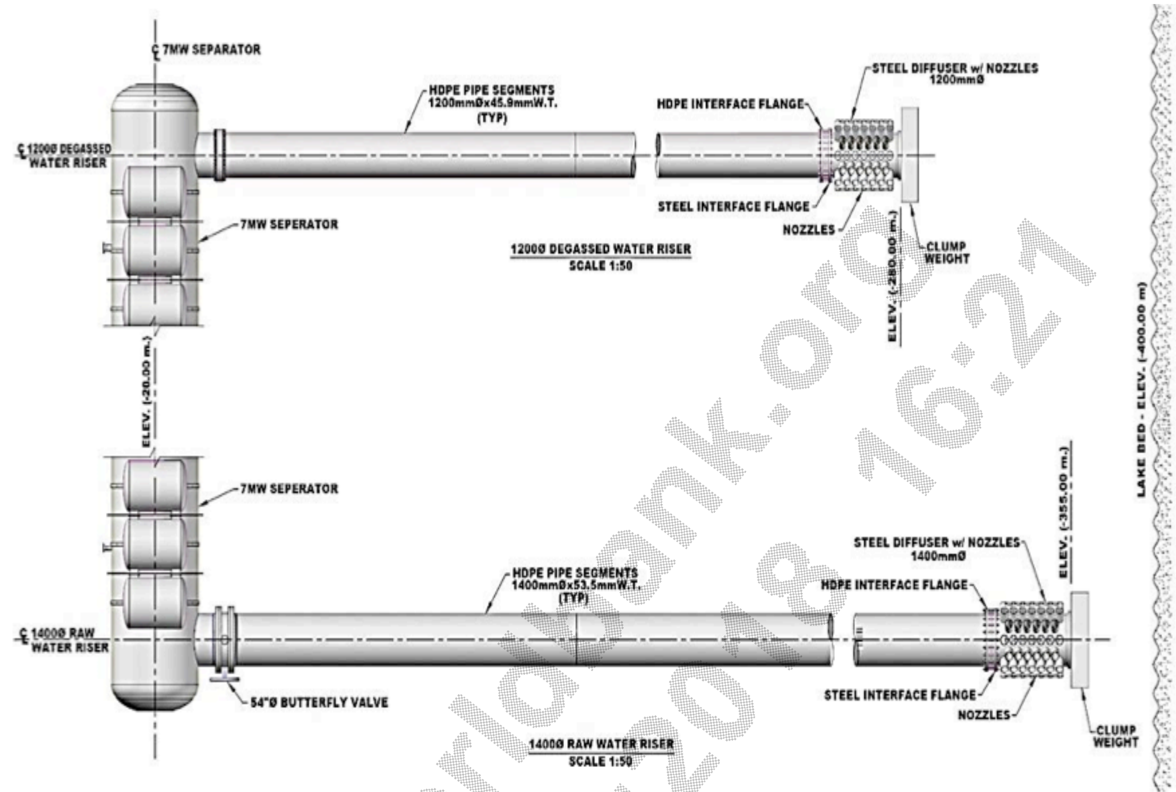


Figure 12: Riser configuration

3.7.4.2 Offshore Gas Plant

Overview

The Offshore Gas Plant comprises the topsides equipment on the offshore barges used for processing the raw gas extracted from the FRSSs so that it is suitable for export to the Onshore Gas Plant.

There are four barges, each linked to two FRSSs. The purpose of the Offshore Gas Plant is simply to drive the gas to the Onshore Gas Plant where the main gas processing takes place via compressors. There are two compressors arranged in two Gas Trains per barge.

A simplified offshore PFD (process flow diagram) is shown in Figure below.

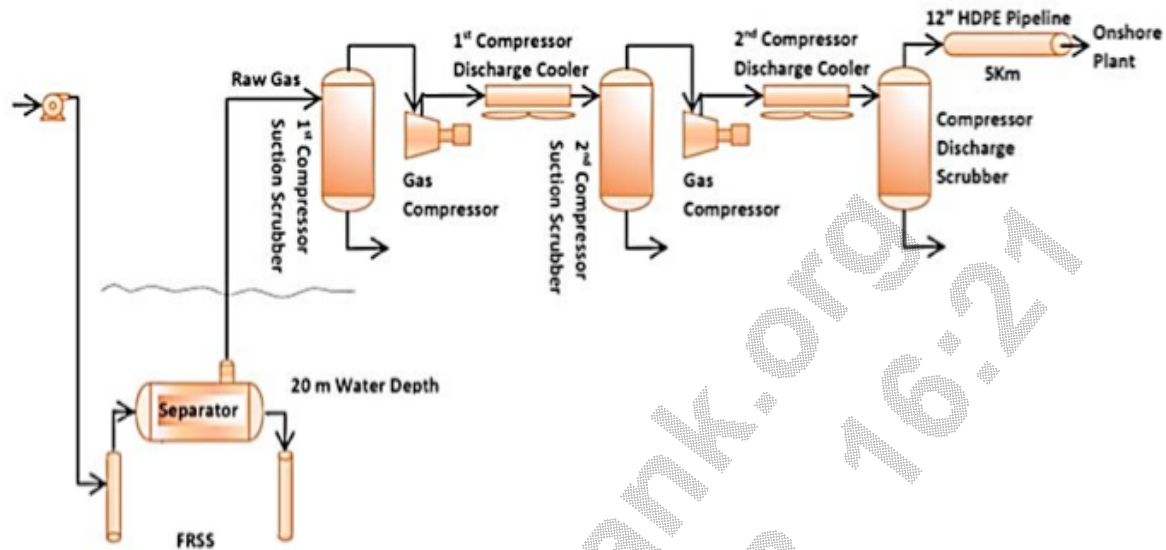


Figure 13: Offshore process flow diagram

Barges

Smaller barges are more maneuverable, de-risking the installation process. And the barges can be constructed in the water, container by container, eliminating the need for the slipway normally required for standard vessel construction.

Spreading the gas extraction across four barges means that the area and weight-bearing requirements of each barge are reduced.
The barges will be constructed of 24 (8 x 3) x 40 ft. containers to be of the correct size to support the Offshore Gas Plant and to provide the necessary stability. This will give each barge the following dimensions:

- Footprint: 36.58 m (120 ft.) x 19.51 m (64 ft.)
- Depth: 2.591 m (8 ft. 6 inch)
- Light draft: 0.670 m
- Deck Loading: 1.50 t/m^2

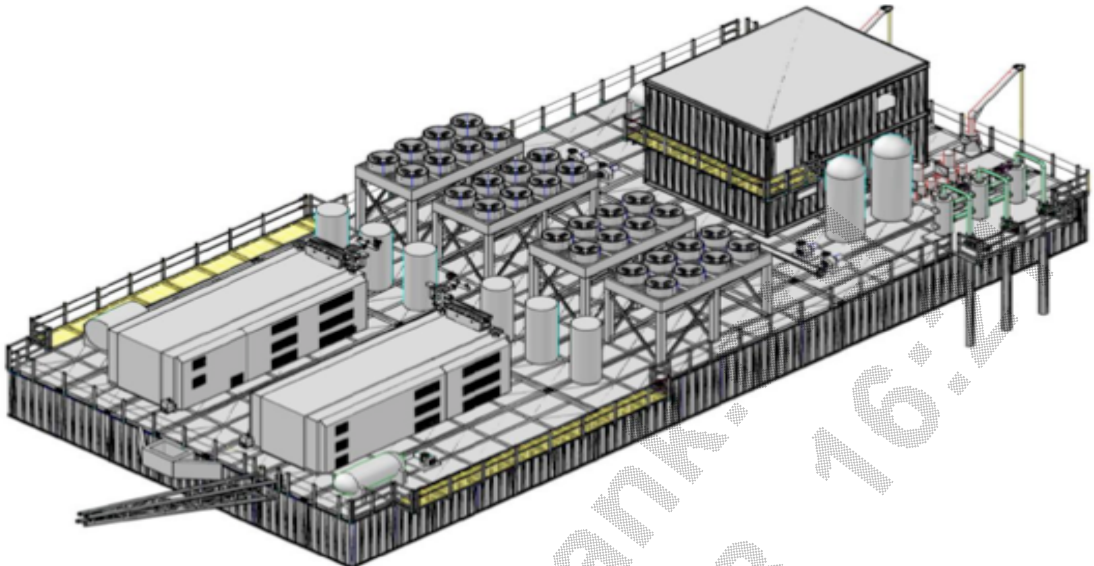


Figure 14: Offshore barge including offshore gas plant

Compressors

The compression process consists of a 1st stage suction scrubber, a 1st stage compressor, a 1st stage air-cooler, a 2nd stage suction scrubber, a 2nd stage compressor, a 2nd stage air-cooler and a discharge scrubber. Air coolers are adequate to remove sufficient condensates from the gas stream for export to the Onshore Gas Plant. This system consumes far less energy and consumables than chilling or dehydration units.
The water discharged from the Gas Trains during compression is discharged to the lake through a discharge riser.

Vent system

A vent system is provided on the Offshore Gas Plant for the safe collection of all process pressure relief discharges, venting and maintenance activities (discussed further in Section 5.7). The vent system comprises vent headers, a 12" disposal pipe, which also serves as a knockout drum, and a vent tip.

Utilities offshore

All equipment on the barge is electric and the power for the facility is taken from onshore by a subsea power cable piggybacked to the export pipeline. Each barge will consume about 1.3 MW of auxiliary load, mainly due to the two compressors. A small backup diesel generator with bunded storage will provide power to critical systems, such as the firewater pump and emergency lighting, when power from onshore is not available.
Potable water will be supplied in containers brought by boat from shore. A small sewerage system will ensure that no human waste enters the lake.

The barges are also fitted an instrument and utility air system, a fire water system and a temporary pig launcher. The latter is provided to accommodate operational pig launching activities on the export pipeline.

3.7.4.3 Offshore pipelines

Pipeline material, sizing and numbers

The compressed gas is delivered from barges 3 and 4 to barges 1 and 2 respectively via 1 x 12" High Density Polyethylene (HDPE) export pipelines, and from barges 1 and 2 to the Onshore Gas Plant via 2 x 12" HDPE export pipelines. The configuration meets the gas flow requirements while providing operational flexibility and redundancy.

Anchoring and support

The export pipeline is held at a depth of -20 m (to avoid risk of damage by other users of the lake) by tethers from the lakebed. The pipeline is tethered every 250m and the tethered position is kept stationary by introducing clamped clump weights. Sagging is limited even in the event of pipeline flooding by buoys attached along the 250 m spans between tethers. Marker buoys are also located on the pipeline at 250 m spacing to mark the route for vessels operating on the lake.

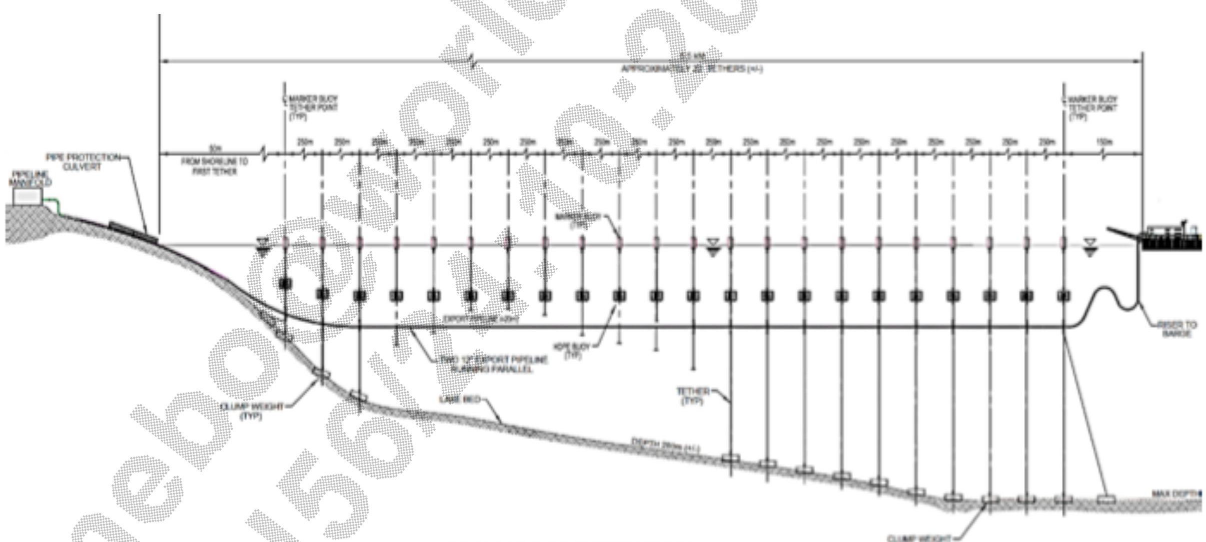


Figure 15: Export pipeline elevation view

Gas line pigging

Provision is made to allow operational pigging to be carried out during shutdowns of the export pipelines.

3.7.4.3 Mass and energy balances

The mass flow and energy balance of the Plant is provided in Figure 12, and an overview of the energy balance in the Wärtsilä engines is given in Figure 13. This shows the volume and composition of gas from each point in the Gas Plant up to the gas header in the Power Plant, as well as the conversion efficiency of the Power Plant and the electrical energy used to supply auxiliary loads and electrical losses.

The estimates of auxiliary load are preliminary at this stage, and were deliberately over estimated (by being based on installed loads rather than running loads) to conservatively estimate the final capacity to be made available at the Connection Point. Using this conservative estimate, the worst case overall Plant efficiency is:

Efficiency

= Output Energy / Input Energy

= Energy at the Connection Point / (Energy Supplied to the Gensets)

= 55.44 MW / (68.11 MW/46%)

= 37.4%

This being in line with the Lake Management Prescriptions' assumptions regarding efficient use of the Lake Kivu methane resource.

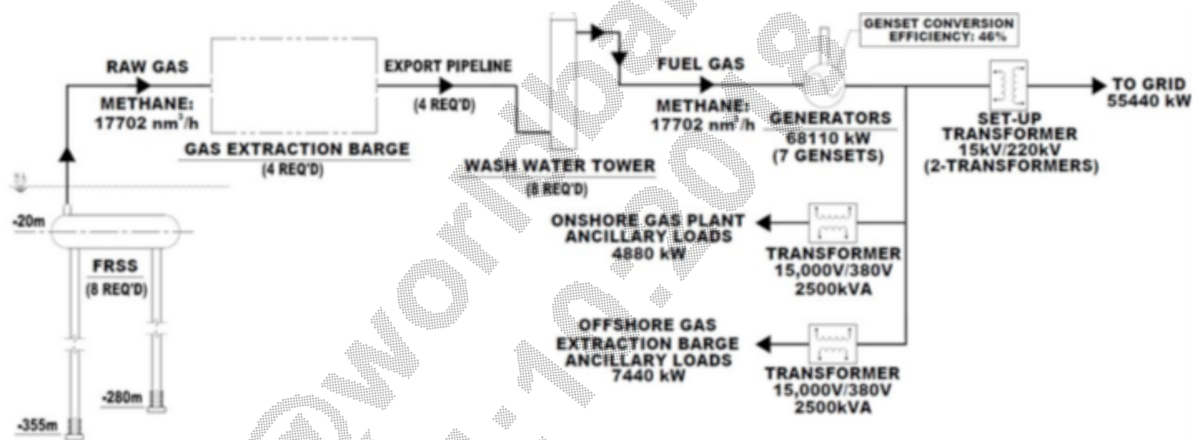


Figure 16: Export pipeline elevation view

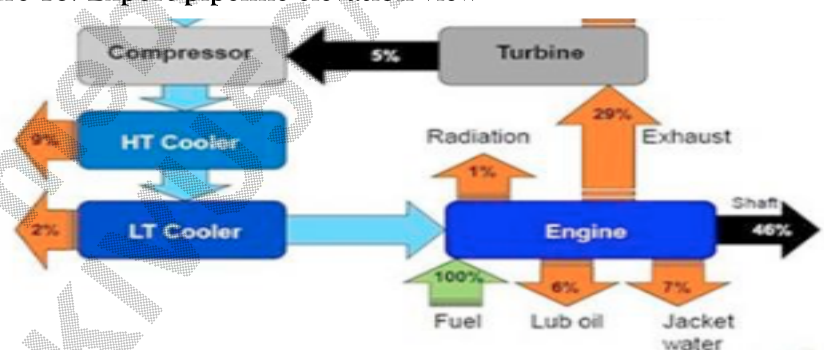


Figure 17: Export pipeline elevation view

3.7.4.4 Onshore facilities

Once the gas is delivered onshore via the export pipeline, the gas is sweetened by water washing, heated to ensure that there is no liquid condensate present in the fuel, metered and delivered to the Power Plant. A simplified Onshore Gas Plant PFD is shown with the figure below

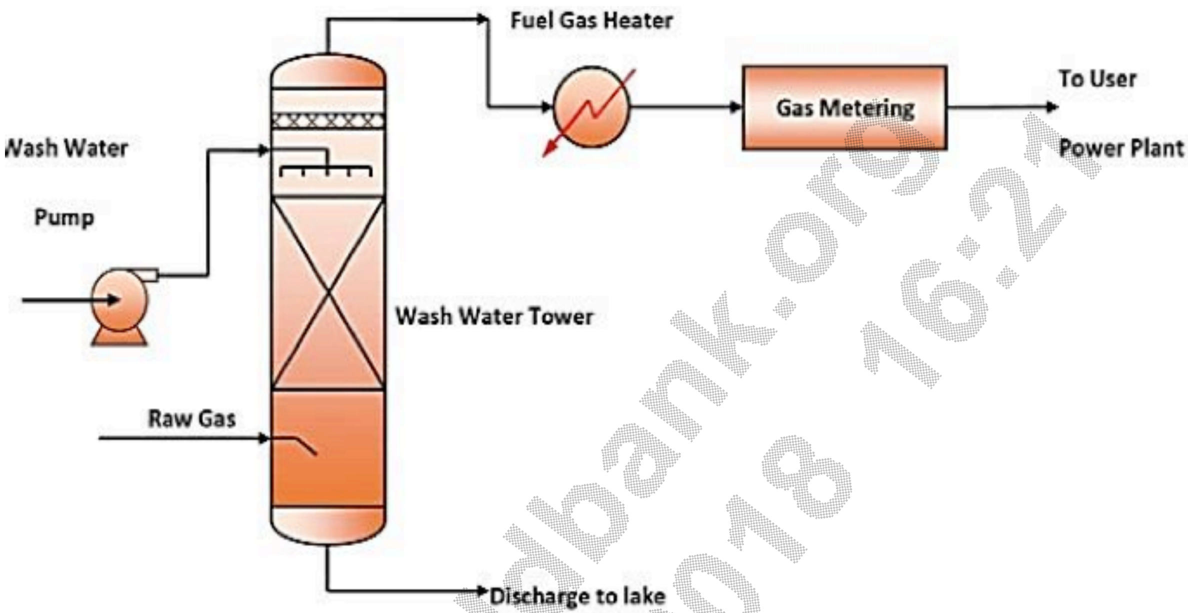


Figure 18: Onshore Gas Plant process flow diagram

Water and wash towers

Once onshore, the gas is sweetened by water washing to remove sufficient CO_2 and H_2S to meet the fuel gas specification. One wash water tower is required for each Gas Train, giving a total of eight towers. The wash water tower is a vertical packed column which will have an operating pressure of 7 bar at 25°C. Raw gas from the export pipelines is pushed up through the wash water tower at a rate of 7304 Nm^3/h to allow the CO_2 and H_2S time to contact with fresh water from the lake and hence be reabsorbed. This process requires a total fresh water flow of approximately 33,500 m^3 per day, pumped in at the top of the wash water tower. The water containing the reabsorbed CO_2 and H_2S is then discharged back in to the lake via the drain header.

The centrifugal wash water pumps are driven by an electric motor that has a required hydraulic power of 537 kW. A strainer is installed in the upstream of the suction of wash water pump.

Discharged water and effluents

From the drain header, the wash water is discharged via a 24" HDPE pipeline.

Gas heating

After sweetening, the fuel gas is fed into a fuel gas heater to keep the gas at a temperature of at least 15°C above the water and hydrocarbon dew point.

Gas metering

Finally, the fuel gas is routed to the gas-metering package using a cone type metering system. The metering system of the Onshore Gas Plant measures the quantity of fuel gas before it is delivered to the Power Plant.

Utilities onshore

The utilities onshore consist of the instrument air, service water, firewater and emergency diesel systems. The potable and waste water systems are discussed in Section 3. Firewater is be sourced from the lake. The power for the Onshore Gas Plant comes from auxiliary transformers located in the Power Plant. An emergency black start generator, with a built-in diesel fuel day tank and filtration and transfer pumps, will be dedicated to lighting, security and other critical systems when this power is not available.

Flaring system

If the Power Plant were to trip suddenly, there would be a quantity of gas that would need to be removed to depressurize the system safely. The only way to do this would be by flaring, which is done on the Onshore Gas Plant. The flare system is designed to accommodate this worst-case relieving scenario and consists of a flare knockout drum, a knockout drum pump, a flare header, a flare stack, and an ignition system. The separated liquid in the flare knockout drum (if any) is pumped out using a knockout drum pump, which discharges the liquids into the drain header. These liquids are then discharged back into the lake with the wash water discharge.

The total volume of gas to be flared would be equal to the quantity in the export pipeline and other piping systems on the Onshore Gas Plant. The very small amount of gas in the offshore compressors and separators would be vented to a safe (inaccessible) location off the barge.
The gas inventory for venting/flaring, based on the gas "trapped" within the incoming and outgoing shutdown valves at each facility is as follows

Offshore: 31 Nm^3 as raw gas for venting

Onshore: 555 Nm^3 as a mixture of raw gas and fuel gas quality (nominally 50% of each) for flaring Flaring/venting is only required during an emergency or under abnormal operations. Under normal operations, all gas is sent to the Power Plant. Venting offshore might also be undertaken as a manual operation for maintenance purposes, which will be executed as detailed in safety procedures to be developed during detail design. There will be designated safe areas and safety gear for the personnel during venting. These will be further supplemented by gas detectors, which will provide audible alarms and strobe lights to get personnel to move to the designated safe areas.

3.7.5 Water extraction and reinjection

3.7.5.1 Water extraction

Each of the eight FRSS modules nominally provides 1/8th of the total installed capacity. This requires a total water extraction for all eight separators of 1,590,400 m3/day (198,800 m3/day each) to produce a total raw gas flowrate of 1,443,200 Nm3/day (180,400 Nm3/day each).
Over the 25-year life of the concession the total volume of water extracted will be around 14,500 billion m3.

Maximum Allowable Amount of Gas
The Maximum Allowable Amount of Gas shall be 600 million normal metres cubed (m^3) of methane gas per Contract Year, as measured at the Gas Metering Point.
Gas Metering Point
The Maximum Allowable Amount of Gas shall be measured at the output of each gas separator (collectively the "**Gas Metering Point**").

3.7.5.2 Lake water reinjection
As discussed above, the degassed water can be re-injected either just below the secondary density gradient in the RZ (Plan A2) or the URZ (Plan B). Density matching and hence CO_2 content is of paramount importance and this will be considered further during detailed design, in close consultation with the Lake Kivu Monitoring Program, and throughout the lifetime of the concession. Throughout this Feasibility Study, it has been assumed that the reinjection level shall be - 280 m, however this can be readily adjusted during detailed design.

3.7.5.3 Wash water extraction
Each wash water tower requires 1,218 m3/h of feed water, with a total requirement of 233,856 m3/day at full load. This is supplied via a 26" OD HDPE intake pipeline which runs from the Onshore Gas Plant to a location almost due north around 600 m offshore. This pipeline is terminated with an intake filter at a depth of - 20 m.

3.7.5.4 Wash water reinjection
Each wash water tower discharges 1,227m^3/h, so 235,584 m^3/day in total. This is re-injected via a 26" OD HDPE discharge pipeline which runs from the Onshore Gas Plant to a location almost due north around 600 m offshore (with 30 m horizontal separation to intake pipeline). This pipeline is terminated with a discharge diffuser at a depth of 80 m below the lake surface. This reinjects the wash water discharge below the biozone.

3.7.5.5 Summary of water extraction and reinjection
Table 5-10 summarises the engineering design output with regards to water extraction and reinjection. As discussed in Section 5.10.2, the depth listed in this table can be modified during detailed design without significant capex impact, provided that the overall performance of the Plant is not impacted.

Table 10: Summary of water extraction and reinjection

Process	Depth	Volumes	Total Volumes
Gas-rich water extraction	- 355 m (LRZ)	1,590,400 m^3/day for 8 FRSSs (198,800 m^3/day each)	~14.5 billion m^3 over 25 years of full production
Degassed water reinjection	- 280 m (top of the URZ)	As above	As above
Scrubber discharge reinjection	- 80 m		
Wash water extraction	- 20 m	233,856 m^3/day	~ 2.13 billion m^3
Wash water reinjection	- 80 m (below biozone)	235,584 m^3/day	~ 214 billion m^3
Flare discharge	With wash water	negligible	

3.7.6 Project staffing

3.7.6.1 Owner's team

Symbion will build a small but strong owner's team of experienced professionals to manage the Project within Rwanda, led by a dedicated Project Manager who has already relocated to Rwanda. This team will largely consist of existing Symbion personnel transferred from other parts of the business, augmented by talented Rwandans who will be trained over the first 12-18 months of construction to take over several of the key roles for the latter half of the construction. As and when required, specialist expertise will be contracted into the team for specific functions.

Throughout the Project, this team will work in close collaboration with the Symbion Rwanda General Manager, who will also oversee all elements of operational readiness in preparation for the transition to full operations. The General Manager and the Project Manager will report to a Lake Kivu Steering Committee within Symbion, ensuring correct project governance.

3.7.6.2 Construction workforce composition

The construction workforce will consist of a combination of expatriate experts and skilled and unskilled Rwandan workers. Symbion will ensure that contractors exclusively hire unskilled labour from the local community, and will put in place systems and processes to ensure that such hiring is done in a fair and transparent manner. Symbion will also regularly audit contractors and subcontractors with regards to health and safety performance and to ensure that they are strictly adhering to Rwandan labour laws.

3.7.6.3 Manning levels

A complete manning curve will be produced during detailed design. At this stage, a peak construction workforce of 250-300 persons is expected, which will probably occur towards the end of the Power Plant construction and the start of commissioning of the first complete train within the Gas Plant, with ongoing construction of the remaining trains.

3.7.7 Workforce accommodation

3.7.7.1 Health and safety

Symbion takes the health and safety of its own workers and those of its contractors and subcontractors very seriously. There will be a Site-wide zero harm policy across the entire Project covering all works at each work front as well as transport to and from Site. Contractors will be strongly encouraged to harmonize their safety policies and procedures to avoid dangerous lack of clarity and confusion amongst the workforce.

All members of the Symbion owner's team will have safety leadership as a primary responsibility, and all persons entering any of the work fronts will be required to be fit for work at all times. Symbion will work closely with local health providers to set up basic occupational health and fitness testing for the workforce.

Symbion and the main contractors will also work together to establish comprehensive emergency management plans.

3.7.7.2 Security

Symbion will undertake several measures to ensure the personal safety of the workforce and to secure the Site from theft, vandalism and so on, including:

- Installing fencing, perimeter lighting and CCTV monitoring
- Installing a gatehouse with swipe card access to limit site access to authorized personnel only
- Engaging an experienced security-contracting firm to provide a continuous security presence
- Engaging logistics and warehousing contractors (engaged by the main contractors) to monitor goods movements
- Working closely with local police and establishing clear protocols for response to incidents from the start of construction Despite these actions, the most important security measure will be to maintain excellent relations with both the local workforce and the broader community.

3.7.8 Associate infrastructures

The access road and power lines construction and land expropriation to be undertaken by GoR are clearly linked with Symbion's activities. Separate ESIA studies commissioned by the Ministry of Infractructure (MININFRA) shall be conducted foe these associated infrastructures before the start of construction activities.

3.7.9 Overall investment cost

The overall capital cost of the Project is expected to be approximately USD 173 million, as shown in the table below.

Table 11: Project investment cost

Item	Cost
Project development, ESIA, management and engineering	$13.0 million
Gas Plant	$89.8 million
Power Plant and step-up transformers	$47.9 million
Support infrastructure, bulk earthworks and construction services	$6.5 million
Operational readiness including first 12 months spares, training and operator mobilisation	$6.8 million
Financing costs	$9.0 million
Total	**$173 million**

These costs explicitly exclude the following Rwandan taxes, duties and costs under the assumption that the Project will be exempt from them under the Concession Agreement.

4.0 Description of Project Environment

This chapter gives background information of the project area including Lake Kivu as a whole then narrows down to the project specific site in terms of its location, administrative set-up, climate, settlement patterns, and the major environment attributes, which will play a crucial role in the identification of impacts and influence the overall direction in the development of the project.

4.1 Terrestrial Environment

4.1.1 Physical Environment

4.1.1.1 Project Location

The Symbion Power Lake Kivu Ltd project facilities will be erected in Rubavu District. The district is located in the Western Province of the Republic of Rwanda. The District of Rubavu is composed of12 administrative sectors, 80 Cells and 525Villages. Rubavu District results from the new administrative division of the country into five provinces and 30 districts. It is located in the Western Province at 152 Km from Kigali. It is bordered on the east by the Nyabihu District,the West and North by DR Congo and south by the District Rutsiro.

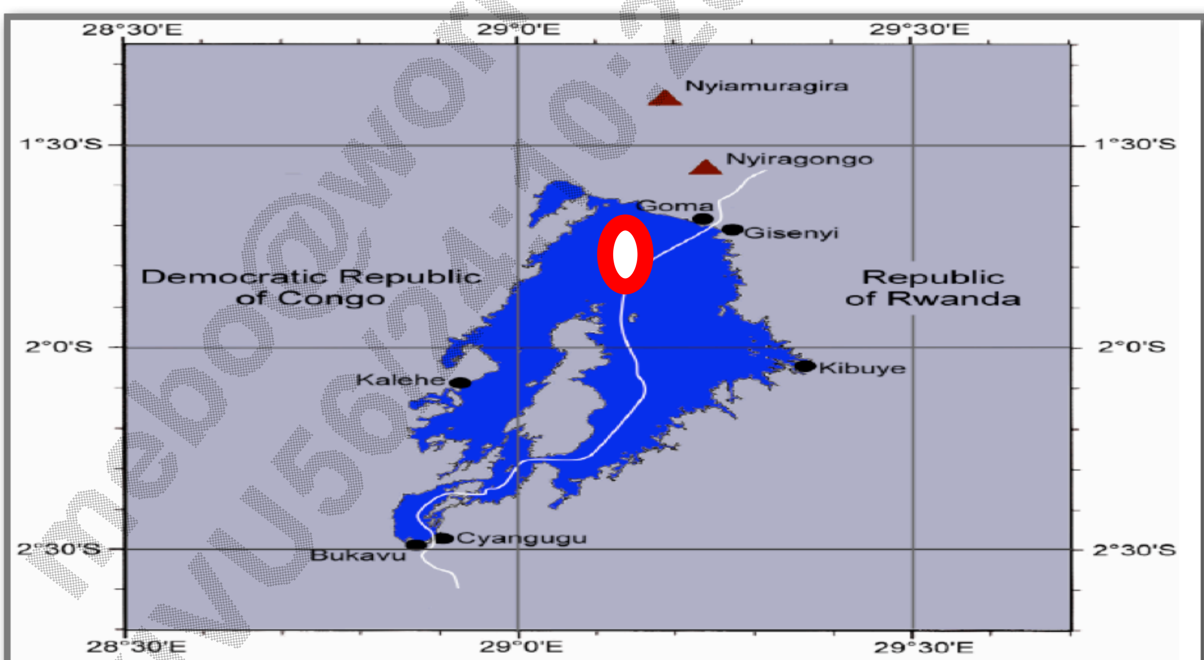


Figure 19: Site location on Lake Kivu map

4.1.1.2 Climatic conditions

Temperatures

Rubavu District has an equatorial climate, altitude average. Average temperatures range from

22°C at the edge of Lake Kivu at 15 ° C on the vertices, where nighttime temperatures can drop to 5°C. The maximum temperature is 32°C.

Rainfall

There is a rainy climate in the West Province with the rainfall intensity increasing towards the Nyungwe forest. Like the rest of Rwanda, the Rubavu District has an alternation of 4 seasons:

- The short rainy season, from 23 September to 21 December;
- The short dry season, from 21 December to 21 March;
- The long rainy season which goes from 21 March to 21 June;
- The long dry season this, from 21 June to 23 September;
- Abundant rainfall and thus under storms. Rainfall in Rubavu District varies between 1200 mm and 1500 mm per year.

However, the climate has some irregularities following some shortage or excess of rains.

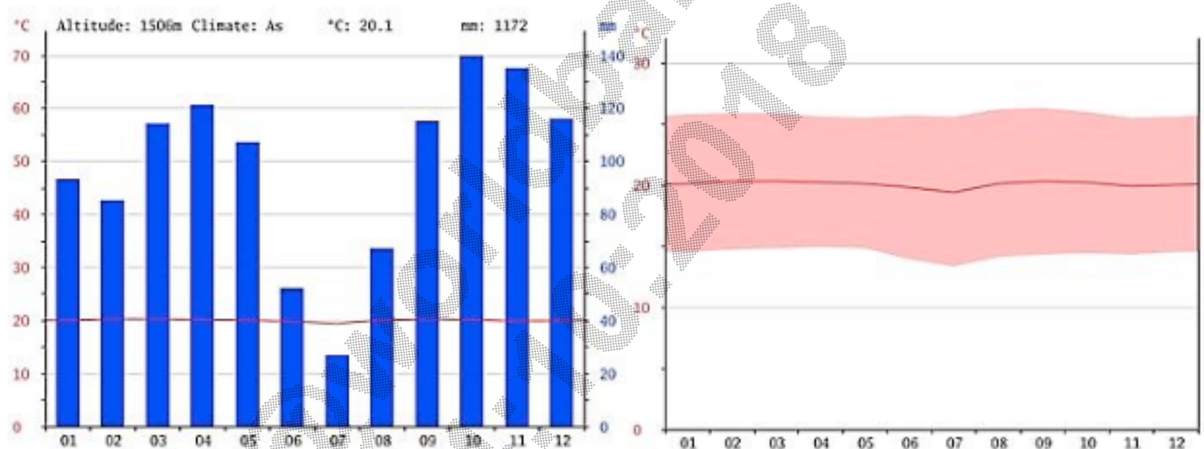


Figure 20: Average rainfall pattern and temperature[5]

Modeled average monthly rainfall for the project area (January 2015- December 2015) is presented by the figure below.

[5] **Design parameters SPLKL**

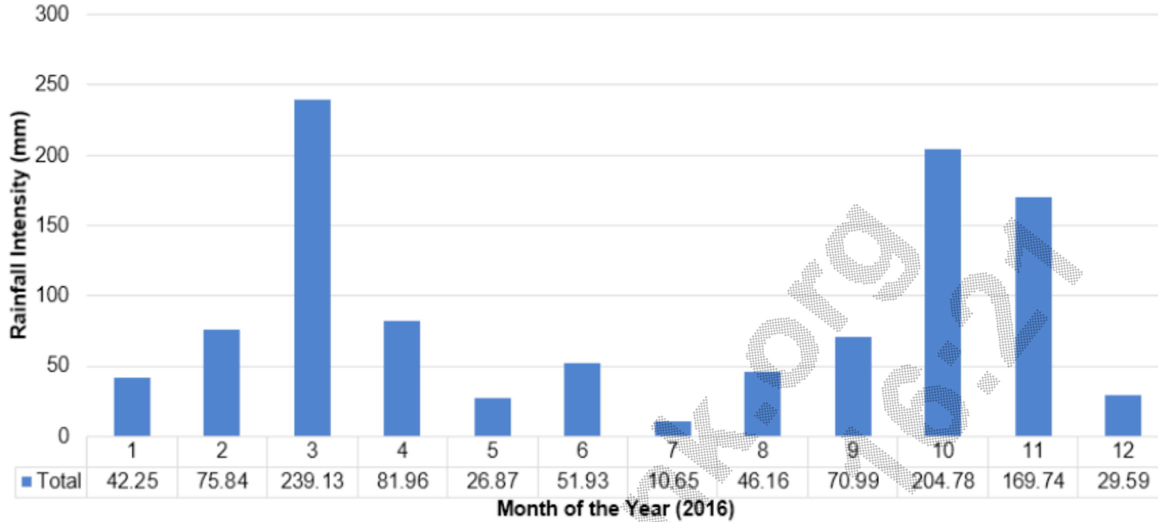


Figure 21: Monthly modelled rainfall MM5 data (Jan-Dec 2016)

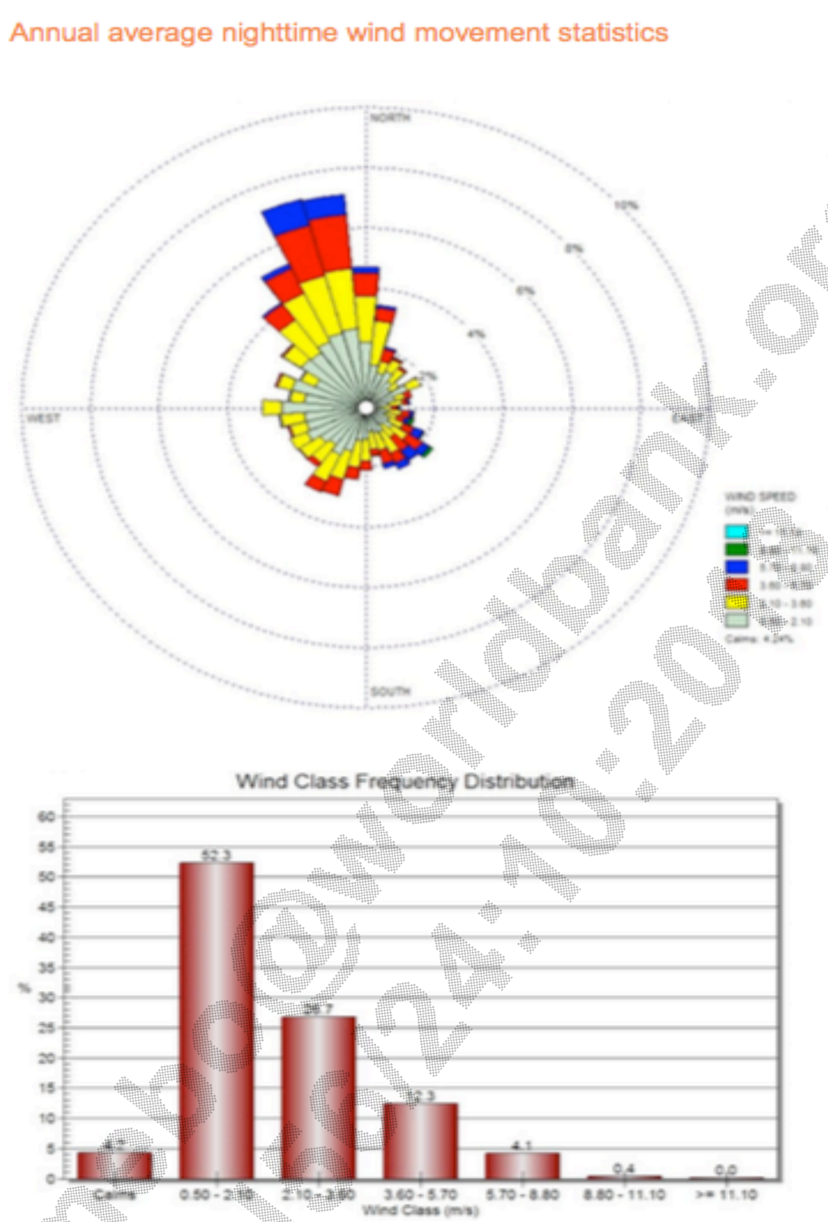
Table 12: Onshore site climatic conditions

Parameter	Value
Air Temperature (ºC)	Min 10 ºC Avg 22 ºC Max 32 ºC
Elevation	4796 ft. (1462 m) above sea level
Significant Wave Heights	1.3 m
Peak Period	4.6 sec
Current: Surface 30 m below surface Lake bottom	1.0 kn (0.514 m/s) Nil[6] Nil
Atmospheric Pressure	Min 24.6" Hg (0.8336 bar) Max 25.15" Hg (0.8515 bar)
Relative Humidity	Avg 60% Max 100%

Annual average wind roses and statistics

With the emissions modelling, annual wind rose was determined as per the figure and annex 5 below. Most of the duration, winds blew from SWW direction at 5.7-8.8 m/s.

The colors used in the wind roses in the figures reflect the different categories of wind speeds and directions.

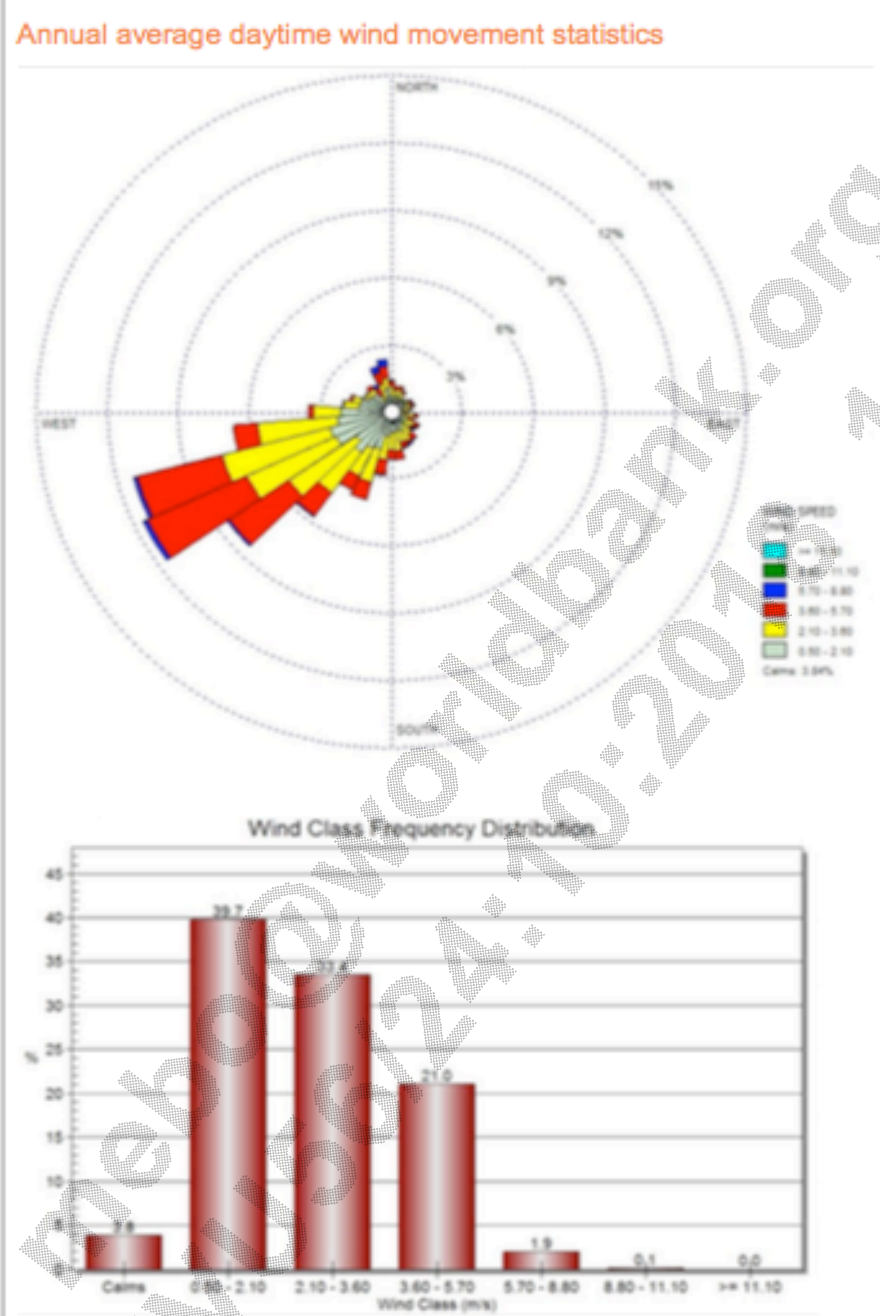


The nocturnal wind speed for the one year period (2015) was generated by filtering the source data from 18:00 hrs in the evening to 6:00 hrs in the morning.

The wind rose revealed the following wind motion trends:

- The winds predominantly flew from the North -North West direction
- The predominant wind speeds range from 5.70- 8.8-0 m/s
- The bar chart shows the relative frequency of daytime wind speed categories over the one year period
- The winds are relatively calm during nighttime

Figure 22: Average nighttime wind movements characteristics



The daytime wind speed for the one year period (2015) was generated by filtering the source data from 6:00 hrs in the morning to 18:00 hrs in the evening.

The wind rose revealed the following wind motion trends:

- The winds predominantly flew from the South West-West direction
- The prevailing wind speeds range from 5.70-8.80 m/s
- The bar chart shows the relative frequency of daytime wind speed categories over the one year period.

Figure 23: Average daytime wind movements characteristics

4.1.1.3 Lake Kivu water quality

The table below gives the water quality of Lake Kivu water based on three samples collected in Rubavu (former Gisenyi), Karongi (former Kibuye) and Ruizi (former Cyangugu).

The trace metal contents are high. The mean monthly concentration of manganese and selenium for the three locations are beyond the acceptable limits of the WHO (0.05 and 0.01mg/l). Cadmium and arsenic were not detected. The concentration of iron and copper were exhibiting significant variations which implies weathering, erosion and other climatically induced factors may play an important role in availability of heavy metals in the lake.

The physicochemical parameters measured with the exception of TDS are within the range recommended for a normal aquatic habitat. Mean temperature readings recorded were in the roand of 8 to 30oC to which fish in the tropics is adapted. Transparency tends to increase during the dry season as a consequence of different degrees of light penetration. Conductivity is higher in dry season. The mean seasonal total alkalinity recorded is high. Oxygen levels recorded is above the limit of 5mg/l recommended by WHO for fish. Conductivity is higher in dry season. Conductivity agrees with the current value of oxic layer, which oscillates between 950 and 1300iScm. The alkalinity values do not exceed the accepted values (30-500mg/l). Salinity is an important ecological parameter that influences the biotic life of biotic organisms as different organisms have optimum salinity level through which they operate. The salinity level is not critical for fresh water fish species.

Water with BOD level less than 3mg/l are known to have not received significant pollution discharges, 8mg/l is indicative of moderate pollution and 12mg/l or more is indicated of a grossly polluted water environment. The values recorded vary between 1.9-4.2mg/l, acceptable values.

Table 10: Water quality of Lake Kivu[6]

	Gisenyi			Kibuye			Cyangugu			
Parameters	Mean	±SD	Range	Mean	±SD	Range	Mean	±SD	Range	ANOVA
Zn (ppm)	4.76a	1.13	3.07-6.90	3.68ac	0.94	3.07-6.13	4.22ab	1.45	1.54-6.13	NS
Se (ppm)	0.40a	0.57	0.00-1.61	0.32ab	0.42	0.00-0.81	0.16ac	0.34	0.00-0.81	NS
Cu (ppm)	0.11b	0.13	0.00-0.37	0.02c	0.06	0.00-0.19	2.37a	6.90	0.00-22.0	*
Fe (ppm)	2.36b	0.96	1.35-4.04	2.62a	1.43	0.02-12.1	2.63a	3.36	0.02-12.1	*
Mn (ppm)	0.85ab	0.83	0.22-3.12	0.69ab	0.42	0.22-1.78	8.45a	24.1	0.45-76.9	NS
Pb (ppm)	ND	ND	ND	ND	ND	ND	ND	ND	ND	
Cd (ppm)	ND	ND	ND	ND	ND	ND	ND	ND	ND	
As (ppm)	ND	ND	ND	ND	ND	ND	ND	ND	ND	
Temperature (°C)	24.56a	0.18	24.1-24.7	24.67a	0.58	23.6-26.0	24.5a	0.31	24.4-24.8	NS
Conductivity. (iS/cm)	1082.4a	45.5	1058-1184	1078.3b	25.9	1058-1147	1082.1a	42.6	1031.-1158	*
pH	8.87a	0.22	8.64-9.31	8.86b	0.20	8.63-9.33	8.91b	0.20	8.60-9.30	*
Transparency (m)	3.11ac	1.10	0.00-4.50	3.67a	0.23	3.10-4.20	3.55ab	0.58	2.00-4.10	NS
Salinity (‰)	0.60a	0.01	0.50-0.62	0.59a	0.02	0.57-0.62	0.61a	0.04	0.55-0.67	NS
Alkalinity. (mg l^{1})	88.14a	5.16	51.7-95.4	79.7bc	7.48	68.9-93.8	81.03b	7.77	70.4-93.2	*
DOM (mg l^{1})	4.29ab	1.09	2.60-5.60	3.92ac	1.06	2.40-5.40	4.68a	0.66	3.60 –5.70	NS
TDS (mg l^{1})	1147.0a	10.38	1081-1163	1125.2c	24.0	1025-1163	1128.1b	19.2	1103-1199	*
DO (mg l^{1})	5.10b	0.58	4.20-6.20	5.10b	0.80	4.10-6.80	5.15a	0.49	2.80-4.00	*
BOD (mg l^{1})	3.03a	0.65	1.90-4.20	3.28a	0.80	2.10-4.20	3.37a	0.49	4.60-6.40	NS
NO_3-N (mg l^{1})	0.11b	0.13	0.00-0.25	0.11b	0.14	0.00-0.35	0.13a	0.14	0.00-0.38	*
PO_4-P (mg l^{1})	0.07a	0.06	0.00-0.91	0.07a	0.08	0.00-0.19	0.05b	0.07	0.00-0.18	*
$S0_4$ (mg l^{1})	12.79a	11.03	0.00-23.2	12.51c	10.84	0.00-23.7	12.73b	11.05	0.00-23.7	*

4.1.1.3 Air quality

Background

There are no major sources of gas emissions in the Rubavu area. There no major industrial facilities currently operating in Bwishura sector of Rubavu District, although there is a plan to make the area surrounding Symbion Power Lake Kivu Ltd an industrial zone (Rubavu Master Plan). In addition, there is no reliable existing air quality data for the Rubavu area. Due to the lack of industrial activity in the area and the lack of reliable data, it is assumed that current air quality conditions satisfy a "moderate" air quality classification according to World Bank criteria. Air monitoring should be performed after the facilities are in operation and confirmatory modeling should be performed using background air quality data collected.

Emission parameters

Atmospheric emissions associated with the proposed Lake Kivu Power generation plant would arise from seven Wartsilla engine generator sets (Wärtsilä 20V34SGC2), each with its own stack. All the individual stacks will be collected to one cluster. The stacks will be located as close to each other as practical possible and form one-stack construction for efficient plume rise.
Emission parameters as supplied by the proponent are as indicated below.

[6] Olapade O, Trace Metal Pollution and Physical Chemical Characteristics of Lake Kivu, Rwanda, 2011

Table 10: Power plant design emission parameters

Stack Parameter	
Exit Temperature (°C)	393
Exhaust gas volume flow for each engine (m^3/s)	32.3
Exit diameter each stack (m)	1.2
Exit diameter -7 engines equivalent (m)	3.17
Stack Height (m)	28, 40, 50
Emission Rate- NOx (g/s)	3.7
Emission Rate- CO (g/s)	5.8

4.1.1.4 Noise and vibrations

An acoustic equipment was used to determine noise background levels. It was duly calibrated to a traceable standard. Field checks were performed before and after each monitoring session. The full details of the noise level meter and noise level meter calibrator is provided along with the current calibration certificates. Identification of each of the measurement location was by GPS coordinates and photographic reports. A written record and subjective notes for any extraneous noise events were also logged for the measurement periods.

Prevailing meteorological conditions at the time of measurement

The prevailing weather conditions during the diurnal (day) measurement period were characterized of south easterly winds with maximum speed of 06 knots on the beaufort scale. the sky was partially covered with cumulus clouds at an average height of 2700 feet and average temperatures of between 23oc to 27oc. There were slight showers in the afternoon that lasted for 25 minutes. the nocturnal (night) schedule was characterized with calm winds with periods of variable winds of between 03-05knots. The sky was covered with few stratocumulus and altocumulus clouds to an extent of 3 oktas with a temperature of between 19oc to 21oc.

Plate 1: Acoustic equipment used to determine noise background levels

Figure 24: Google map showing the receptor points of noise measurement (rp 01 in blue is the proposed site)

ID	Location of Sampling, Description and sources of noise	GPS Location
RP 01	The point is located at the base of the peninsular the centre of the proposed site. The noise environment at this point is also influenced by occasional motorcycle traffic on the nearby road, and activities at the activities at the nearby beach. Other sources are chirping birds, croaking frogs, and insects at night, people talking passing by and children playing.	S: 01° 45' 34.4" E: 029° 16' 35.3"
RP 02	Located North of the site. The noise environment at this point is influenced by occasional boat traffic on the adjacent Lake Kivu, cows mowing and people voices from the village. There were also birds chirping and croaking frogs during the night.	S: 01° 45' 29.1" E: 029° 16' 41.9"
RP 03	Point is located at the West side from the proposed site at the top of the Peninsular. Noise environment influenced by security officers' walkie tokies, people passing by canvassing in loud tones and chirping birds and crickets.	S: 01° 45' 35.1" E: 029° 16' 21.9"
RP 04	Located South of the proposed site approximately 200M from the site in a residential home. The noise is affected by construction works at the nearby homestead, chirping birds, playing children and passersby and occasional airplane passing over.	S: 01° 45' 37.3" E: 029° 16' 34.7"
RP 05	Located South East of the proposed site in close proximity to the road leading to the site. The measurement point is directly opposite a homestead. The noise environment is affected by playing children, iron sheet beating at the homestead, firewood splitting, passersby and chirping birds.	S: 01° 45' 43.7" E: 029° 16' 38.5"
RP 06	This point is located to the East of the proposed site at the Rible Methodist church. Noise environment is affected by people talking, children playing, radio playing at the nearby home, birds chirping, frogs croaking and crickets during the night.	S: 01° 45' 37.9" E: 029° 16' 43.4"
RP 07	The point is located above the proposed site in close proximity to the road approximately 300M from the proposed site to the South East. Noise environment is affected by chirping birds, noise from activities in the nearby homesteads, frogs croaking and insects at night.	S: 01° 45' 36.5" E: 029° 16' 39.5"
RP 08	This point is located at a residential home south of the Proposed site approximately 1KM overlooking the proposed site. The noise environment is affected by typical village activities, birds chirping, frogs croaking and crickets and insects with occasional airplane	S: 01° 45' 53.7" E: 029° 16' 36.6"

	passing over.	
RP 09	This point is located at the local shopping centre (Rusisiro) South East of the proposed site approximately 800M from the proposed site. The noise environment is affected by activities of the shopping centre e.g. playing children, loud music, motorcycle and people canvassing in loud tones.	S: 01° 45' 54.1" E: 029° 16' 43.4"
RP 10	This point is located at the local mosque (Alimasidi Dji Ibunia Basa) to the North North East of the proposed site approximately 1.3 KM. the noise environment is affected by the Lake waves, activities at the nearby beach and occasional motorcycle traffic from the nearby road.	S: 01° 45' 15.6" E: 029° 16' 51.6"
RP 11	This point is at the local health centre (Centre de Sante Hopital Kigufi) in Kigufi area approximately 2KM from the proposed site to the NNW of the site. The noise is affected by children around, excavation works at the nearby road construction and waves from the Lake. Night noise affected by waves, frogs, insects and crickets.	S: 01° 45' 02.2" E: 029° 16' 42.5"

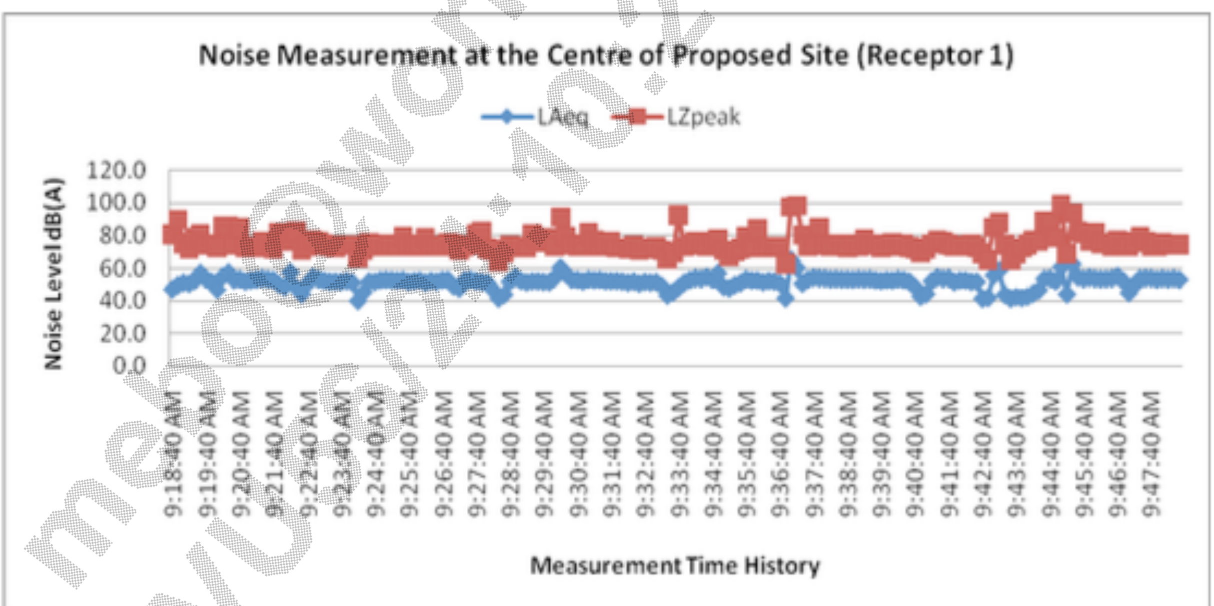


Figure 25: Centre of the proposed site)

Table 10: Summary of diurnal noise levels

RECEPTOR POINT	LAeq	LAmin	LAmax	LApeak (max)	LA 10	LA 50	LA 90
1	**53.1**	34.8	69.5	98.9	54.6	51.8	44.0
2	**44.3**	33.6	58.9	95.9	43.7	38.9	36.3
3	**46.2**	36.3	59.1	97.8	49.7	43.8	39.7
4	**46.6**	36.2	60.5	98.5	50.1	44.5	39.8
5	**46.9**	34.8	68.7	92.3	49.3	44.2	39.3
6	**50.5**	38.4	69.3	99.7	53.0	47.4	43.5
7	**46.1**	31.6	63.6	90.9	48.7	43.2	36.5
8	**48.7**	34.5	62.7	94.4	52.7	44.1	38.0
9	**68.2**	44.2	88.3	103.2	70.6	60.5	51.6
10	**52.4**	44.5	65.3	88.3	54.9	51.1	48.4
11	**49.4**	44.9	64.0	78.0	53.3	50.5	47.6

Table 10: Summary of nocturnal noise levels

RECEPTOR POINT	LAeq	LAmin	LAmax	LApeak (max)	LA 10	LA 50	LA 90
1	**48.9**	43.9	64.4	97.3	50.2	48.0	45.9
2	**47.8**	42.4	63.2	96.7	57.6	48.7	44.3
3	**53.1**	43.5	65.0	95.3	54.9	52.4	49.0
4	**48.2**	31.7	63.4	96.5	52.3	42.0	34.6
5	**45.2**	41.2	61.2	95.2	40.2	37.4	33.5
6	**36.0**	23.6	50.6	90.9	38.7	34.6	29.0
7	**48.1**	22.3	74.8	96.2	45.2	36.6	30.3
8	**60.3**	36.1	86.0	101.2	59.2	50.8	44.4
9	**45.7**	31.7	61.2	94.4	48.7	43.3	39.5
10	**49.9**	20.9	71.9	97.9	45.4	38.2	31.0
11	**47.2**	25.8	77.0	94.5	41.6	35.0	32.9

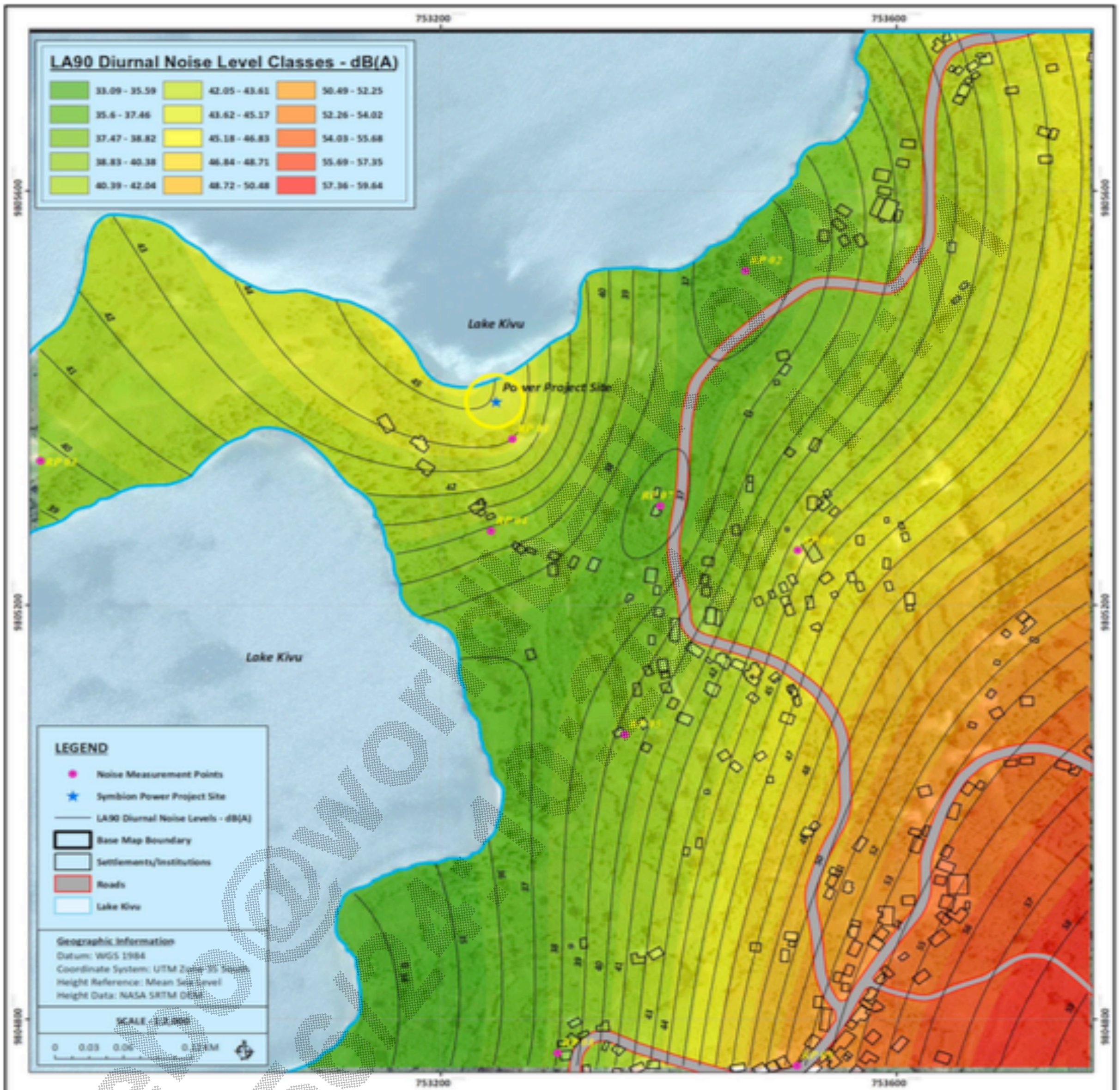


Figure 26: Project area LA90 diurnal noise levels

-The LA90 diurnal noise levels are higher in the South-Eastern region of the project area domain.
-The LA90 diurnal noise levels dissipate towards the North-Western quadrant of the project area domain.
-The red to greenish yellow color ramp shows the relative noise intensities across the project area domain. The noise contours lines in black show lines along which the noise level is constant and the actual noise intensities in dB(A).
-The LA90 diurnal noise intensities range from 33 – 60 dB(A).

-The settled areas of the project domain are relatively noisier during daytime.

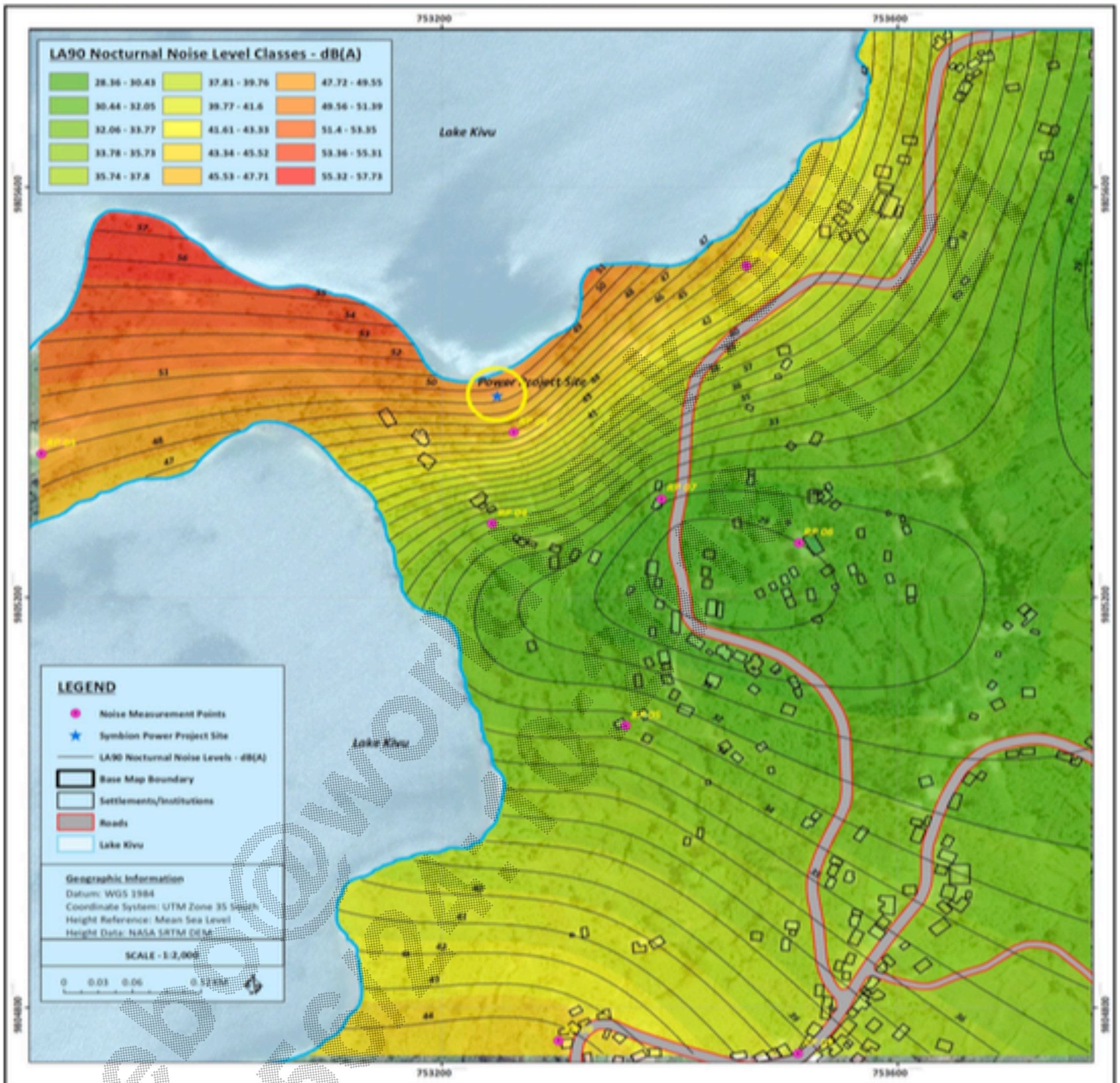


Figure 27: Project area LA90 nocturnal noise levels

-The LA90 nocturnal noise levels are higher in the North-Western region of the project area domain (around the proposed project site).
-The LA90 nocturnal noise levels dissipate towards the western quadrant of the project area domain.
-The red to greenish yellow color ramp shows the relative noise intensities across the project area domain. The noise contours lines in black show lines along which the noise level is constant and the actual noise intensities in dB(A).
-The LA90 nocturnal noise intensities range from 28–58dB(A).

-The settled areas of the project domain are relatively quieter during nighttime.

Noise is not a major concern in the immediate area surrounding the site. There are no sources of significant noise emissions at the site other than natural background noise levels common in an isolated area along the Lake Kivu. Noise levels within Rubavu are typical of any non-industrial area and are largely not even associated with heavy vehicle traffic.

4.1.1.5 Topography

The immediate surroundings on the gas and power plant site and Rubavu's relief is broken, with mountains covered by several rivers. The altitude of the site and the surrounding varies between 1458 meters at the edge of the Lake Kivu and 1898 meters at the top or the highest point. The site itself however is almost flat with gent slop towards the north.

Plate 2: Topography of the gas and power plant site

Plate 3: Topography in the immediate surroundings of the project site

The topography used for the measured and the modelled area was obtained from Shuttle Radar Topography Mission (SRTM) data sets. SRTM data sets result from a collaborative effort by the National Aeronautics and Space Administration (NASA) and the National Geospatial Intelligence Agency (NGA-previously known as the National Imagery and Mapping Agency), and the participation of the German and Italian space agencies to generate a near global digital elevation model (DEM) of the earth using radar interferometry. The topography of the proposed project area was processed in AERMOD software to show the topographic configuration across the project area domain.

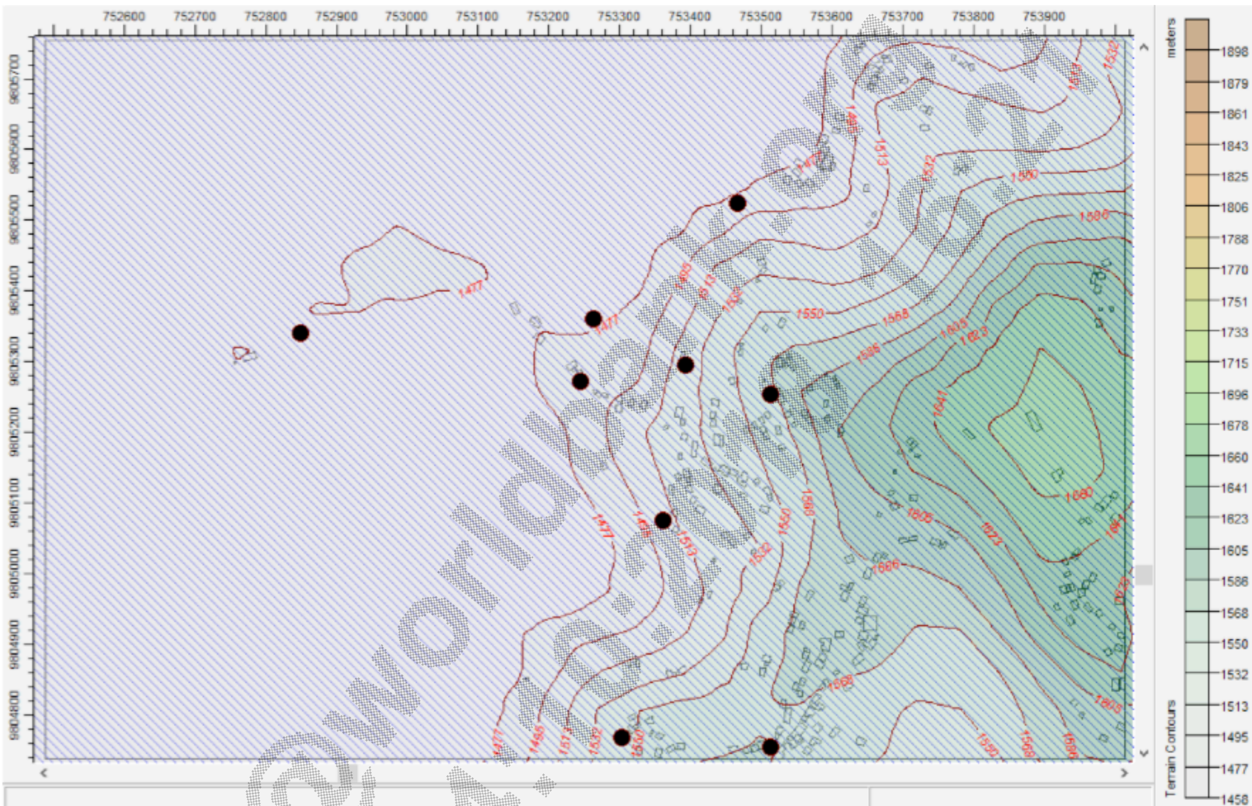


Figure 28: Project area topographic configuration

4.1.1.6 Geology and Soils

Geologically, the project site is occupied by metasedimentary sequence of Mesoproterozoic age consisting of Gishwati complex comprising micaschists with muscovite and biotite and metaquartzites with chlorite and biotite, as well as small pegmatitic granitic inclusions and doleritic sills.

The orientation of metasediments is generally north – south changing to north west-south east, dipping 24^0 to 65^0 east. The rocks of the area have been affected by Kibaran orogeny of Mesoproterozoic age and the east african rift which begun at the end of Oligocene.

Some lineaments oriented northeast south west affected Gishwati complex. The rocks are fractured and folded.

The metamorphic grade in Gishwati complex is higher. It is characterized by the presence of garnet and biotite. The quartzites are recrystallized.

The high metamorphism is the result of thermal influence at regional scale in relation with granitic intrusions (Kigeyo and Gisenyi granite).

Colluvium deposits (photo 1) are generally developed at the base of hill slopes of the area. Alluvial and eluvial deposits (photo 2) of Quaternary age are recorded in the surrounding areas of Kivu Lake. They consist of fine to medium clayey sand, sand and gravel and grey to dark silty and sandy clay.

Plate 4: Colluvium deposits developed at the base of hill slope

Plate 5: Eluvial and alluvial deposits developed on the edge of Kivu Lake

Plate 6: Outcrop of metasediments developed on hill slope

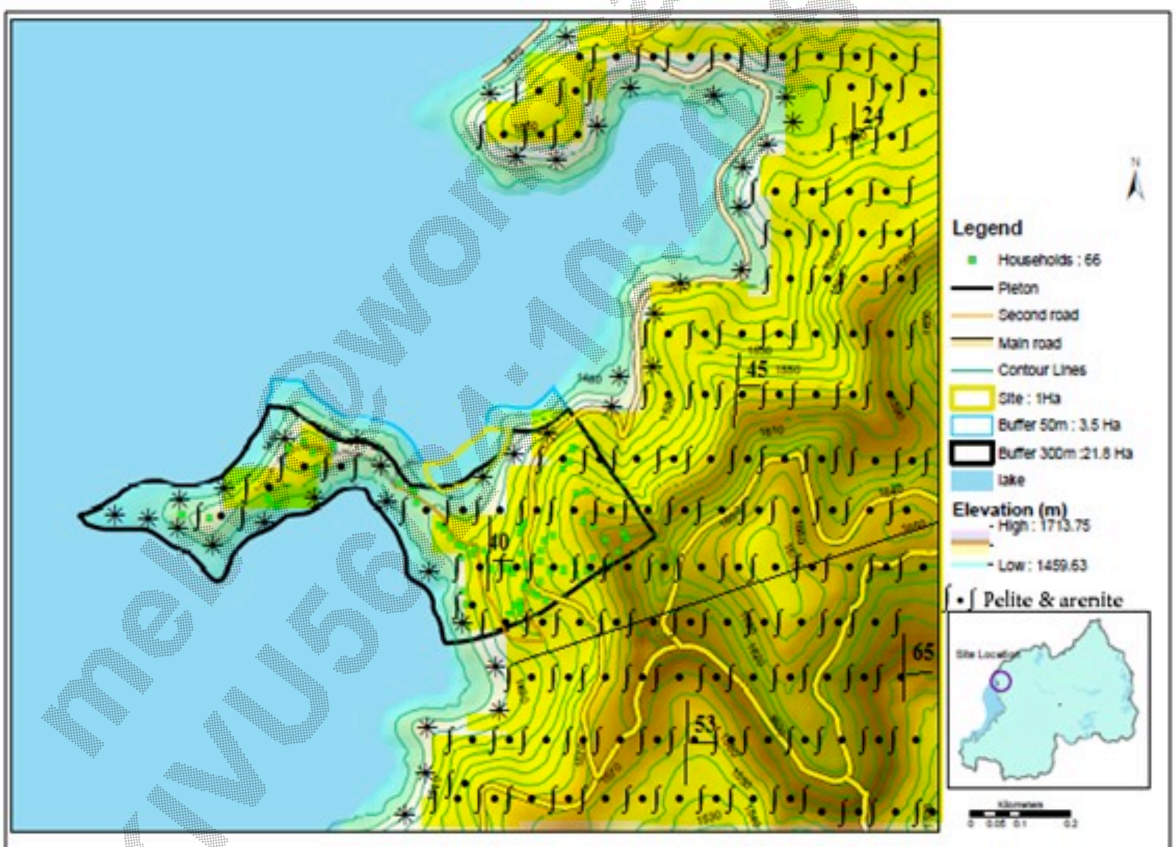


Figure 15: Geological map of Busoro area

LEGEND

ʃ.ʃ Micaschists and metaquartzites as well as small granitic inclusions and doleritic sills.

+ + + **Alluvial** and eluvial deposits of Quaternary age
Lineament
¢ Dipping of layers

Metasediments (photo 3) are covered mostly by soils (Dystric Regosoils and Dystric Leptosols) with centimetric to metric thicknesses
Regosols are generally very weakly developed soils in unconsolidated materials that have only an ochric surface horizon. The *ochric* horizon is a *surface* horizon lacking fine stratification and which is either light colored, or thin, or has a low organic carbon.
Some regosols have a base saturation of less than 50 percent, at least in some part of the soil between 20 cm and 50 cm from the surface
Leptosols are very shallow soils grouping together all soils that are less than 50 cm thick to hard rock but also deeper soils that are extremely gravelly and/or stony or soils having a mollic horizon directly overlying hard materials.
A mollic horizon is a surface *horizon* of mineral soil that is dark in color, and relatively deep, and contains (dry weight) at least 1 per cent organic matter or 0.6 per cent organic carbon.

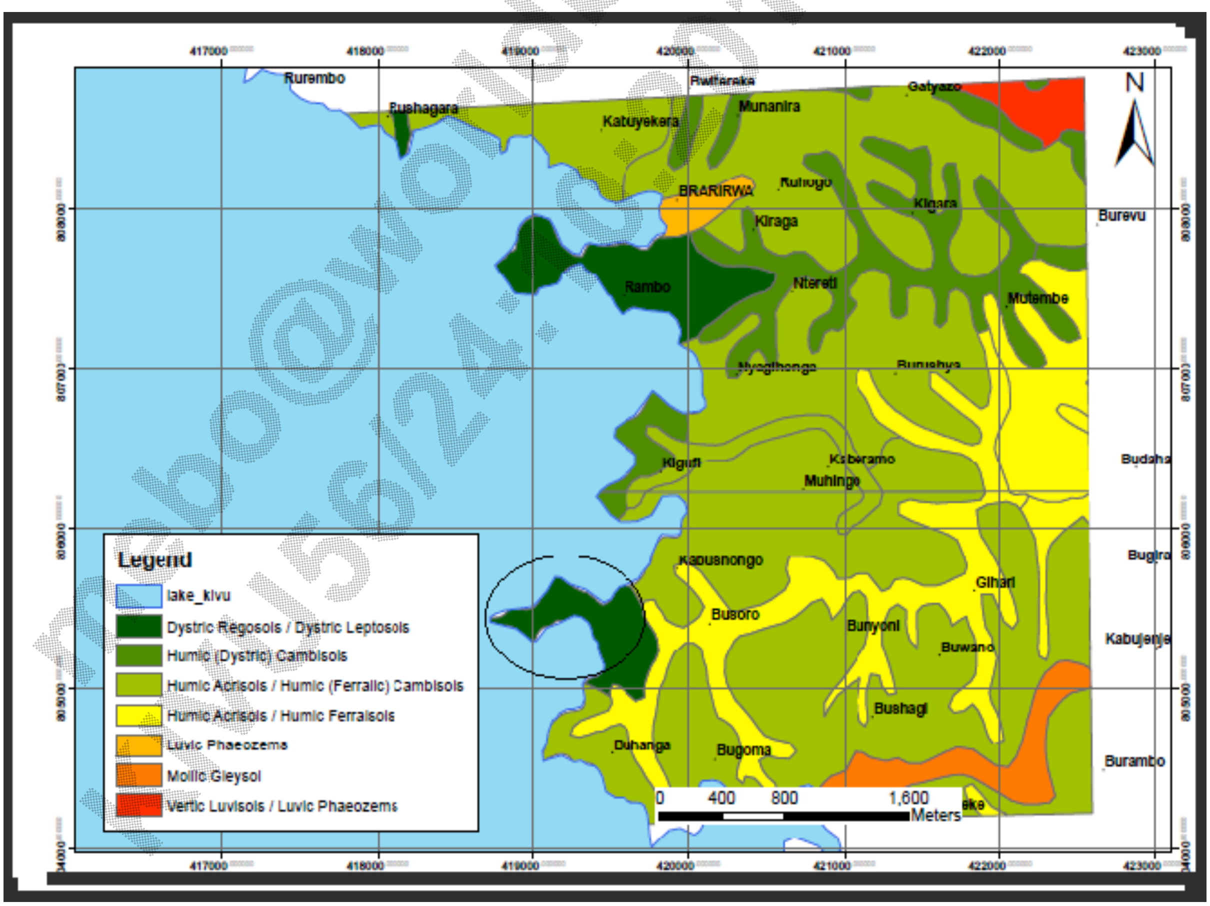


Figure 29: Soil map of Busoro area

From the seismic point of view, the project site is located in a seismically active zone with weak to medium seismic intensity (7).
It would be desirable to take into account all the seismic parameters required during the construction of infrastructures and structures.

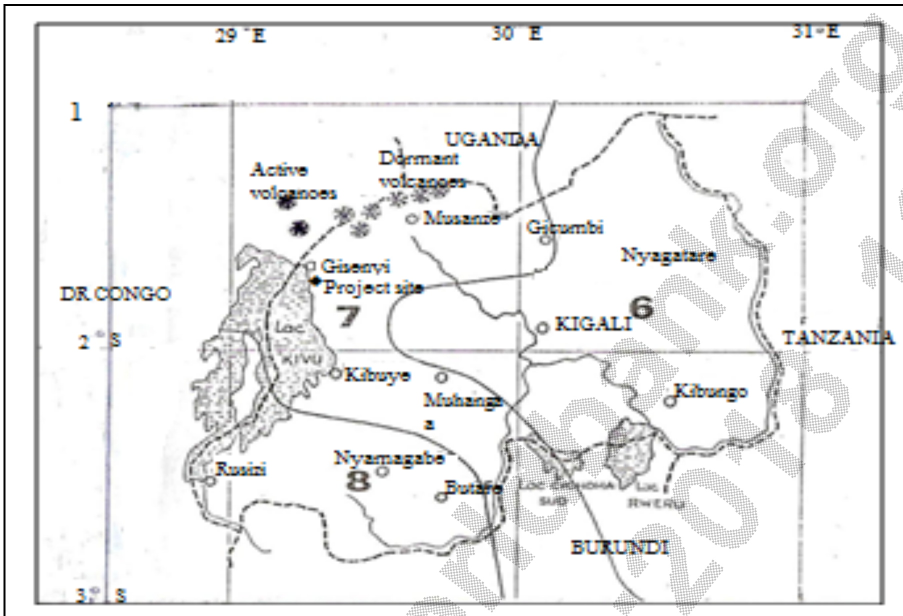


Figure 30: Seismic intensity

8: Medium to high seismic intensity **7**: Weak to medium seismic intensity **6:** Insignificant seismic intensity

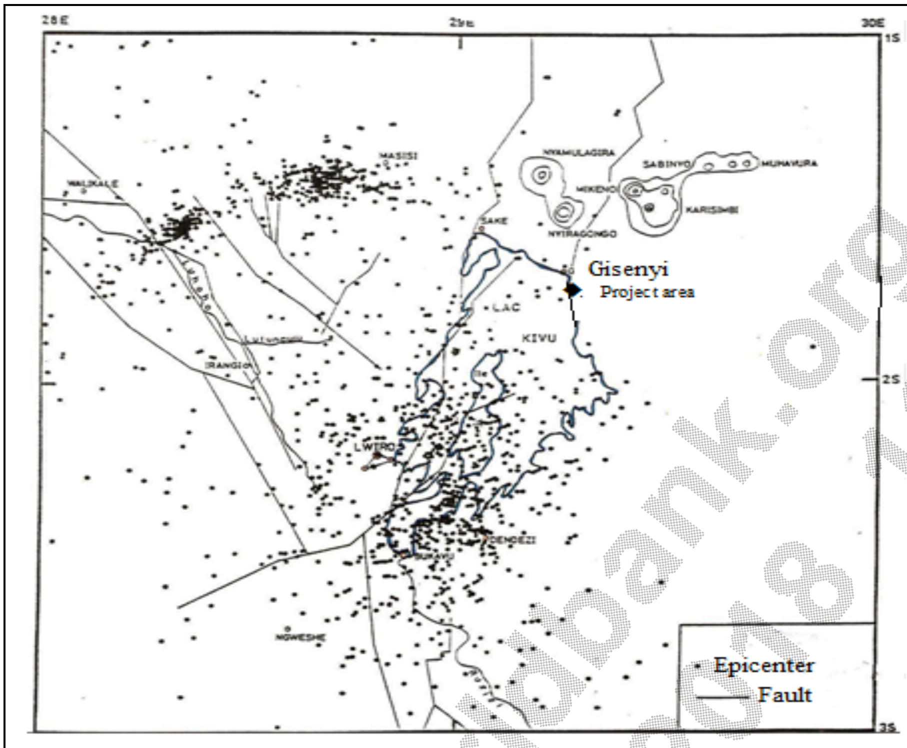


Figure 31: Earthquake epicentres in and around Kivu Lake since 1973 (Lwiro Geophysics Dpt, DRC)

4.1.1.7 Hydrology and Water Resources

Rubavu District suffers from lack of water network. This part, which is entirely on land of lava, has no permanent rivers, except Mizingo and Mutura, which have their sources in the natural forest of the Congo-Nile.

The lack of water sources and rivers is a major problem in this part of the District. The drainage system of the South District is attached to the Lake Kivu basin. Sebeya River ends its course in Lake Kivu with two falls and Rubavu Gihira that allowed the installation of hydro. Pfunda River flows into the Sebeya after stagnating in the great marsh Pfunda on a 15 km run.

4.1.1.8 Seismic load

By extracting data from the global seismic hazard map prepared by the global seismic hazard assessment program (GSHAP), the corresponding map for Rwanda is provided in figure 14. According to this map, Rwanda may be divided into three zones i.e. Zone 3, zone 2 and zone 1. The project sites lie on zone 3 with the range of peak ground acceleration (PGA) of 0.8-to1.6 m/s2 or 8.2 to 16.4 % of gravitational acceleration. The design PGA of these two sites can therefore be taken as 0.12 g[7].

[7] http://www.preventionweb.net/english/professional/maps/v.php?id=7483

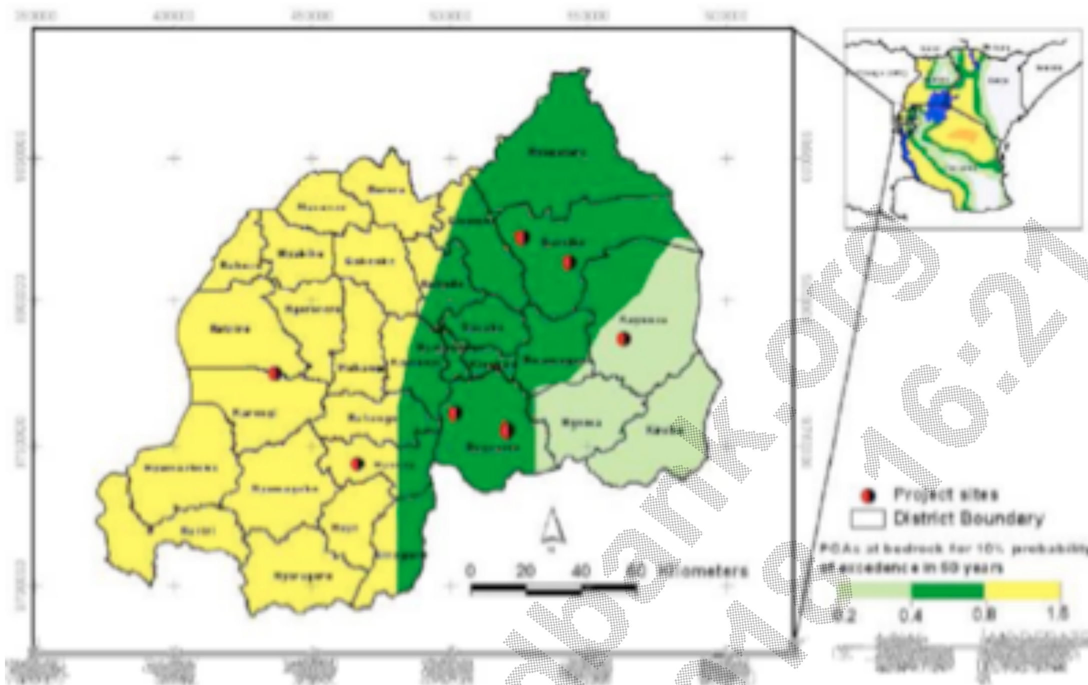


Figure 32: Seismic hazard map of Rwanda[8]

If the information is correlated with the Mercalli scale the zone corresponds with scale VI as shown below.

Table 13: Mercalli Scale[9]

Instrumental Intensity	Acceleration (g)	Velocity (cm/s)	**Perceived Shaking**	**Potential Damage**
I	< 0.0017	< 0.1	Not felt	None
II-III	0.0017 - 0.014	0.1 - 1.1	Weak	None
IV	0.014 - 0.039	1.1 - 3.4	Light	None
V	0.039 - 0.092	3.4 - 8.1	Moderate	Very light
VI	0.092 - 0.18	8.1 - 16	Strong	Light
VII	0.18 - 0.34	16 - 31	Very strong	Moderate
VIII	0.34 - 0.65	31 - 60	Severe	Moderate to heavy

[8] http://www.preventionweb.net/english/professional/maps/v.php?id=7483

[9] The national risk Atlas of Rwanda, 2014

IX	0.65 - 1.24	60 - 116	Violent	Heavy
X+	> 1.24	> 116	Extreme	Very heavy

There are some new warnings that the seismic activity could shift below Lake Kivu and that then a major outburst from the lake is to be feared (Tedesco 2002, Interview with International Federation of Red Cross and Red Crescent Societies), but the recommendations which were drawn by representatives of large organisations for this case, to evacuate the population of Goma to Bukavu, are not adequate. A possible evacuation of inhabitants of the Kivu region must be outside the Lake Kivu catchment area because such a large gas cloud would flow via Bukavu to Lake Tanganyika (see Tietze 1978, 1991).

4.1.1.9 Land Uses

There are a number of new commercial and residential facilities being constructed in the centre of Rubavu in general. The case is however not the same in the surroundings of the Busoro Peninsula. There are still some low standing houses around the sites and most of available land is used for cultivation.

The main land use in the zone, in spatial terms, is residential with very few commercial settlements. The Project represents a significant addition to the area-developed infrastructure. The construction activity in the zone must be viewed as a microcosm of the driving elements in Rubavu's long-term development strategy.

Land use in Rubavu is primarily centered on cultivation of food crops and settlement. The local communities cultivate a variety of food crops under mixed cropping. They include bananas, cassava, passion fruits, avocado, coffee, mango trees, maize, eggplant, and tea among others.

Cultivation occurs along the steep slopes predominant in the area without proper soil conservation techniques, a practice that accelerates soil erosion. However, it is worth noting that terracing as a means of harnessing soil erosion is practiced in some parts of the project area. A few of the local communities also keep livestock mainly cows under zero grazing.

Plate 7: Land uses around the onshore site

4.1.1.10 Historical and cultural sites

There are no historical and cultural sites in the immediate environment of the sites and the areas where the onshore installations and the marine landing site will be located.

4.1.2 Biological Environment

4.1.2.1 Flora and fauna

Flora

Rubavu District has two very important natural reserves for the balance of the ecosystem. This is in the northern part of the District, part of the National Park Birunga consisting mainly bamboo. There is also Gishwati, which is composed of the woodlands of eucalyptus, pinus, cupressus of lustanica of Gravillea robusta and acacia.

The site for terrestrial construction of the Symbion project show little vegetation which has been altered by human intervention for agricultural and touristic purposes. The most frequently observed crops were banana plantations of Musacae family and *Zea mays.* Apart from agricultural plant species. The surrounding "natural vegetation" is comprised of secondary disturbed vegetation, primarily shrubs, herbaceous plants and several species of grasses, including razor grass, *Pennisetum* and *Paspalum* species. A number of exotic tree species have been found on the project site such as bamboo, *Bambusa vulgaris*, *eucalyptus* and *Euphorbia* species, guava and Mango trees.

Plate 8**: Vegetation on the project site**

The crops under cultivation include beans, sweet potatoes, banana, soya, maize, peanuts and vegetables. The onshore site is occupied by grass and natural vegetation.

Fauna

Natural wildlife in Rubavu District consists of the animals living in the park Birunga (buffaloes, antelopes, monkeys, hares, porcupine peak), some rare animals like the jackal, leopard, golden cat, genet and mangosteen and various birds.

It should be noted that Lake Kivu lies within the Albertine lift which harbours endemic mammals, birds, and amphibians.

The terrestrial fauna of Lake Kivu and the project site is mainly characterized by bird's species migrating within Kivu Islands. During the site visit, a number of bird's species could be observed.

Two endemic mammals have been reported around Lake Kivu even if none of them has been observed in the project area.

- Congo clawless otter – This otter has been recorded in Lake Kivu, predominantly around the offshore islands.
- Ruwenzori otter shrew – This species is nocturnal and highly specialized, hunting invertebrates in hilly sites around streams
-

Plate 9: Vegetation in the surroundings of the project site

Conservation plan and species of particular importance

There is no official conservation plan concerning the project site and around it.

Even if no endangered species were noticed on the project site and around it, some species inventoried on Kivu islands are already registered on the International Union for Conservation of Nature (IUCN) Redlist and therefore need more attention for their conservation, (conservation Plan for Kivu Islands)[10]. This includes the Marsh Mongoose (*Atilax paludinosus*) and many water bird species. There are also small mammal species and amphibians that are listed as vulnerable by the IUCN Red List that are found on the islands located in Lake Kivu[11].

4.1.2.2 Sensitive Ecosystem

Lake Kivu is a sensitive ecosystem and a real Eldorado under supervision. In terms of the amount of methane it contains, Lake Kivu, situated between the Democratic Republic of Congo (DRC) and Rwanda, also provides fish for the local populations. With major changes looking to take place in the next few decades, it is imperative we understand the mechanisms and empower the stakeholders who will have a role to play in its exploitation. Since 2002, one

[10] https://www.iucn.org/

[11] Conservation plan for Kivu Islands

of the least studied great lakes in the region has gradually revealed a good number of its secrets to an international team of researchers from all fields. The report from the EAGLES project (1) (East African Great Lake Ecosystem Sensitivity to changes), financed by the Belgian Federal Science Policy (BELSPO), marks an end to this series of expeditions. It provides new keys to understanding how the lake functions and places its biogeochemical evolution in a historical, climatic and ecological perspective, at the heart of a problem where the sirens of economic profit are wailing on the one hand, and global warming forecasts are sounding the alarm bells on the other.

4.1.3 Socio-Economic Environment

4.1.3.1 Introduction

A socio-economic survey was conducted in Rubavu district, Nyamyumba sector, Busoro cell and Kabushongo and Buhanga Villages with the objective to know the socio-economic status of the population and the area to be affected by the gas to power project. Primary data were compared with secondary data in order to get a more realistic and updated socio-economic situation. A" Reasoning Method "was used to determine a sample of 120 persons, all adults, representing 33% of all households. The sampling took into account the activities of the population in the project area i.e. farmers, artisans, fishermen and populations whose part of their fields may be impacted during the construction of the gas and power plant and those living along the road that is being enlarged.
The population covered by the project area is 360 households divided into two villages (Imidugudu) namely Kabushongo and Buhanga villages further divided as follows:
- Kabushonga with 176 households for a total population of 894 inhabitants
- Buhanga with 184 households for a total population of 896 inhabitants.

The total population of these 2 villages covered by the project area amounts to 1,790 inhabitants.

The purpose of the survey that reached out to a total of 1,790 inhabitants was to identify the population to be directly and indirectly affected by the activities of the Symbion Power Project within the project area. The survey was mainly to assess the socio-economic impact of the project activities in Rubavu District focusing on the villages located within the project area and around it.

4.1.3.2 Population and Demography

The total population of Rubavu district is estimated to 422 348 compared to 404 278 according to the NISR/Census provision result 2012. The female sex is represented by 208 938 against 195 340 of male sex. This means that the female sex is 51.68 and the percentage of male sex is 48.32%. The density of population is 1,041 inhabitants per Km2. The population growth rate is 3.3(DHS4) from 2002 and the sex ratio is 93 men for 100 women.

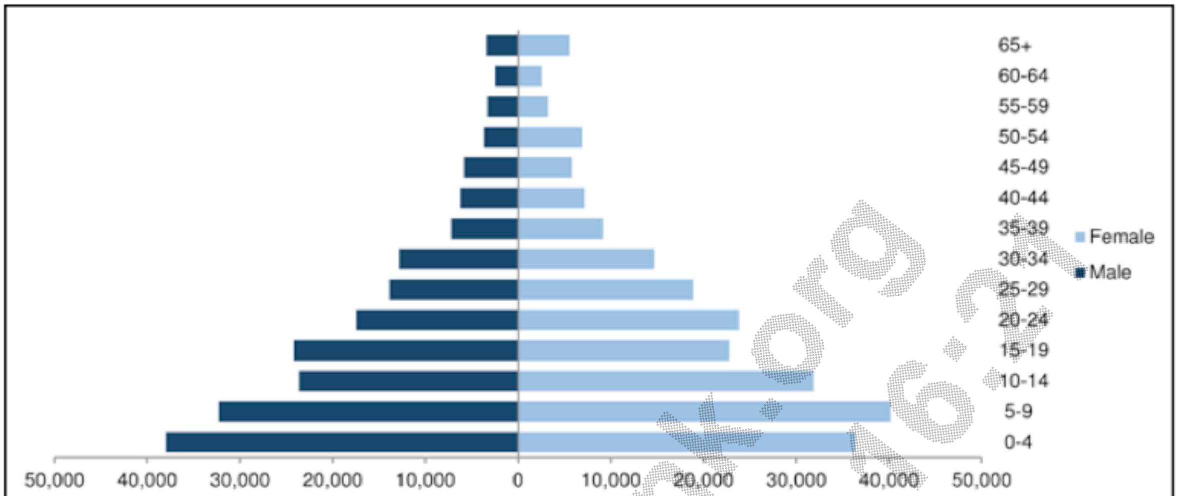


Figure 33: Distribution of the population in Rubavu by age groups and sex[12]

Figure 9 below presents the ratio of females per 100 males by district. It shows that females outnumber males in Rubavu district with 118 females per 100 males, which is above the national average of 111 females per 100 males. Rubavu is ranked second of all districts for the highest number of females per every 100 males, after Nyamasheke.

The average size of household in Rubavu district is about five persons per household (5.2), which is slightly above the national average household size (4.8). Rubavu has the second largest mean household size of all districts, after Rusizi district (5.4).

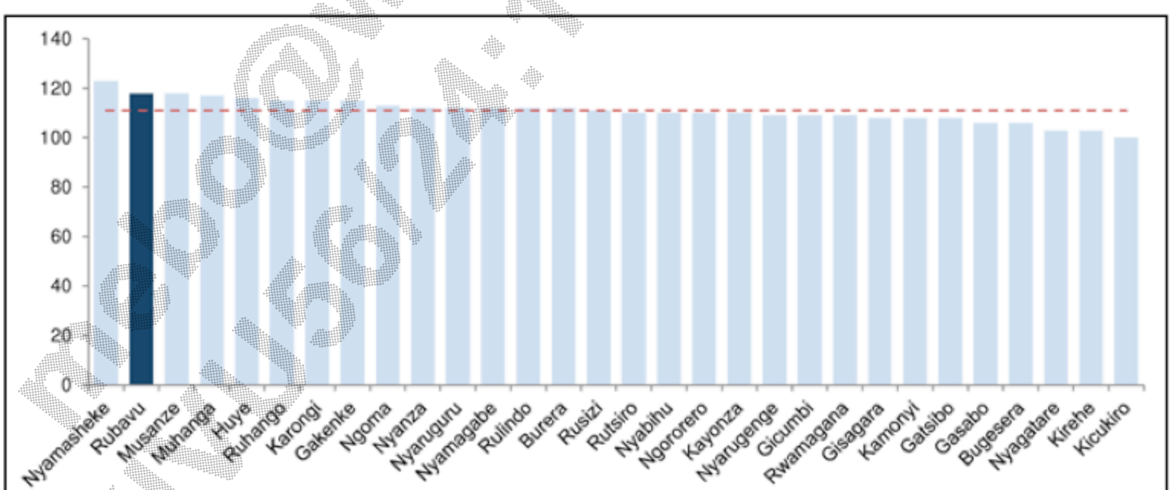


Figure 34: Number of females per 100 males, by district

4.1.3.3 Employment /Economic Trends-Local Economy/Occupation/Incomes

The table below presents the percentage distribution of usual employment, unemployment, and economic inactivity among persons aged 16 years and above by district.

[12] EICV3, 2012

In Rubavu district, the overall employment rate is 79.6% of the resident population aged 16 years and above, the unemployment rate is 2% and the economic inactivity rate is 18.7%. For comparison, the national average employment rate is 84%, the unemployment rate is 0.9% and the economic inactivity rate is 15%.
The population of the district aged 16 and above is estimated at 213,000. As shown in Figure 10, the Rubavu district employment rate is below the national average. Among Western Province districts, Rubavu is ranked second last after Rusizi (77.9%).
Rubavu includes the third largest city in Western Province after Rusiszi and Karongi and this may explain the position it has in terms of a relatively low employment rate.
Considering the findings from EICV3 in related to the education, the literacy rate of Rubavu district is 68.8% among population aged 15 and above. This number is not different significantly with the rate at national level, which is 69.7%. Whereas, the percentage of individuals aged 6 and above that have ever attended school is estimated to 82.6% against 83.2% at national level. This means that 16.8% represents those are never attended school.

As a rate of individual with net attendance in primary school, Rubavu district accounts 89.7% against 91.7% at national level and 23.3% against 20.9% in secondary school. Concerning the % of the users satisfied with education services, 77.5% are satisfied with education services attending against 81.9% in all Rwanda, 22.3% against 16.6% who have the problem with education service attending, while 0.2% against 1.5% at national level confirm that they don't know for the total population of 3 437considered by the EICV3 in the country against 139 in Rubavu district[13]. The critical situation above explains the low income of HHs of Rubavu district, which reduces the level of investment in social and human capital formation.

The use of computers among population aged 6 and above is 6.0% confirmed to use computer before and have the confident to use it again. This means that the computer literacy in Rubavu district is highly superior to that of the population of Rwanda. The rate of the users of computers before but not confident to use it again is respectively 3.1% and 2.6 at national level. Form this situation, the EICV revealed that 90.9% in Rubavu district have never used computer before against 93.5% at national level. In those cases the program of government should be reinforced in order to attain at least 50% proposed by Vision 2020.

[13] DDP. 2013-2018

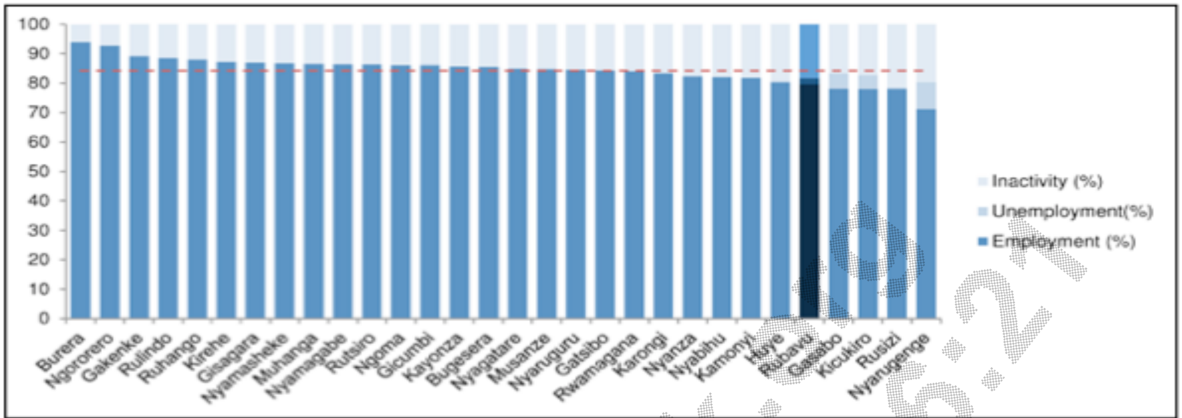


Figure 35: Economic activity: Employment, unemployment, and economic inactivity among persons aged 16 and above (usual), by district.

Data collected from 120 households randomly selected in the Project area gave roughly an amount of 30,000 Frw / month as the average income of farming households operating at least ½ ha, while for those households practicing other activities in addition to agriculture such as breeding of small livestock (goat, poultry, or having a small shop), the monthly income can reach 70,000 Frw. For the category of fishermen having their canoes and nets and having a mall land for agriculture activities can win over 80.000Frw/month. But there is also in the project area a category of people who just have a plot where are constructed their houses. Those live on a day-to-day basis and accounts for about 15% of households in the project area. The largest expenses in the project area are food expenditures. For this analysis, we considered the prices of the most consumed products in the project area per month as well as the expenses related to purchases made during the month. For predominantly agricultural households, we have considered that food expenditures can reach 30,000 Frw/month because these households are almost self-sufficient except for the purchase of some basic products (meat, salt, sugar, matches, soaps). For the households with fishermen, the expenses are higher, estimated to 50,000Rwf because they have more income.

4.1.3.4 Agriculture

In Rubavu District, agriculture has for a long time been a core sector of economy in terms of its contribution to domestic income and employment. Even agriculture through its chare in total GDP, agriculture remains important because it provides the basis for growth in other sectors such as manufacturing and services. Being the largest employer, the majority of women in Rubavu district is employed in agriculture as primary producers and contributes 29.3percent of agriculture production against 45.7 at national level. The land management proposed the kind of agriculture such as Maize in sectors of Mudende, Bugeshi and Busasamana. The beans are proposed in sectors of Nyakiriba ,Rubavu,Kanama,Nyundo and Nyamyumba. The potatoes in Mudende, Bugeshi, Busasamana and Cyanzarwe.

Table 14: The size of cultivated land per household compared with the results at national level

EICV3/2011 /2012	**Mean size of cultivated land (ha)**	**Median size of cultivated land (ha)**	**Size of cultivated land**				**Total**
			<0.3 ha	0.3-0.9 ha	0.9-3 ha	>=3 ha	
All Rwanda	0.59	0.33	45.8	37.6	14.7	1.9	100.0
Rubavu	0.26	0.13	74.3	21.4	4.1	0.2	100.0

In the light of the table above, the rate mean size of cultivated land is 0.26% against 0.59% at national level. The EICV results show that 74.3% of households have less than 0.3Ha. This size of cultivated land is very low compared with the total at national level. Then the households with the land over 3 hectares are estimated to 2 per 1 000 against 19 per 1 000 in the country. This is a main factor, which can be analyzed to explain the poverty if the HHs income is measured as dependent variable in Rubavu district.

Fishery in the project area

There are two types of fishing around Lake Kivu:

The artisanal fishery

It is operated by the fishermen grouped in a cooperative called APELAC. Fishermen are scattered in different fishing zone up to the District of Rutsiro at more or less 32 km. Currently there are 208 of them registered in the cooperative. They have adequate fishing facilities such as nets, canoes and are subject to a certain regulation (fishing period, size of the nets). This cooperative also has drying mesh at the entrance to the town of Gisenyi where it sells its production

Individual Fishing

It is conducted by individuals who have their boats or those who rent. This category of fishermen is not registered with the District administration. Their exact number is unknown. They are called "Clandestines". They fish all along the lake very late at night and work in networks with other fishermen from the other shores of the lake. It happens that they are arrested by the administration and pay fines because they do not comply with the fishing regulations (fishing period, types of net).

It should also be pointed out that this fishing activity in the project area generates a lot of income for those who are really practicing but to do it and gain some money, one needs to own his canoe and nets. Currently, the price of fresh fish (Isambaza) in the town of Gisenyi or Goma is between 1500-2500Frw/kg, especially between the months of August until December when fishing is abundant in the lake. But it happens that the price doubles especially during the great rainy season.

Currently, the Government of Rwanda has put in place regulations to protect fishery resources and some taxes have to be paid.

During our survey, we found that the fishery had been banned during the whole month of December 2016 in order to allow the fish to grow because this fish resource could be exhausted if not regulated (fishing period, type of net).

4.1.3.5 Infrastructure

Housing and Energy

Housing

74.5% of households in Rubavu district use beaten earth as their flooring material. 22% of households have a cement floor, which is higher than the national level of 17%[14].
Compared with other Western Province districts, Rubavu is ranked first with the highest percentage of households using cement floor; it is ranked fourth countrywide. In Rubavu district, 13% of households are using mud-covered tree trunks as their main wall material; 51% are using mud bricks and 24% mud bricks covered with cement.

The survey revealed the most common type of habitat in the surroundings of the project area is the clustered rural settlement (known as Umudugudu). Overall 36% of the private households are of that type. It is followed by dispersed/isolated housing (28%) and spontaneous/squatter housing (22%). In rural areas the predominant type is clustered rural settlement (umudugudu) and dispersed/isolated housing with 41% each, and the spontaneous/squatter housing with 17%.

Energy

The survey in the immediate environment of the project site revealed only 22.3% have electricity in their homes, 18.5% use an fueled lamps, 36% use candles and 8.7% are using firewood for their household energy supply. This low rate of electrification in the project area is due to several factors including:
- High number of dispersed dwellings
- Very rugged topography; and
- Poverty in general.

During the survey, the population mentioned in order to subscribe to power supply it is compulsory to pay a one-time amount of 58.000Frw to buy a cash power. After that, the subscriber pays for consumption on a monthly basis. This has been and is still a big challenge for the access to electricity.

The primary sources of energy used for lighting by households were categorized as follows: electricity, oil, lamp, firewood, candle, lantern, battery, and other unspecified sources.
In Rubavu district, 21% of households use electricity as their main source of lighting, ranking the district first in Western Province.
On average the urban areas have 46.1% of household using electricity as their main source of lighting, compared with only 4.8% in rural areas and 10.8% at national level.

[14] EICV3, 2011

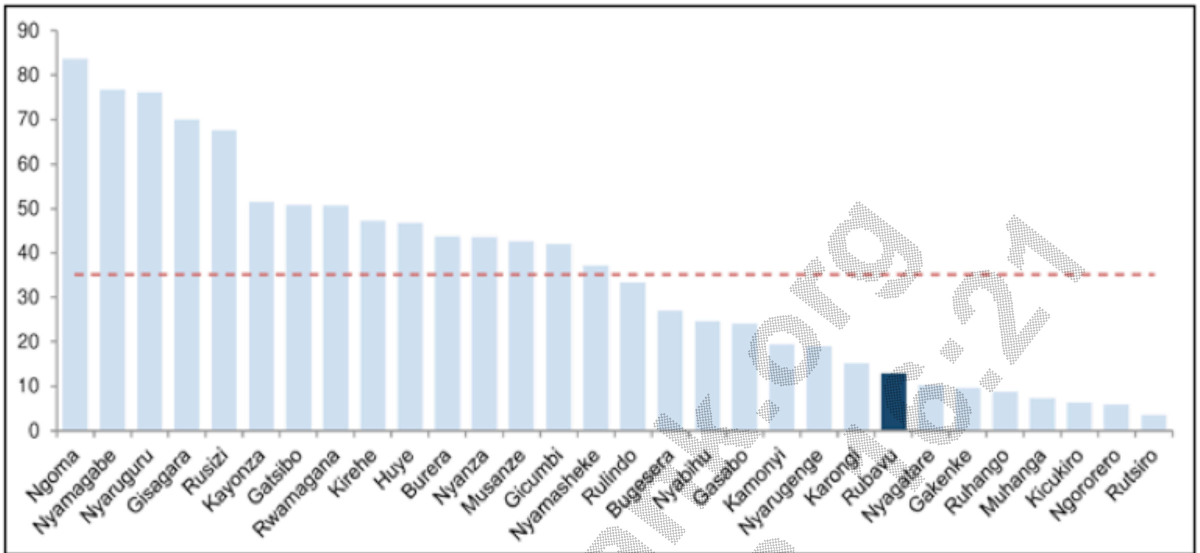


Figure 36: Percentages of households with mud-covered tree trunks as wall material per district

Energy Sector Baseline scenario

According to the national energy statistics, 86% of energy is produced from biomass, whereas 11% is generated from hydrocarbons and 3% is sourced through electric power.

Biomass consists of firewood, charcoal or agricultural residues (mainly from cooking within Rwandan households). This strong reliance on biomass may lead to depletion of forest resources and soil erosion if not sustainably managed.

Hydrocarbons in Rwanda are mainly used in the transport sector but are also used for the production of electricity through diesel generators. Diesel generators produce 42% of the electricity produced in Rwanda.

On the other hand, 55% of national electric energy is produced from Hydropower sources; this equals an installed capacity of 42.8MW. Out of this Rwanda is importing around 12MW from SINELAC based on a regional tripartite agreement involving parties from Burundi and the Democratic Republic of Congo.

The national hydropower plants have been rehabilitated and water level management has improved to reach almost maximum production capacity. Reports indicate that power generation plans have been developed for new national and regional hydro projects, while efforts have been stepped up to advance methane-to-power projects.

Plate 10: Power supply infrastructure around the project site

Heavy fuel oil generation is also on the upswing because the generation cost per MW is substantially lower than that of diesel-based generation.

Electricity supply is currently stable without load shedding and is sold at Rwf112/kWh to the end retail consumers. At present the national power utility company REG supplies electricity to around 92,000 customers.

Of the energy produced today, 70% is consumed in Kigali. Strategic interventions are currently being developed to increase regional access to electricity by the extension of the national grid and through the set-up of isolated grids from micro-hydro plants and through decentralized energy sources, such as solar energy for electrification of remote public institutions and households.

By the EDPRS period ending in 2012, the energy sector is expected to connect 200,000 households to electricity, compared to the 70,000 households connected at present, and it is projected that over 300 administrative centers and service delivery points, 1,000 schools, and 180 health centers countrywide will be connected.

Table 15: Generation of roadmap to achieve required supply

	Project	Capacity	Total Capacity
2013/14	Installed capacity		119.6
2014/15		70.5	190.1
Hydro	Mushishito HPP (Rukarara V) (Phase I)	2	
Hydro	Nyabarongo I EHP	28	
Thermal	Rental (Thermal Power Plant)	4	
Solar	Rwamagana Solar Power Plant	8.5	
Methane	KivuWatt Methane PP (Phase I)	25	
Peat	Gishoma Peat Power Plant	15	
Hydro	Mukungwa I HPP	-12	
2015/16		65	255.1
Hydro	Mushishito HPP (Rukarara V) (Phase II)	3	
Hydro	Mukungwa I HPP	12	
Hydro	Micro Hydro (IPPs)	10	
Solar	Rwinkwavu Solar Power Plant	10	
Import	Interconnection (Ethiopia-Kenya-Uganda-Rwanda)	30	
2016/17		58	313.1
Hydro	Micro Hydro (IPPs & REFIT)	12	
Thermal	Kigali Special Economic Zone (KSEZ) HFO	40	
Solar	Nyagatare Solar Power Plant	10	
Thermal	Rental (Thermal Power Plant)	-24	
Import	Interconnection (Ethiopia-Kenya-Uganda-Rwanda)	20	
2017/18		251	564.1
Hydro	Ntaruka B HPP	5	
Hydro	Micro Hydro ((IPPs & REFIT)	14	
Solar + Bioenergy	Solar + Bioenergy (REFIT)	12	
Methane	Symbion Methane PP	50	
Peat	Hakan Peat PP (Phase I net Output)	70	
Import	Interconnection (Ethiopia-Kenya-Uganda-Rwanda)	100	
Total Generation/Import Capacity End EDPR II			564.1

Regulatory and national energy security issues

Appropriate attention should be given to specific but critical issues relating to the adoption of electricity and gas legislation, regulation and tax exemptions on renewable energy and energy efficient imports.

Efforts will be made to improve the quality and continuity of the electricity supply by improving the maintenance of generation and transmission equipment with the help of a fully trained staff.

Rwanda projects that by 2020, at least 35 % of the population will be connected to electricity (up from the current 6%), and the consumption of wood used as source of energy will decrease from the current 94% to 50% of national energy consumption.

To further ensure energy security, Rwanda's unique methane gas reserves in Lake Kivu could potentially fuel 350 MW of power. The Government is currently negotiating gas concessions and power purchase agreements with various private sector utilities to further develop these reserves.

Further development of hydropower is also seen as a critical part of realizing an optimal energy matrix that will bring energy security. Thus, new hydro generation projects at different stages of development are at both national and regional levels.

Rwanda is also exploring its geothermal potential along the Rift valley while at the same time increasing its use of solar energy for remote institutions and households. The Government is also engaging in the development of a methane gas to liquid project.

A number of investors have already shown interest, Kivuwatt is producing 25MW and Symbion project is still in the feasibility stage. The production of liquid fuel within the country would reduce Rwanda's dependence on imported petroleum products, which burden the national economy.

The recent discovery of oil in the East African Rift System in Uganda and the analysis of satellite images indicate that Rwanda may also possess oil resources.

An exploration agreement has been signed with a private company that is currently conducting an airborne magnetic and gravity survey to analyze the sedimentation area in the Kivu Basin. Other proposals endeavor to even further diversify Rwanda's energy matrix. Studies have indicated the possibility of producing biogas from geranium leaves and sorghum stems. Installation of bio digesters for several institutions and private entities is underway. Retrofitting of petrol engines to use biogas, the construction of several improved stove models that operate on sawdust, wood, peat, or briquettes of various origins as well as the pyrolysis of peat include some of these measures.

Considering all these possibilities, the EDPRS period is set to realize tangible progress on improving Rwanda's energy security by developing its energy matrix.

Electricity network

The national grid consists of high and medium voltage transmission lines and low voltage distribution lines under management by REG. With support from MININFRA, REG aims to increase electricity connections to at least 350,000 consumers by 2012.

Reports indicate that this goal will require an extension of the network by approximately 4,000 km of transmission and distribution lines, a rehabilitation of the existing network and a reduction of technical and commercial losses.

These conditions will be achieved through improved technologies and maintenance as well as through tracking attempted fraud by individuals.

Currently REG is supplying stable power to 110,000 customers out of which 80% are using the cash power system, which requires prepayment and buying units from REG vendors. Ultimately, the target is to transform the whole system into prepaid connections.

In Kigali local connections to the distribution network have been outsourced by REG to the private sector on a trial basis. Ultimately, REG aims to gradually transfer distribution networks to private investors, in the same way that it is now relying on the private sector for generation.

The Kampala- Kigali Oil Pipeline Project

Oil products on the Rwandan market come almost exclusively via the Northern Corridor: from the Kenyan port of Mombasa on the Indian Ocean, then through Kenya via a pipeline that runs from Mombasa to Eldoret, where the products are distributed by truck tankers to Uganda, Rwanda, Burundi and parts of the DRC.

The long distance from Mombasa increases oil product costs, as well as vulnerability and dependence. The dependence on Kenya was especially felt during the recent crisis this December, during which time the only alternative route was through Tanzania.

In order to increase the reliability of supply and minimize the transport cost of imported oil products, the Government of Rwanda has joined Kenya and Uganda in the East African oil pipeline project. Extension of the existing pipeline from Eldoret to Kampala was awarded to Tamoil East Africa, through a concession contract.

Rwanda is expecting to benefit from further extension of this pipeline from Kampala to Kigali, a length of approximately 600 km. Currently, the possibility of further extending this pipeline to Bujumbura is also under discussion.

To this end, a memorandum of understanding was signed in March 2008 between the Government of Rwanda, the Government of Uganda and Tamoil Africa Holdings Ltd, the private company selected to develop the project on a build, own and operate basis.

The selected company, which is already incorporated in Rwanda, is soon starting on conducting the technical feasibility study on the Kampala to Kigali pipeline.

A market survey by SAIC (Science Applications International Cooperation), carried out through financial support from the United States Trade Development Agency, confirmed the project's commercial viability and found that the construction of this pipeline is expected to lower costs of trucking from US$56.89 per cubic meter to about US$42.44 per cubic meter, which would thereby ease the oil tariff.

The construction of the Kampala to Kigali Pipeline will create a need for additional investment in the storage capacity of the country. The existing storage in Kigali can currently accommodate up to 17,500 cubic meters of petroleum products.

In order to meet the growing demand of petroleum products, two storage facilities, Bigogwe with a capacity of 5,000 cubic meters and Rwabuye with a capacity of 4,000 cubic meters, are being rehabilitated with funds from the national budget. Work on Bigogwe is nearing completion and work on Rwabuye will start soon.

Prospects for Oil Exploration in Rwanda

In response to Rwanda's dependence on oil imports at present, the Ministry of Infrastructure is seriously assessing possibilities for oil developments in Rwanda, through both exploration and conversion.

Such initiatives, though in early stages of development, are likely to bring significant economic gains to the country in terms of balance of trade.

Rwanda has recently seen an increased interest in oil exploration from international private companies, especially in the Western Rift Valley. This development is the direct result of the recent oil discovery in the Northern part of the Rift Valley in Uganda by the Heritage Company.

The structural similarities between the two sides of the Rift Valley appear to be the main factor for the renewed interest in oil exploration in Rwanda.

The presence of methane gas dissolved in the deep waters of Lake Kivu, which originates partly from the earth crust, is interpreted by some experts as an indication of probable oil presence below the Lake sediments.

The area under survey is in the Western part of Rwanda along Lake Kivu and covers 1,631 km^2. After studying the existing literature, Vangold embarked on a satellite study of the Lake that suggests that there are a number of oil seeps on the surface of Lake Kivu.

The indications were positive enough to warrant an airborne magnetic and gravity survey of the exploration area, which was undertaken in September 2008.

2086 km of airborne survey were recorded, and the data were analyzed to indicate the size and nature of the Sediment Basin under and around Lake Kivu. The results of this survey not available were expected in early 2009.

However, it is certain that additional exploration still needs to be undertaken in order to clarify the resources of the Lake. More detailed magnetic and gravity data will be collected from a boat survey on the Lake.

If all indications of petroleum potential remain positive, Vangold will embark on a seismic survey next year in cooperation with other partners.

Other Initiatives

In a bid to reduce dependence on conventional oil imports, new concepts to produce hydrocarbons locally, in partnership with the private sector, are presently being discussed.

Proposals have been received from a number of investors. One promising endeavor is the conversion of Lake Kivu's Methane Gas to a liquid. It is technically possible to transform this gas into either LPG or even diesel, which could be used to drive ordinary cars or other engines.

Another potential option, which Rwanda is currently exploring, is the local production of biofuels from plants like Jatropha among others. Several trees have recently been planted for this purpose in the Eastern Region of Rwanda.

Wind Energy in Rwanda

In Rwanda, the development of wind energy has not yet been given priority, because of the lack of detailed and reliable information on wind regimes and potential exploitation sites.

However, since demand for electricity is growing and GoR is trying to diversify Rwanda's energy sources as much as possible, it is currently exploring its national wind generation potential.

In Africa only a few countries have so far been able to establish a consistent program for using wind energy, namely South Africa, Egypt, Morocco and Tunisia, where a total capacity of 1,000 MW has been installed to date.

Wind energy is a particularly interesting possibility for our rural electrification objectives, because wind energy can be exploited and distributed on the spot, wherever the wind regime allows, and can thus distribute power to areas far from the national grid. Moreover, a turbine of 300 KW could be sufficient in supplying more than 1,000 households with electricity.

Ongoing initiatives:

The first step in exploring the national wind generation potential is the development of a wind atlas. Such an atlas identifies windy sites and estimates the exploitable wind energy capacity at different points throughout the country.

Creating such an atlas would require detailed meteorological surveys and the erection of wind potential measurement instruments in promising sites. Moreover, data will have to be collected over a period of about one year to gain valid results.

The necessary studies for the development of the wind atlas will start this year and are financially supported by the Belgian Government.

Next steps shall include a pilot operation of setting up two or three wind turbines of 100 KW to 300 KW with funding from the European Commission in an effort to improve access to electricity in rural areas.

All these initiatives will then be harmonized with the development of a strategy for wind energy exploitation, taking into account not only the meteorological and technical potential but also the institutional, regulatory and financial mechanisms for successful implementation. The study will start late 2008.

The primary sources of energy used for lighting by households were categorized as follows: electricity, oil lamp, firewood, candle, lantern, battery, and other unspecified sources.

The map presented in the figure below presents the distribution of households using electricity as the main source of lighting by district. In Rubavu district, 21% of households use electricity as their main source of lighting, ranking the district first in Western Provence.

On average the urban areas have 46.1% of household using electricity as their main source of lighting, compared with only 4.8% in rural areas and 10.8% at national level.

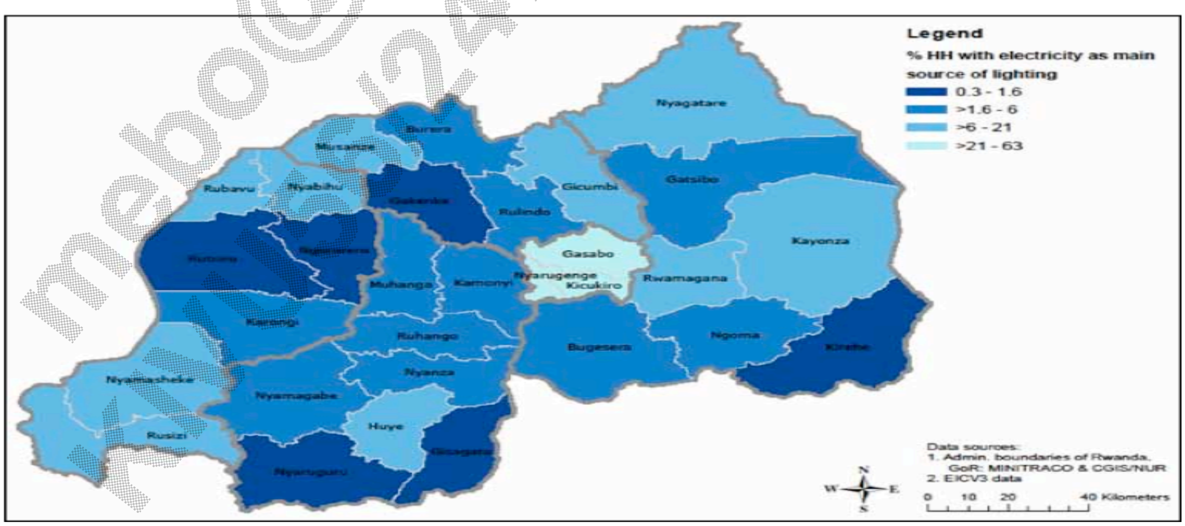


Figure 37: Percentage of households with electricity as main source of lighting by district

Transport and commerce

The sector of agriculture will be supported by achievement of the priorities of environmental and resource management based on forest cover at 29% and transport sector by improving the road network and in Kivu Lake at100 % in Rubavu district and organize rural grouped settlements at 70 %.

An efficient transport system is a prerequisite for economic and social transformation. In Rubavu district the transport system currently comprises of roads, air and water transport modes. In nominal terms, the roads of the rural areas of the district are in bad conditions and one urban road is paved.

There is a non-paved road crossing the surroundings of the project site from the district headquarters to the Nyamyumba Sector via the Busoro Cell. This road is being upgraded to a bitumen road and should be the one to facilitate the transport of materials to the project site.

The transport of goods and people is done with some old mini-buses going from the city of Gisenyi to the sector of Busoro, but the transport of motorcycles is the most used and the fastest. Few people are still using the bicycles to move from one point to the other but most of the time from Busoro to Rubavu, around the brewery.

Lake Kivu water is also contributing to the trade between different points of the country including Busoro but also the trade between Rwanda and DRC. For this specific project we were interested in the trade between Rubavu and Goma. The project area is also a crossing point for the different canoes coming from the other coastal regions of Lake Kivu, which supply the town of Gisenyi and the city of Goma with different products especially fruits and vegetables (mango, papayas, avocados).

Most of the women in the project area buy and transport agriculture products for resale either in Goma in the DRC or in the town of Gisenyi. Transport of the products to Gisenyi or Goma generate more income as the cost of the specific product can double or significantly increase.

Education/Schools

Considering the findings from EICV3 in related to the education, the literacy rate of Rubavu district is 68.8% among population aged 15 and above. This number is not different significantly with the rate at national level, which is 69.7%. Whereas, the percentage of individuals aged 6 and above that have ever attended school is estimated to 82.6% against 83.2% at national level. This means that 16.8% represents those are never attended school.

As a rate of individual with net attendance in primary school, Rubavu district accounts 89.7% against 91.7% at national level and 23.3% against 20.9% in secondary school. Concerning the % of the users satisfied with education services, 77.5% are satisfied with education services attending against 81.9% in all Rwanda, 22.3% against 16.6% who have the problem with education service attending, while 0.2% against 1.5% at national level confirm that they don't know for the total population of 3 437 considered by the EICV3 in the country against 139 in Rubavu district. The critical situation above explains the low income of HHs of Rubavu district, which reduces the level of investment in social and human capital formation.

The use of computers among population aged 6 and above is 6.0% confirmed to use computer before and have the confident to use it again. This means that the computer literacy in Rubavu district is highly superior to that of the population of Rwanda. The rate of the users of computers before but not confident to use it again is respectively 3.1% and 2.6 at national level. Form this situation, the EICV revealed that 90.9% in Rubavu district have never used computer before against 93.5% at national level. In those cases, the program of government should be reinforced in order to attain at least 50% proposed by Vision 2020.

Water and sanitation

The main water supply infrastructure in the project area consists of public taps and deep borehole pumps. There are residents of Busoro cell who collect water from both protected and unprotected sources. There is number of 3 public fountains for both villages which is insufficient in relation to the number of the population. There is an old water pipe in the town with constant repairs due to poor management and vandalism of the installations. Water for domestic, institutional and limited commercial use is obtained from various sources in the surroundings.

According to the results of the third household living conditions survey (EICV3), In Rubavu District, the total access to clean water of population 74% against 74.2% at national level. This indicator shows that the target of Vision 2020 and 7 YGP of 100% is possible. In this district the rainwater use is estimated to 6.6% against 0.4 at the use of rainwater at national level. However, the public standing pipe is used at level of 59.6% against 25.7% in Rwanda. The challenge is remarkable for the high use of rainwater by households at district level. This situation should be due to the long distance to attain improved water source and low level of understanding to the importance of sanitation in community. In addition, the rate of the households using the surface water i.e. the rivers and lake's water, is still high compared with the total improved water source. It is on the percentage of 5.2 against 11.6% at national level. Then, the rate of borehole is 0.00% against 1.8% at national level. The number of households with piped water into dwelling is 12.4% against 5.9% in Rwanda. In fact, as well as there were an improvement in sector of water and sanitation in Rwanda in general and particularly in Rubavu District, the challenges are still noted in terms of the mean time to access to main water source in minutes is 14.9% in Rubavu District. The use of less than 60 minutes to access to the main source water is 5.9% against 5.7%. The efforts are must be oriented to protection all water points. This could explain the high morbidity rate of the diseases form unsafe water such as diarrheas and intestinal infections of 17% and 13%.

Figure 10 shows that the majority of households in Rubavu use a public standpipe (60%), followed by a protected spring (15%). However, 7% of households in this district still use an unimproved drinking water source.

Rubavu district has achieved the EDPRS national target for the water and sanitation sector, which is to in- crease access to drinking water to 85% by 2012, and has even surpassed it by 8 percentage points.

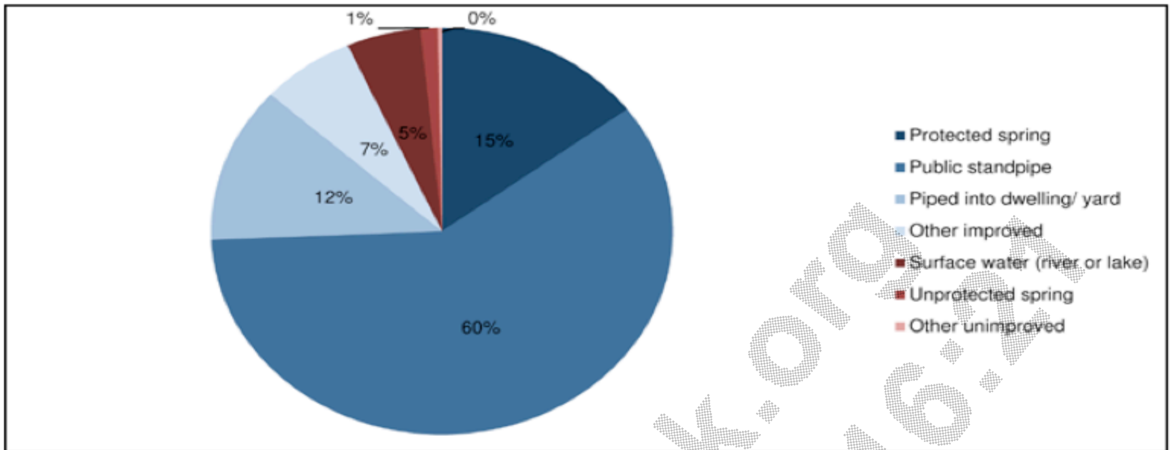
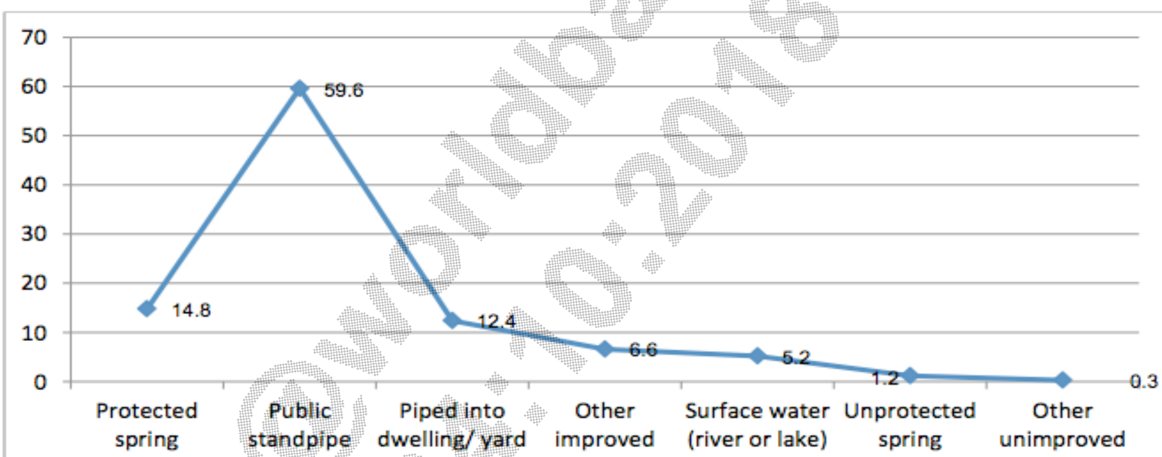


Figure 38: Main sources of drinking water in Rubavu



Concerning the sanitation, the total improved sanitation is 80.1% against 74.5% at national level while the vision 2020 and 7 YGP suggest attaining 100%. In turn the percentage of households with flush toilet is 2.3% in Rubavu district, and the households using the pit latrine with solid slab are on the rate of 77.8% at district level against 72.8% at national level, but the users of pit latrines without slab are 4.1% into 19.4% at national level. Among the population of Rubavu district, the rate of 15.6% doesn't have the toilet facilities against 6.1% at national level.

Solid waste

According to the survey, the main modes of waste disposal used by the private households are the compost dumping. Nyamyumba Sector within which the project site is located utilizes the compost at 53%. The disposal mode varies from one household to the other depending on the location from the main road. For instance, urban households collect and dump their waste mainly to the private dust bins (34%), to the compost dumping site (31%) or to the bush (15%).

In rural areas, the households collect and dump their waste mainly to the farms (37%), to the compost dumping site (36%) or to the bush (22%).

Considering the domain of waste management, in Rubavu district we account 30.6% of compost heap against 59.4% at national level. The problem identified in waste management is that 52.1% throw the solid waste in bushes or field because the rate of the households affiliated to the rubbish collection services are still low, even for those who use the rivers and lake respectively 10.4% against 5% at national level and 1.9% against 2.5.

In Rubavu district the rate of the use of publicly managed area is estimated to 5.1% against 1.9 at national level. This explains again the insufficient of partners involved in waste management at district level.

Health

There is a Health Centre in Nyamyumba which is located in the Busoro cell closed to the two villages within which the onshore site is located. The health center includes a team of health professionals providing basic health care services. In general, the most frequent diseases are amoeba, ascaris and malaria. The first two are caused by the consumption on non-boiled water from Lake Kivu. The two villages Kabushongo and Buhanga have no health center. Residents move away to the Busoro cell at approximately 2 km from their homes. For complicated cases, the patients are transported to Gienyi for an appropriate treatment.

For the whole district, the individuals affiliated to mutual insurance are 55% against 68% at national level. This rate is still low compared to the EDPRS and 7YGP of 100%. The low health insurance rate leads to the low use of consultation in curative services, which is estimated to 51.5%, while the World Health Organization stipule that this indicator should be at least 50%. The rate of delivery assisted by the health professional is 74.1%. Then, the vaccination is estimated to 93.9% for VAR. The under use of health services in Rubavu district should be due to geographical, cultural and financial inaccessibility of the community of rural areas.

The district of Rubavu is doted by one hospital with 18 doctors in which 2 doctors are specialists, one in ophthalmology and another one in the endoscopy; 183 nurses in which 23 of A1 level; and 60 of A2 level, and 4 with A3 level. Then, the number of laboratory technician is 11 among them 6 at A1 level and 5 of the level of A2.

13 workers among which 7 on level of A2 and 5 on level of A1 endow the social services. The number of Health centers is 10 with 6 Health posts. The women who realize four times of antenatal consultation are at the rate of 93% against 98% at national level according to the data from DHS 4. This rate should be 100% according to Vision 2020 and 7 YGP.

4.2 Aquatic Environment

4.2.1 Lake Kivu main characteristics

Lake Kivu lies in the Western Rift Valley, enclosed on three sides by land, which rises steeply from the lake to altitudes of over 2000 m and to 4507 m just to the north. The lake is 100 km long, and has a maximum width of 50 km almost exactly along the parallel 2°S. There are 68 islands in the lake, most of which are small and located within Rwanda, but notably Idjwi Island is 40 km long with an area of 69 000 ha and located in the Democratic Republic of Congo (DRC).

Table 16: Physical-chemical data of Lake Kivu

catchment area	≈ 7000 km^2
lake area	≈ 2400 km^2
lake level (above sea level)	1462-1463 m
discharge rate	≈ 3.2 km^3 / a
maximum depth	485 m
volume	≈ 500 km^3
depth of thermocline	
wet season	20-30 m
dry season	40-50 m
oxygen: max. depth limit	50-70 m

Thermocline: is a thin but distinct layer in a large body of fluid at which the rate of decrease of temperature with increase of depth is the largest.

4.2.2 Hydrology

The Lake receives run-off from the surrounding mountains, with at least 30 rivers entering it along the highly indented Rwandan shore. In addition, it is believed that warm water is injected into the lake from submerged hot springs, and that the effluents from the small group of Mokoto Lakes (in DRC) reach Lake Kivu underground. Rainfall in the catchments exceeds 2400 mm and is not markedly seasonal. The lake is deep, c. 480 m, with layers permanently stratified. Lake Kivu is the most highly stratified lake in Africa. Water density increases towards the bottom, but not as a steady gradient; there are a series of discrete layers. The surface water has a salinity of 1%, and the top 70 meters are mixed, but it seems that below this the hypolimnion (dense, bottom layer of water in a thermally-stratified lake that lies below the thermocline) is completely stagnant, highly saline, and very rich in nitrogen and phosphorus. The pH of the surface waters is about 9.1. It appears that natural phenomena, other than earth movements and the pouring of hot lava into the lake do not cause upwelling of the bottom water, which is highly nutritive but contains much dissolved sulphide and methane. The temperature at the surface is close to 25°C, decreasing with depth to about 22°C at 70 m, but then increasing again to 25°C at 375 m depth. The 70 m contour is very close to the shore, and since only the upper 70 m of the water column is oxygenated, it has been estimated that only 12% of the lake floor receives any oxygen. This is the most saline lake in the Western Rift Valley.

4.2.3 Aquatic flora and fauna

Phytoplankton of Lake Kivu

There is little information regarding the phytoplankton, but it is neither diverse nor abundant. Compared to earlier studies, the biological baseline study of Lake Kivu conducted from 2012 to 2014 showed that diatoms are by far the dominant class of the phytoplankton– mainly Synechococcus spp. and thin filaments of Planktolyngbya limnetica – and by pennate diatoms, among which Nitzschia bacata and Fragilaria danica are dominant[15]. Seasonal shifts occur, with cyanobacteria developing more in the rainy season, and the diatoms in the dry season. Other main groups are cryptophytes, chrysophytes, chlorophytes and dinoflagellates. According to a survey conducted in the period 2002-2008, the composition of the phytoplankton assemblage was almost homogeneous among lake basins[16]. The same survey revealed high abundances of the centric diatom Urosolenia sp. and the cyanobacterium Microcystis sp. near the surface under diel stratification conditions.

[15] **Sarmento et al.2007, Biological baseline report, 2014**
[16] **Sarmento et al.2007, Biological baseline report, 2014**

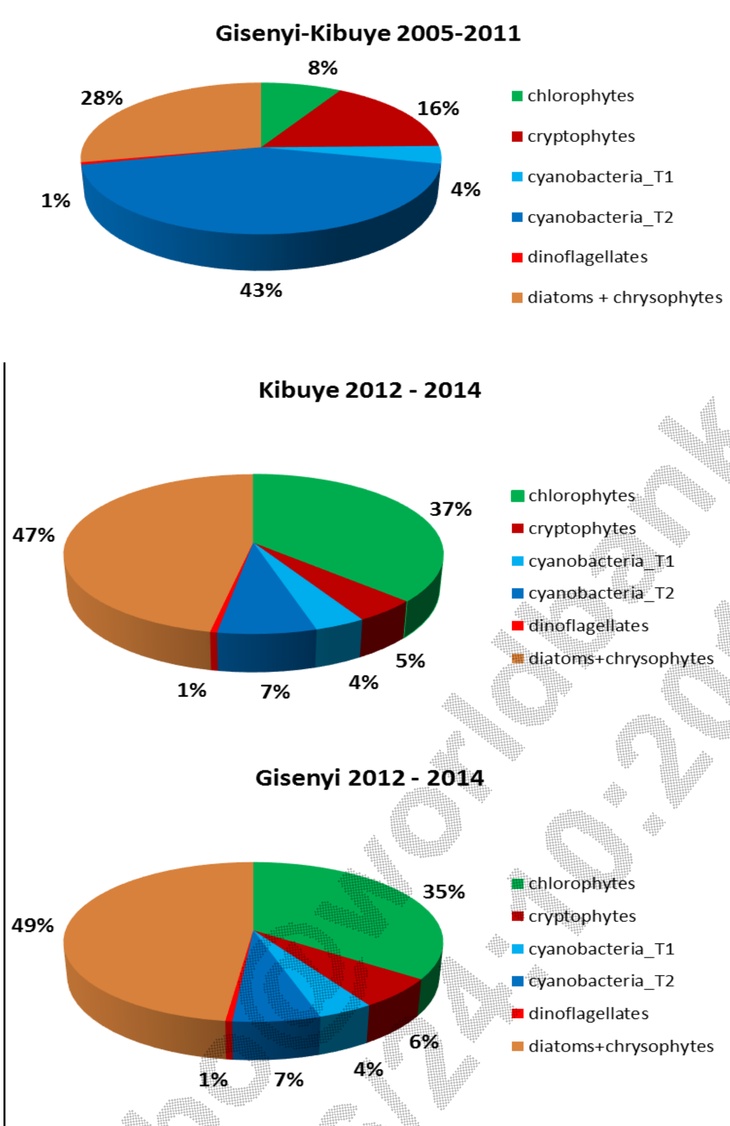


Figure 39: Relative contribution of the phytoplankton groups to chlorophyll a in Lake Kivu, averaged for the period 2005-2011 (top) and for the baseline period (middle and bottom)[17]

Benthic invertebrate assessment

Despite its recognized ecological importance, the benthic community is still one of the least known biological communities in Lake Kivu. Very few or no studies have been conducted to assess the benthic invertebrate diversity yet these organisms are reliable bioindicators widely used to assess the environmental and ecological health of a given aquatic environment. Dusabe and Apio (2014) conducted an assessment of macroinvertebrate diversity of 53 rivers (29 catchments) draining into Lake Kivu on the Rwandan side, belonging to the Congo basin

[17] Biological baseline report, 2014

drainage system, using the Biological Monitoring Working Party (BMWP) Score, deriving from it, the Average Score per Taxon (ASPT), and the Baur Biotic Score.

Forty-eight macrozoobenthos families were recorded from Rwandan rivers draining into Lake Kivu. Odonata constituted the dominant group with 37.08% of all (4099) individuals collected. Mollusca, Ephemeroptera and Diptera were next with 19.01%, 16.57% and 14.10%, respectively. Uncommon groups were Hemiptera (3.37%), Coleoptera (2.34%), and Trichoptera (6.49%), while the Plecoptera were represented by only one specimen (Biruyi River, Nkora catchment). These could be the most likely groups of taxa which could be found in the main basin of Lake Kivu where the Symbion project will be located.

However, habitat availability for aquatic invertebrates in Lake Kivu is generally poor due to the limited rocky riffle areas and macrophytes. In addition, the very limited littoral zone (less than 10% of the total lake surface) and the gradual decrease of dissolved oxygen concentration with relative to depth exert a great influence on the dynamics of benthic invertebrate abundance and diversity. The habitat integrity was observed to be altered, with impacts resulted from farming and recreational activities noted along the project construction site.

Fish fauna

With only 29 species of fish described[18], among which several were introduced, the fish diversity of Lake Kivu is very low compared to its great neighbours (Lake Tanganyika, Lake Victoria, Lake Edouard, Lake Albert….). This low diversity is linked to the geological history of the lake characterized by catastrophic event such as drought, higher salinity and hydrothermal events which had severe effect on its ecosystem in general and on the fish fauna in particular[19]. Fish occupy the oxic layer, limited to the upper 60 m of the water column. Native fish include species of Barbus, Clarias, Haplochromis, as well as the Nile Tilapia[20]. In 1959, *Limnothrissa miodon*, locally known as Isambaza, was intentionally introduced from Lake Tanganyika and successfully colonized the pelagic part of Lake Kivu[21]. The "Tanganyika sardine" became the most abundant species in the lake and has constituted the basis of a pelagic fishery for the population of the two surrounding countries i.e Rwanda and D.R Congo. For most specialists of fisheries, the story of the Isambaza in Lake Kivu has widely been described as a success[22].

Fish diversity

Lake Kivu has been always described as a species-poor lake[23]. At present 29 fish species are known from the Lake, five of which are introduced and 24 native ones. The majority of the natives (16) belongs to one family, the Cichlidae.

---

[18] **Snoeks et al., 1997**
[19] **Elmer et al.2009**
[20] **Snoeks et al., 1997**
[21] **Collart, 1960**
[22] **Gozlan , 2008**
[23] **Snoeks 1997**

<u>The non-cichlid taxa</u>

- *Limnothrissa miodon* belonging to the family clupeidae is endemic to Lake Tanganyika. It has been introduced in 1959 in a sample of juveniles mixed with *Stolothrissa tanganicae*, which was the Tanganyika sardine actually targeted for introduction in Lake Kivu (Collart 1960).
- Five species belong to the family Cyprinidae. *Raiamas moorii, Labeobarbus altianalis, L. altianalis altianalis, Barbus' kerstenii* and *B.' pellegrini*
- Catfishes represented by two widespread *Clarias* and *Amphilius uranoscopus* living in the affluent rivers of Lake Kivu
- Recently, a new taxon has been added to the list of Kivu species, i.e. *Lamprichthys tanganicanus*. This fish is an endemic to Lake Tanganyika. How exactly it arrived in Lake Kivu is unclear. Muderhwa and Matabaro (2010) postulated that juveniles of *Lamprichthys* might have been introduced in 1959 together with those of *Limnothrissa miodon*. Because of its much lower fecundity compared to that of *Limnothrissa* and the possible stronger predation on its fry, it has taken a long time for this species to become abundant. It is a pelagic dweller living in coastal areas and is one of the most abundant fishes in these areas in Lake Tanganyika.

The Cichlids

19 pecies of cichlids have been recorded from Lake Kivu.

- 4 tilapia species; *Oreochromis niloticus* is native and three have been introduced to the Lake
- 15 endemic haplochromines; they are essentially located in the littoral zone of the lake, although some species can be present in the pelagic zone. The list of the fish diversity will be produced in the annex of this report

The list of fish species found in Lake Kivu is provided in annex 2

Fish abundance

In Lake Kivu, 5 major taxa are more abundant than others and are the ones targeted by fisheries, which makes them the more economic important fish species of the lake. These include: Tanganyika sardine" *Limnothrissa miodon*, *Haplochromis* spp., the recently introduced *Lamprichthys tanganicanus*,"Tilapia" (actually 3 species of *Oreochromis* and *Tilapia rendalli*) and *Clarias* spp. (*C. gariepinus* and *C. liocephalus*).
Limnothrissa miodon is the far most abundant and targeted fish species in Lake Kivu (figure below). Its stock has been assessed by several fisheries experts due to its economic importance for the surrounding population from Rwanda and DR Congo.

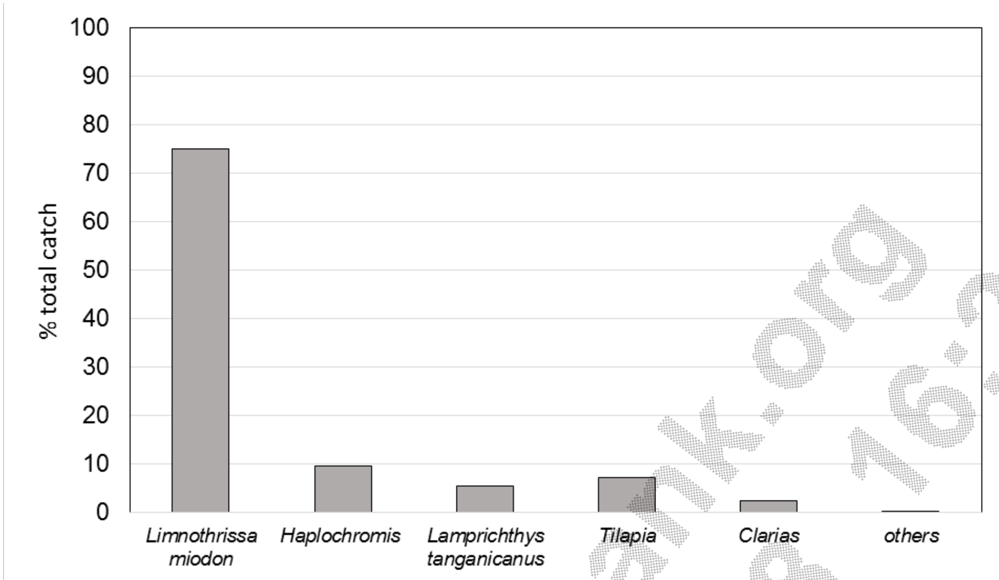


Figure 40: Average composition of the fish catch in Lake Kivu from October 2011 to December 2013[24]

The most recent stock assessment of *Limnothrissa miodon* has been carried out by Lake Kivu monitoring programme (LKMP) using hydroacoustic surveys. A total of 4082 tons of fish have been estimated for the whole lake, 29% of the stock was estimated to be produced in the Northern basin where the project will be located (LKMP fish stock assessment report 2015).

As mentioned earlier, information regarding the phytoplankton is littele, but it is neither diverse nor abundant. The macrophyte flora, which extends down to a depth of 8 m is extremely poor, and there is only a narrow fringe of lake bottom above this depth. The deep lake floor is covered by organic zone, although towards the shores the bottom is sandy but encrusted with calcareous scale. Here *Cladophora sp* is the dominant plant. Higher up there are beds of *Ceratophyllunz demersum, Najas marina* and *Potamogeton pectinatus,* the latter species being the most abundant. Around the shallowest margins there are beds of *Phragmites mauritianus* and species of *Cyperus* and *Scirpus.* The fish fauna is poor, comprising just 16 species. Of these, 3 also occur in Lake Tanganyika, namely *Barbus serrifer, Barillus moori* and *Clarias mossambicus.* The first and last have wide distributions and may have been exogenously introduced, but *Barillus moori* is found only in these two lakes.
There are 6 species of *Haplochromis*, all endemic, and a distinct subspecies of *Oreochromis niloticus ssp. regani*, which suggests that speciation has occurred in the lake over the last 20,000 years. There are no large predatory species in the lake. Birds and otters are the principal piscivores (meaning predators of fish), and the lake supports many birds of passage.

[24] **EAGLES report 2015**

4.2.4 Fisheries

The principal fishing activities take place on Lake Kivu, where there are more than one hundred teams of fishermen. The monthly production of fish is estimated roughly at 36,210 tons. The main fish species in the lake are isambaza, tilapia and indugu.

4.2.5 Human Impact & Utilisation

Limnothrissa miodon was introduced some years ago, and a small sardine fishery has developed, but prior to this establishment there was no commercial fishery of significance. The introduction in Lake Kivu of the *Limnothrissa miodon*, a sardine endemic to Lake Tanganyika, created major changes in its food web. For the first time, this introduced planktivore fish, which ate the plankton nearby the shore, causing alterations in the zooplankton structure. In particular, the mesozooplankton size and abundance dramatically decreased and one of the main grazers, *Daphnia curvirostris*, disappeared[25].

A recent study [26] shows that zooplankton have evolved to a new state. Present mesozooplankton (Planktonic animals in the size range 0.2-20 mm) is dominated by cyclopoid copepods (freshwater invertebrate animal with one eye), with cladocerans (benthic marine invertebrates) and rotifers (aquatic multicellular organisms having a ciliated wheel-like organ for feeding and locomotion) in smaller proportions. The larger copepods manage to reduce predation pressure by migration into the deep mixolimnion (the upper layer of a meromictic lake, characterized by low density and free circulation) at daytime. However, the sardine predation affects the cladoceran *Diaphanosoma excisum*, whose size is significantly reduced. In general, the abundance of zooplankton (microscopic animals which move passively in aquatic) seems to depend more on phytoplankton (free-floating aquatic plants) resource, suggesting a bottom-up control cause of the above-described food web.

The phytoplankton changed from a cyanobacteria-chlorophyte assemblage[27] to diatoms and cyanobacteria as the dominant groups in the 2000's[28]. However, the evolution of the primary biomass is difficult to assess, as previous studies were based on limited samplings over short period of time.

Lake Kivu has a higher phytoplankton biomass and a lower zooplankton production than Lakes Tanganyika and Malawi. This relatively high phytoplankton biomass may be explained by the modification to the predatory chain caused by *Limnothrissa miodon*. Actually, the zooplankton grazers, now fed upon by the introduced sardine fish, reduced their top-down control over the edible phytoplankton (Sarmento et al. in press.). Another factor responsible for this low trophic efficiency may be the disappearance of Daphnia, an efficient and large grazer (Isumbisho et al. in press).

The main hypothesis for the increased production of methane is a rise of the nutrient inputs caused by the fast-growing population in the catchment of Lake Kivu. The second hypothesis for the increased methane gas production internal to Lake Kivu is, thus, the change in the

---

[25] Dumont 1986

[26] Isumbisho et al. in press

[27] Hecky and Kling 1987

[28] Sarmento et al. in press.

internal food web induced by the introduced sardine. The nutrient sedimentation depends on the phytoplankton community and the zooplankton composition[29]. Zooplanktons tend to maintain a constant chemical composition, even when the chemical composition and availability of their resources is changing, a process known as homeostasis. Regulation is performed through excrements, which become enriched in the non-limiting nutrient. In particular, Daphnia has a high bodily demand in P, as opposed to cycloid copepods, which need to consume more N. In Lake Kivu, it can therefore be expected that the sedimentation of P has increased since the disappearance of Daphnia. In consequence, the modification of the plankton species may have disturbed the nutrient cycling in Lake Kivu.

4.2.6 Lake Kivu zones

The following four zones in Lake Kivu are illustrated in Figure 4. Depths are as measured in 2004.

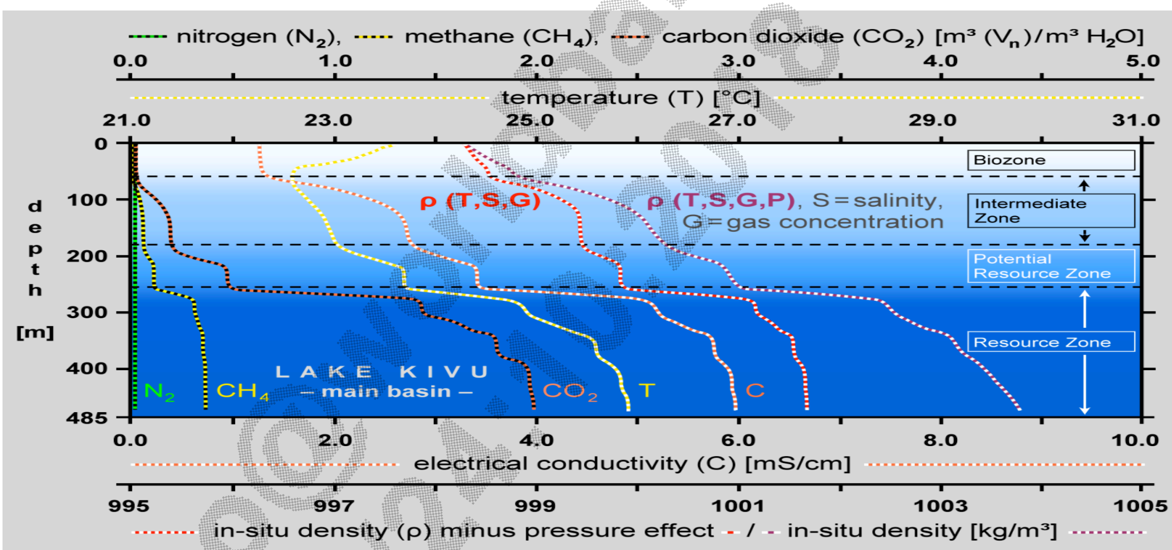


Figure 41: Vertical profiles in Lake Kivu (T), electrical conductivity (C), methane (CH_4), carbon dioxide (CO_2) and nitrogen (N_2) concentrations, and density (ρ)

Biozone:
It is the upper, oxygenated part of the lake water body, about 70 m deep, where algal biomass provides food for zooplankton and fish. This zone becomes practically homogenised during the dry season, and is strongly stratified during the rainy season when usually only the top 40 m contain oxygen. The lower limit of the Biozone is marked by a less steep density gradient (see definition below) from -60 m to -120 m, with its centre at about -85 m.

[29] Darchambeau 2003

Intermediate Zone (IZ):
The -85 m density gradient and the Intermediate Zone (below the Biozone and above the Potential Resource Zone) cover a significant density range. At the top of the -85 m gradient, the concentration of hydrogen sulphide is zero, while the concentrations of methane and carbon dioxide are very low, as in the Biozone. The concentrations of these gases increase with depth down into the Resource Zone. The nearly homogenous Intermediate Zone ranges from about -120 m to -180 m. Below it is a secondary density gradient layer from -180 m to -200 m, with its centre at -190 m. The methane resources of this zone are not expected to be exploitable for many decades into the future.

Potential Resource Zone (PRZ):
This nearly homogenous zone reaches from about -200 m to about -250 m. Below this zone the main density gradient in the lake ranges from -250 m to -270 m with its centre at -260 m. Some of the methane in this zone may become exploitable within the next several decades if methane accumulation continues at the current rate.

Resource Zone (RZ):
The Resource Zone reaches from below the main density gradient at -270 m to the bottom of the lake, and contains the bulk of the methane that is commercially exploitable. This zone is differentiated into more homogenous upper **(URZ)** and lower **(LRZ)** parts by a secondary density gradient layer between -300 m and -320 m with its centre at -310 m. In addition to methane, this zone contains substantial amounts of carbon dioxide, nutrients and salts. Thus, Resource Zone waters are significantly denser than the rest of the lake waters.
Density Gradient Layers:
In between the different relatively homogenous layers of the lake in which the water parameters do not change significantly with depth, there are transitional layers where parameters such as conductivity, density and gas concentrations change rather rapidly with depth. These "density gradient layers" appear to act like flexible barriers because the bulk of dissolved gases; nutrients and salts are found below the gradients. The dissolved gases largely remain trapped in the deeper lake thus building up an exploitable deposit. The different gradients may be named for the span from top to bottom (e.g. -60 m to -120 m) or by the depth of the centre of the gradient (e.g. -85 m).

4.2.7 Rate of gas extraction

Lake Kivu contains very large quantities of accumulated methane that should be removed expeditiously to reduce the risks of uncontrolled gas outbursts. At the same time, methane is continuously produced in the lake, though the rate has only been estimated and will remain highly uncertain without years of monitoring. In the future, once methane levels are reduced to a safe level, gas production can be sustained for a long-term period at a reduced rate.

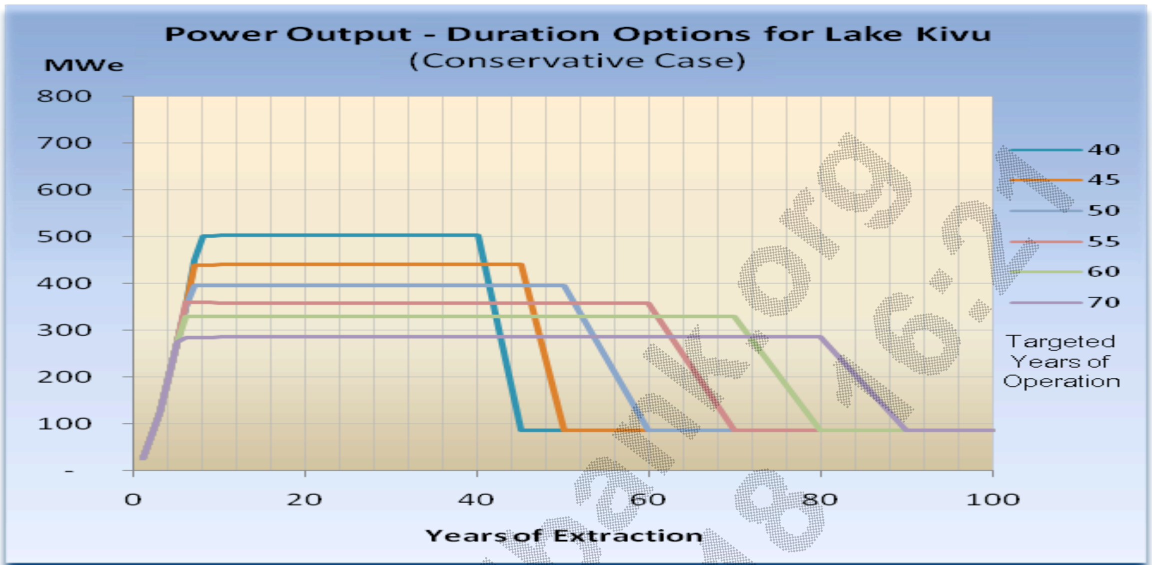


Figure 42: Approximate "conservative" power vs. lifetime options for RZ gas extraction from Lake Kivu

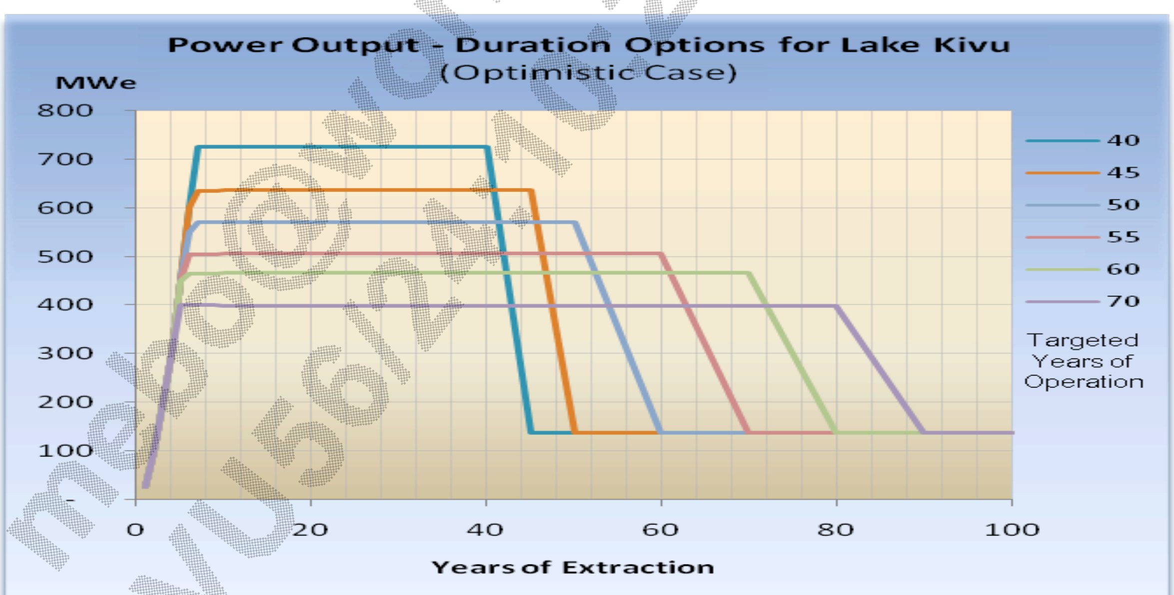


Figure 43: Approximate "optimistic" power vs. lifetime options for RZ and PRZ gas extraction from Lake Kivu

Figures 25 and 26 conceptually represent the nature of the resource harvesting options available to the two governments sharing the resources, presented here in terms of total power available over different extraction periods. The first figure represents the total calculated power available over time from the Resource Zone in both the Rwandese and Congolese waters of the lake, assuming conservative recovery and power conversion efficiencies. These were estimated at 300 TWh/km^3. The second figure includes production also from the Potential Resource Zone and at higher, but achievable, recovery and power conversion efficiencies (425 TWh/km^3).

Of course, detailed monitoring of the gas resource, and gas and power production, is required to confirm the position and shape of the curves in these two figures, especially when PRZ production is included. The power yields are based on assumed efficiencies in the conversion of the thermal energy in the produced gas to electrical power. The actual efficiencies of gas extraction and power conversion will be a function of the technologies employed, and will strongly influence the total power that can be produced.
Thus, the curves are illustrative only, and must not be taken as a prescriptive guide for concessioning gas production. The figures illustrate that higher total power production rates to harvest the accumulated gas in the lake mean a shorter lifespan of the project and thus, reduced economic feasibility of establishing the power generation and transmission system. The upward sloping lines on the left represent the time needed to build up the power market and transmission system. The lowest horizontal lines on the right, at about 90 MWe and 130 MWe, indicate the highly uncertain rate of methane production in the lake, and thus the kind of variability there may be in the long-term sustainable rate of power production.

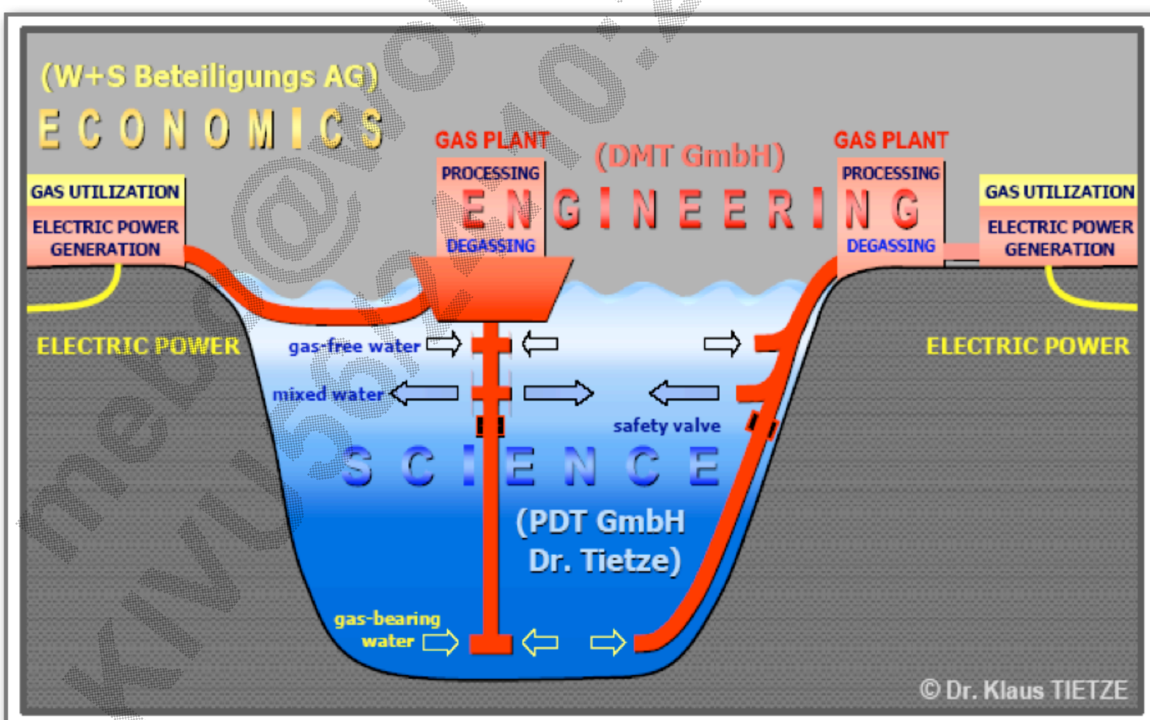


Figure 44: Scheme illustrating Close cooperation at the interfaces during exploitation of the Lake Kivu gas[30]

[30] PDT GmbH. Dr. Tietze, blue

The figure illustrates the necessary cooperation at the interfaces of Economics, Engineering and Environment during exploitation. The gas extraction in Lake Kivu is essential for safe and environmentally friendly as well as economically viable exploitation.

Preliminary economic analysis of the methane reserves makes clear that it is more profitable to harvest the methane reserves at high rates than at low rates. And so, from an economic standpoint, a rapid harvesting of the methane reserves is most profitable. However, because rapid harvesting of the reserves may affect the biozone of Lake Kivu through influx of nutrients, the secretariat of the NCEA recommends letting the speed of nutrient influx determine the maximum acceptable speed of methane harvesting.

4.2.8 Carbon dioxide in the Lake

Carbon dioxide in Lake Kivu has a multi-faceted role. It represents a threat, but is also a resource. As a carrier gas, it enables the production of methane, but it contaminates it as a fuel. It is a co-product of methane in the gas generation process, but has limited economic value. It can asphyxiate people in a gas eruption, but it also helps stabilize the density of deep water.

4.2.9 Analysis of Lake Kivu stratification

Water structures and Lake Kivu stratification

The waters of Lake Kivu manifest a particularly obvious 'stair-like' stratified structure following the variations of their physico-chemical parameters with depth. The exact explanation of this phenomenon of stratification is complex. The waters of the lake are made up of homogenous layers - where mixing by convection easily takes place - separated by layers with a high-density gradient, which act as barriers to the mixing process.

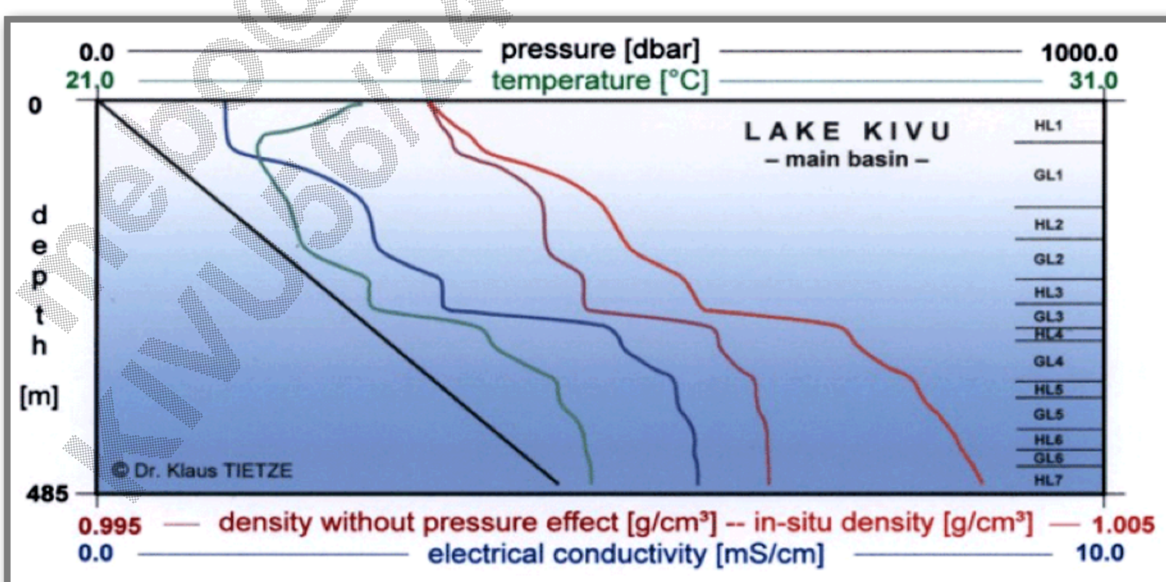


Figure 45: Vertical section of density, conductivity, temperature and pressure taken together: average of 23 profiles[31].

The analysis of the gas content profiles of Lake Kivu indicate that the gas deposits are confined to the interior of the depth contour -270m and that a layer favoring the harnessing of the waters of Lake Kivu is to be found at a depth of approximately 350 m. Analysis of water taken from this depth shows that it contains dissolved gases of the order of 2,5Lgas/Lwater… This gas is made up of 5/6 CO_2 (2, 1 LCO_2/Lwater), and 1/6 CH_4 (0,425 LCH_4/Lwater).

Response of Lake Kivu stratification to lava inflow and climate warming
During the eruption of Nyiragongo Volcano in January 2002 about 10^6 m3 of lava entered Lake Kivu. The high concentrations of CO_2 and CH_4 dissolved in the deep waters of Lake Kivu raised serious concerns about a potential gas outburst with catastrophic consequences for the population in the Kivu-Tanganyika region. Therefore, 3 weeks after the volcanic eruption, an ad hoc lake survey of the stability of the water column stratification was performed. Vertical profiles of temperature and turbidity revealed signatures of the lava, which had penetrated to 100 m depth; however, there was no substantial warming or destratification of the gas-containing deep layers below. The deep double-diffusive structures also remained unaltered. Based on these observations, it was concluded that a thermally driven gas outburst in Lake Kivu is not to be expected from future eruptions of comparable dimensions. In addition, the recent measurements allowed for an update and gave new insight into the stratification and double-diffusive mixing phenomena in Lake Kivu. A comparison with former measurements revealed a warming of the upper part of the lake of up to 0.58°C within the last 30 years, which could be attributed to climate variability (Klaus Tietze and all, 2002). Assessing the risks caused by any further climate change or variability, It was pointed out by the study that the overall stability of Lake Kivu is relatively high, the double diffuse structures are were preserved (meromictic lake) and that an increase in temperature within the upper part of the permanently stratified part of the water column is related to long-term changes.

Lake Kivu and gas outburst risk assessment
Expeditions conducted by Martin Schmidt of Eawag, the Swiss Federal Institute for Environmental Science and Technology concluded that the residence time of the gases below 260 m depth is on the order of 800-1000 years. The methane produced today in the deep waters will remain there for almost 1000 years, and the increased methane production in the sediment can thus lead to dangerous concentrations within the time frame of a century.
An exceptionally strong heat input into the deep waters of the lake is necessary to trigger a gas outburst from Lake Kivu. This could only be caused by an eruption of magma into the deep waters of the lake. It is very unlikely that a lava inflow at the lake's surface could carry enough heat to the deep waters to produce a dangerous plume. However, the required heat input will strongly decline if the dissolved gas concentrations further increase in the future.

[31] **K. Tietze 1974 - 75.**

Monitoring of gas concentrations

Exploitation of the methane contained in the lake would lower the risk of a gas outburst from the lake. It was recommended that the methane be exploited, provided that it is done in a way that the ecosystem of the lake is not seriously affected. It is very important that the concentrations of dissolved gases are regularly monitored. Measurements indicate that the concentration of dissolved CH_4 has increased by 15-20% within the last 30 years. If the concentrations continue to increase in this way, they could approach saturation within less than a century, and the risk of a catastrophic gas outburst would steadily grow. It is therefore recommended that the gas concentrations in Lake Kivu be measured every 10 years, such that an approaching saturation would be observed in time for preemptive measures.

5.0 Project Alternatives

This chapter describes and examines the various alternatives available for the project. Alternatives examined and assessed during the study included alternative sources of energy, renewable energy sources other than generators, site alternatives in project location (particularly considering location-based impacts and land use conflicts), process alternatives (evaluation of the processing alternatives open to the project with the objectives of minimising raw material use, waste generation and energy requirements), technological alternatives (examining any alternatives in technology open to the project as well as alternatives in equipment and facilities, so as to determine the most affordable options), and finally a "No Project" alternative (assessing the impact of the scenario if no project is undertaken).

5.1 Alternative Source of Energy

The alternatives to developing Symbion Power Lake Kivu Ltd are analysed, developing an alternative source or sources of power would mean that the up to 50 MW to be provided by the Symbion Power Lake Kivu Ltd project would be supplied in a comparable time frame and with an equivalent economic benefit. The alternatives would have a long-term significant effect on the economy and the people of Rwanda

At present, the only feasible alternative for large-scale power generation in Rwanda appears to be thermal power. However, thermal power is not only more costly than Symbion Power Lake Kivu Ltd's projections, it also has negative environmental effects including air pollution, noise, potential for spills, and greenhouse gas emissions. Details on the alternative generation technologies, including wind, solar, geothermal, methane and thermal are provided in the following section.

The final two subsections demonstrate why Symbion Power Lake Kivu Ltd is the preferred next gas-burning reciprocating engines project, and why the proposed configuration at the site is the preferred design for the facility.

5.1.1 Wind and Solar

There is little potential for wind-generated electricity to contribute to the national network because Rwanda lacks a sufficiently windy climate.

While Rwanda has reserves for solar electricity generation, the potential for solar power's becoming a significant energy source is low because of the comparatively high kW/h purchase price. Thus, at present in Rwanda, wind and solar, along with micro and mini hydro, are considered to be viable sources of electricity for rural, off-grid people but not for large-scale (eg. 50 MW), reliable, base load power. The Photovoltaic Market Transformation Initiative (PVMTI) of the International Finance Corporation and the Global Environment Facility has been present in Rwanda since 1998, with the aim of promoting sustainable commercialization of photovoltaic technology in the developing world by providing examples of successful and replicable business models that can be financed on a private basis.

5.1.2 Diesel Power Plants

The Rwandan power grid suffers from both energy and peak period capacity shortages. The only viable alternative for meeting these shortages (other than with gas engines like those proposed for the Symbion Power Lake Kivu Ltd project) is mid-sized diesel generation. Given the relatively small incremental demand requirements, technologies such as coal power plants would not be suitable.

5.1.3 Biomass

With a population characterized by low household incomes and low purchasing power of consumers, which prevents the trading of commercial forms of energy, biomass (mainly firewood, charcoal and crop residues) accounts for 95% of traditional energy consumed in the urban and in the rural areas owing to the lack of economic capacity for importing other alternatives, and also owing to the low technological capacity for developing alternative energy sources with a higher energy intensity (such as natural gas or hydropower).
As a consequence, households and medium-scale enterprises are forced to utilize charcoal, firewood, and agricultural residues as their source of energy for both home and business use. The situation has resulted in the hillsides being stripped of trees, causing serious erosion, which has caused a decreased agricultural productivity of the arable land.

5.1.4 Geothermal

Another alternative source of energy in Rwanda still under investigation is geothermal fuel. A geothermal project feasibility study is to be undertaken in Cyangugu and Gisenyi. It is estimated that geothermal resources can provide between 170 MW and 320 MW.
Rwanda's energy demand is characterized by a low per capita consumption of commercial energy (petroleum and electricity) and a high dependence on non-commercial energies, including biomass fuels in the form of firewood, charcoal and bio-waste. Biomass energy for the foreseeable future will remain the main energy source.

5.1.5 Methane Gas

The GoR has signed a Purchase Power Agreement (PPA) with Symbion Power Lake Kivu Ltd to develop methane gas from Lake Kivu for power generation; it will bring 14 MW to the grid in Phase1 and a total of 50 MW in Phase 2.
The exploitation of the natural gas resource from Lake Kivu (comprised of approximately 55 billion m^3 of methane) remains the GoR's priority. The Symbion Power Lake Kivu Ltd project is regarded as the best energy development alternative for a number of reasons, including: its relatively low construction cost and short lead time, its relatively low estimated operating costs, its potential for further development in response to Rwanda's growing power needs, and the diversification from hydro power it will provide.

The methane resource is also attractive from a global environmental view, as the replacement of fossil fuels by methane would lead to reductions in greenhouse gas emissions. Methane could also possibly be used in the future as a fuel source in various industries and as an automotive fuel. These uses would all have net positive environmental impacts. Further, the methane-fired generation facility would provide ammonia as a byproduct, which could be used to generate a fertilizer industrial facility. Having identified Lake Kivu as its preferred alternative energy source, the GoR has been limited in the development of this resource due to a lack of sufficient funds and specific technology to develop this unique gas deposit trapped in the depth of Lake Kivu.

5.2 Alternative technology

5.2.1 Physical arrangement

The main project designs involve: tapping the deep waters by a gaslift, improving the methane gas concentration by water washing under pressure, and piping the gas onshore where it fuels a power plant to generate electricity.
During the preliminary design of the gas extraction installations, different physical arrangements were taken into consideration:
- Offshore installation, with the gas scrubbers and gas – liquid separator located offshore, on a floating platform;
- Onshore installation with the gas scrubbers and gas – liquid separator located onshore, and;
- Semi-offshore installation with the gas scrubbers located onshore and the gas liquid separator located offshore. The separator consists of a horizontal cylinder with two elliptical caps on both ends

Offshore installation

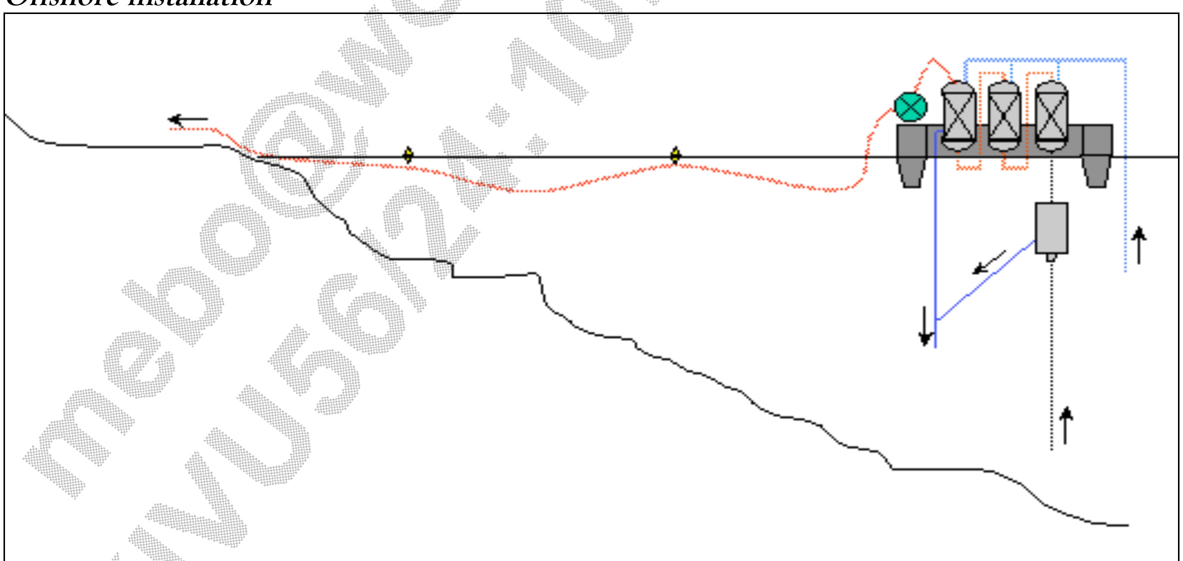


Figure 46: Offshore (extraction and treatment on barge)
Separator under the lake surface

Table 17: Offshore installations: advantages and disadvantages

	Advantages	Disadvantages
Offshore	Open choice of site on the lake. Maximum reduction in all piping. Number of extraction installations a priori unlimited. Mobility of harnessing stations. Preservation of extraction columns due to the lack of friction on lake bottom. Less loss of capacity and less risk of blocking because of the vertical nature of the columns. Increased yield due to the separator being at depth. Increased yield due to the separator being at depth. Its function creates a large horizontal water/gas interface surface area and shorter vertical route for gas bubbles to travel. The design allows the shortest solution resident time necessary to liberate the gas from the water. The separators tethered at -20m are operated at almost the ambient temperature and the hydrostatic pressure, approximately 2 bars(g).	Added investment for the design and manufacture of the barge. Transport of workers and maintenance material by boat. Presence of a purified gas pipeline under the lake surface. In the scenario where the separator is on the barge, the yield will be equivalent to the onshore solution and the main advantage of the offshore solution would be lost.

Onshore installation

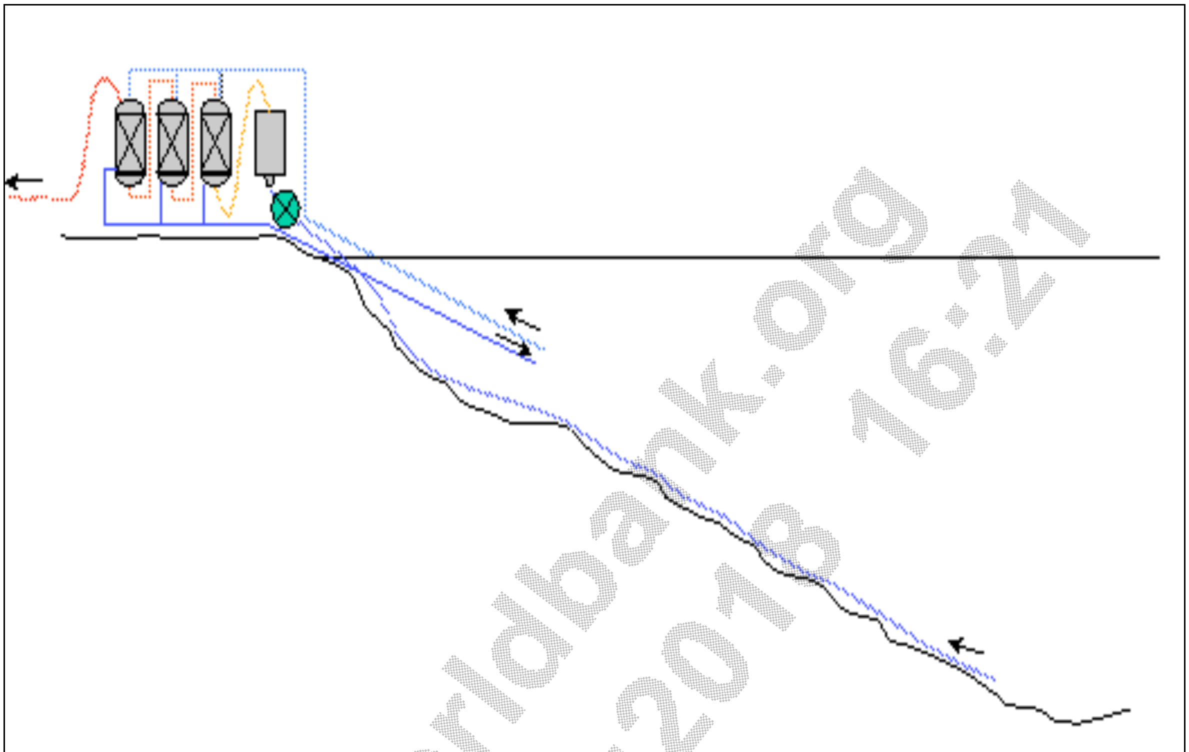


Figure 47: On-shore (extraction and treatment system on the lake shore)

Table 18: Onshore installations: advantages and disadvantages

	Advantages	Disadvantages
	Separator below lake surface	
On-shore	Pressure equivalent to immersed solution	Prohibitive cost of the trench protecting the entire installation. Scarcity of sites likely to comply with the requirement of such a solution
	Separator below lake surface	
		Low pressure in the separator a large amount of gas to be processed proliferation of machinery/equipment Energy cost of the extra maintenance. Taken together, these are serious inconveniences associated with an entirely onshore solution for the installation. Corrosion of the pipe to shore

		from the entrained H_2S.
Common		
	Ease of access for subsequent work. Ease of access for personnel No sunken cables	Lengthening of the harnessing and suppression columns Serious charge loss due to the profile of lake bed Scarcity of sites with sufficiently sloping sides

Semi-Offshore installation

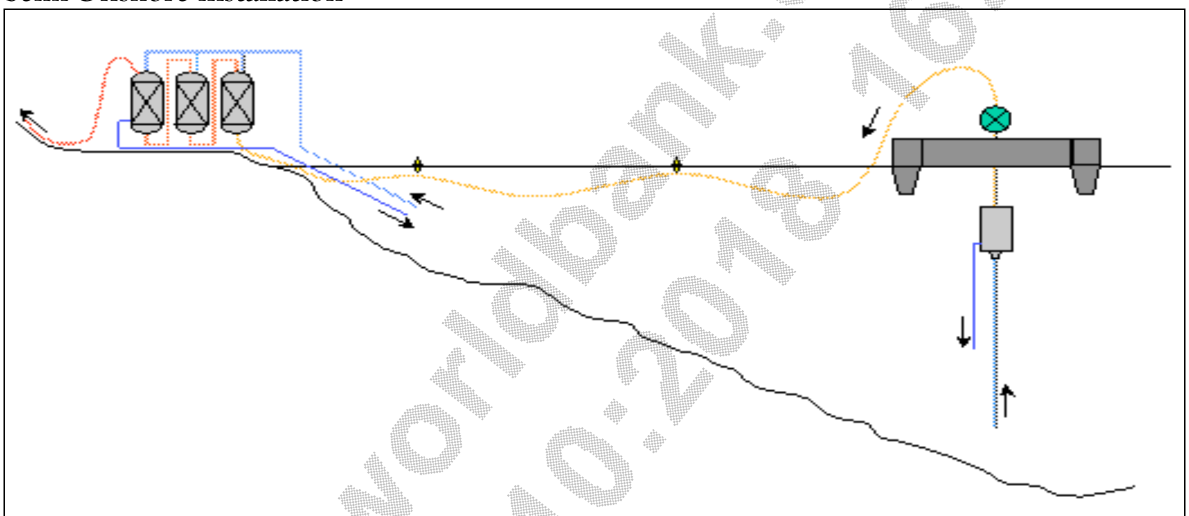


Figure 48: Semi-offshore (extraction system on barge and treatment on shore)

Table 19: Semi-offshore installations: advantages and disadvantages

	Advantages	Disadvantages
Semi-offshore	Preservation of extraction columns due to the lack of friction on the Lake's bottom. Less loss of capacity and less risk of blocking because of the vertical nature of the columns. Increased yield due to the separator being at depth.	Presence of an unrefined, potentially corrosive gas pipeline under the Lake's surface. Separation of the station into two distinct units resulting in the doubling of security, service and maintenance personnel. Large volumes of raw gas to compress and send onshore increasing capital and operating costs for additional compressive power. Choice of lake site dependent on where treatment plant could be established onshore.

		Note: in the event that the separator is on the barge, the yield would be equivalent to the onshore solution and the main advantage of the offshore solution would be lost

The semi-offshore and offshore installations seem to be the best alternatives. Simulations of the FRSS conducted by Symbion show the pressure of the functional operator separator is the optimum pressure to maximize methane liberation while constraining CO2 liberation, and so forming the first step in achieving the required fuel gas specification.

Table 20: Gas composition post separator (per separator)

Parameters	Unit	Value
Physical properties		
Pressure	kPa	297
Temperature	°C	25
Gas Flowrate	Nm^3/h	7305
Liquid Flowrate	m^3/h	-
Composition		
Methane	%-mole	30.3
CO2	%-mole	67.2
H2S	%-mole	0.14
Nitrogen	%-mole	1.32
Oxygen	%-mole	0.00
H2O	%-mole	1.06

Symbion has considered allocating the offshore and onshore process with ultimate goal to have offshore as little as possible. The wash water towers were first proposed offshore but discounted this option for the following reasons:

- Locating more of the gas processing offshore increases construction risk and complexity.
- Placing the wash towers onshore reduces the visual impact of the barges.
- This would require larger and stronger barges.
- Maintaining offshore equipment is more challenging, and would require that the barges be manned during operations.
- Because the distances between the extraction point and the onshore plant are 5 km to 7 km, the pressure within the separator is not high enough to overcome the pressure loss along the pipeline and drive gas to the onshore plant. Therefore, the compression is the only major element located offshore with the rest of the process onshore.

Locating the compression onshore, which would eliminate the need for barges entirely, is not practical as it might compromise the separator pressure and the integrity of the export pipeline, and excess water vapour could impede gas flow in the export pipeline.

5.2.2 Gas-Liquid separation process (Submerged separator and non-submerged separator)

Plant reliability and maintainability, operating cost, investment cost and methane gas utilization efficiency will largely depend on the water degassing system, which is the key step in the gas extraction process.

5.2.3 Specifying a higher CO_2 content in the fuel gas

The 20% CO_2 content in the fuel gas is based on the specification provided by Wärtsilä, the manufacturer of the gas engine generating sets (gensets) on which the Feasibility Study has been based. Wärtsilä will guarantee the power output at the generators and the energy efficiency (heat rate) for a fuel gas matching that specification. However, a fuel gas specification with a higher CO_2 content could be desirable for several reasons, including the following.

The Lake Management Prescriptions has targets to vent up to 50% of the CO_2 extracted from the lake to atmosphere, as this will further reduce the risk of limnic eruptions. This is only feasible by passing CO_2 gas into the Power Plant to be vented via the Power Plant emission stacks. However, it is noted that this would be extremely difficult to achieve in practice due to the basic fact that CO_2 is a fire extinguisher and so higher levels in the fuel gas will derate the output of the gensets. This must therefore be treated as an aspirational target, rather than a fixed requirement.

It is desirable that the Power Plant be sufficiently flexible to handle possibly significant variations in the underlying resource and the functioning of the Gas Plant, which will mainly be seen as increases in the CO_2 in the fuel gas.

The wash water towers, which increase the methane concentration, consume considerable amounts of electrical energy. Allowing a higher CO_2 content would allow the wash water pumps to be turned down and hence reduce auxiliary power and increase power provided to the grid. Symbion and Antares therefore reviewed alternative gas specifications with Wärtsilä by considering two alternative fuel gas specifications. The outcome of this review is provided in Table below.

Table 21: Review of alternative fuel gas specifications

Parameter	Base Specification	Increase CO_2 Spec 1	Increased CO_2 Spec 2
CO_2 content	20%	35%	42%
MWe output	9.73	8.757 (10% derating)	8.757 (10% derating)
Energy efficiency	46%	44.1%	43.8%
Starting	OK	OK	Needs separate starting fuel

Reviewing these results, it is clear that by increasing CO_2 vented through the Power Plant stack, other Project objectives are impacted. A 10% derating in power output would reduce the Plant installed capacity to less than 50 MW and also reduce Symbion's revenues by 10%, making the project commercially unviable. Adding more capital equipment to boost the installed capacity backup to 50MW would have the same effect. Therefore, the electricity tariff would need to increase by an equivalent amount, impacting REG. In addition, the decreasing efficiency would mean more methane would be consumed, which violates another of the Lake Management Prescriptions to use the lake resource as efficiently as possible. Performance data related to the engines of two other manufacturers, MWM and GE Jenbacher, was briefly compared against the Wärtsilä data. These engines are specifically designed to accept gases with higher CO_2 content. Despite this, similar power output derating (running on biogas, landfill gas etc compared to natural gas) and efficiencies are quoted for these machines. Therefore, Symbion rejected the option of basing the Plant design on a higher CO_2 content fuel gas specification. Nonetheless, the fact that the chosen units can operate on such a gas at least meets the objective of Plant operational robustness. During detailed design, Symbion and its contractors will continue to examine cost-neutral methods of venting, or otherwise extracting more CO_2, rather than retuning it to the lake with the wash water discharge.

5.2.4 Number of barges

Symbion alanalyzed the advantages and advantages of having two barges instead of four. This implies a larger barge compared to what is proposed in the feasibility study. A larger barge would need to be constructed out of steel, built on slips, rather than containers, which can be, assembled in the water. Two large barges constructed of containers would not be strong enough to sustain the entire process. This would increase costs, schedule and risk. In addition, small barges are easier to manoeuvre and install compared to larger ones. Smaller barges will allow each to be commissioned as it is completed, allowing power to be provided to the grid sooner.

5.2.5 Gas lift vs water jets

In order to initiate the siphon process, Symbion considered using water jets instead of gas lift. Gas lift involves injecting air into the raw water riser at around - 40 m to - 60 m. The change in density of the column of water above the injection point is sufficient to overcome the friction loss in the system and initiate the auto siphon process. Water jets would instead be located at the upper end of the degassed riser and directed downward.

The water jet option was discounted for the reasons below.

Even though the water jets would be located at the top of the degassed riser making for an easier installation, the system would be less efficient overall.

Water from jets at the top of the degassed riser would have a high likelihood of spilling across to the raw water riser, further degrading the efficiency of the system.

Gas lift is well understood and commonly used in the offshore industry.

5.3 Alternative Sites

5.3.1 Onshore site

Busoro site was compared with other sites in order to come up with the best alternative for the construction of the gas and power plant. Most of the sites were eliminated to keep two including Busoro as the first site. The second site had the disadvantage of being an additional 3.5 km further from the first site along a road, which becomes progressively more challenging for transport of heavy equipment. The site itself adjoins a sheltered inlet and is very marshy in areas. The elevation change from the road is more gradual and the unpaved road goes down to lake level. Busoro site has the advantage of being flat and relatively spacious to accommodate both of the gas and power plants and there are no dwellings on the site. However, due to its low-lying nature it is also wet and marshy in areas, which would almost certainly require extra drainage and civil works to infill the area to above the lake elevation.

SPLKL proposes to construct the gas and power plant on Busoro site and within 50meters Lake Kivu buffer zone. The proposed site doesn't comply with the Ministerial Order determining the length of land on shores of lakes and rivers transferred to public property - N° 007/16.01 of 15/07/2010. According to this ministerial order, the land within a distance of ten (50) meters from the lakeshore and the land on the river shore within the distance referred to in Article 3 are reserved as natural vegetation.

SPLKL and GoR has agreed on constructing the gas and power plant within the Lake Kivu buffer zone on Busoro peninsula and the GoR has committed to avail this land before the construction activities start. It is however important to explain why the buffer zone and the Busoro peninsula were seen as the only option and the best site alternative for the 50MW gas to power plant.

Having the gas and power plant out of the buffer zone would have the following disadvantages:

A drop of pressure on gas processing which would a serious negative impact on amount of gas generated from the different stages and so the calorific power of the fired methane gas. A low calorific value means less optimum use of the generators and less power generated through a Nm3 of gas and so negative impact on the profitability of the project.

In order the project to be implemented in a commercial context, the construction should be accepted but adequate mitigation measures must be proposed to ensure the project is not impacting negatively of the sensitive ecosystem which is the Lake Kivu. The project has the potential to pollute the lake and destroy the lake biodiversity. Mitigation measures accompanied with monitoring of Lake Kivu water quality were proposed in this report.

In addition to the profitability of the project, Busoro peninsula was chosen because of its more or less flat topography. This implies less excavation works, less noise and vibrations and at the end less project cost.

The GoR has availed 4.08hectares to the project after relocation of 31 households. The NOx and COx fallout areas have been determined through simulations. Although, the fallout areas are within the populated zone of the project area domain, the predicted values are below the IFC guideline value for NOx and East African Standard value for CO (Annex 8). There is therefore no exclusion zone beyond the 4.08 hectares allocated for the project after expropriation and compensation.

5.3.2 Offshore site

Alternative sites mean another location for the power plant and the gas extraction facility. The location of the gas extraction facility is dependent on results of the bathymetric study. Methane gas can be extracted only from some points that have a specific depth. The actual location of the gas extraction facility has taken into consideration the stratification of Lake Kivu and the distribution of the gas throughout it. Rubavu and Karongi are potential sites for the gas extraction facility installation, which is not the case for Rusizi.

The location of the power plant has taken into consideration the following factors:

- No observable terrestrial natural values on the site;
- The power plant located nearby Lake Kivu;
- Power plant located in an industrial area and in compliance with the Rubavu Master Plan;
- Facility and possibility of connecting to the national grid, via REG power lines;
- Land requirement and landscape. The location has taken into consideration the size of the power plant and the area required for its installation as well as probable future expansions. The power plant will be located on a cape very close to the shore.
- Compliance with the Management Prescriptions (MPs) in consideration of the technical guidelines and the concessions plan development.

5.4 "No Project" Alternative

A "no project" scenario was also considered for this study. The "*no project*" scenario is not an option in this case due to the need to reduce gas levels in the lake in order to avoid the hazardous consequences of a spontaneous future gas eruption with the possibility of a large number of fatalities. The conclusion of the Expert Committee in 2006 was:

"*The irrefutable conclusion by the Expert Committee is that from the point of view of risks, the environment and economics, the only viable action is to produce the methane gas in Lake Kivu and use it for power production. To do nothing is clearly unacceptable because of the risk, and to vent the lake instead of producing gas is worse from all points of view*"

Whilst this could be prevented by venting, as happens currently in Cameroon, there are environmental consequences associated with venting as both CO2 and CH4 are greenhouse gases (GHGs) and methane gas is 21 times more potent GHG than CO2.

While it is generally accepted that such a cataclysmic event could occur sometime in the next 100 years given the estimated build-up of gas, it is also possible that unpredicted volcanic activity could mean that the cataclysmic event could happen much sooner than predicted (IFC/World Bank, 2009) and means that gas extraction should be considered sooner rather than later.

The costs of not having a power project could result in economic losses stemming from power cuts to industrial operations, agriculture and agro industries, domestic operations as well as losses to other targeted socio-economic activities of the proposed project.

The no project scenario would mean the status quo of the area and therefore no positive or negative impacts resulting from the project's implementation.

The no project option would mean the following forgone costs and benefits:

- The project's targeted consumers would forgo improved electricity supply;
- The anticipated generation of employment opportunities through expansion of business activities enabled by the project would not occur;
- The rural electrification program would suffer;
- There would be increased pressure to use biomass as a source of energy.

The project will result in a direct injection of more than 173 million USD into the local economy; therefore, the no project alternative would at the very least mean foregoing such investment.

6.0 Symbion Power Lake Kivu Ltd project environmental and social impacts

This chapter address the potential environmental and social impacts of the Project. In this report, environmental impacts are defined to include socio-economic, cultural, physical and biological changes resulting from the implementation of the SPLKL project through its different phases. The chapter is divided into two parts: the first describes the impacts of the Symbion Power Lake Kivu Ltd project's onshore installations, and the second addresses the impacts of the offshore installations.

The project will add significant capacity to Rwanda's grid and could forestall country's power rationing. However, poor planning and maintenance of the project could result in adverse impacts on the environment that supports millions of Rwandese by diminishing the air quality or by upsetting Lake Kivu's gas equilibrium.

The SPLKL Project has been designed in two phases. In the first phase 14MW will be generated and in the second phase an additional 42MW will be added. Our assessment of the environmental impacts analyses these two phases based on the construction involved and the operations of the power plant and gas extraction and treatment facilities. The gas extraction and treatment facilities comprise four similar platforms, and environmental impacts identified on one platform will be similar to those on other platforms. The design ESMP will be applied to all these platforms.

The project's environmental impacts are classified as positive or negative. However, this study goes further and characterizes the impacts in terms of their magnitude, significance, time of occurrence, extent, reversibility and scope.

For any significant negative impacts identified as a result of the project, mitigation measures are proposed to ensure compliance with applicable Rwandan laws and regulations, and meet the requirements of international standards, including the IFC PS 1 through 8. Mitigation is considered under the following classifications:

- Avoidance – avoiding environmental damage at source through design;
- Minimize – lessening the severity of an impact which cannot be avoided entirely;
- Mitigation and compensation – acknowledges that some negative consequences will stem from development, but provides means by which the conditions can be compensated for or improved; and
- Enhancement – increasing the effects of positive impacts.

This assessment has proposed cost-effective measures to mitigate (preventing, minimizing, compensating or enhancing beneficial impacts) anticipated environmental and social changes and impacts during project implementation and operation, or further reduce the residual environmental and social changes inherent in the selected project design and propose optimized alternatives as necessary. The scope will include technical, social, and institutional measures to be implemented as integral elements of the project. The measures will inform technical designs of the project components (under the feasibility study). The extent to which the different mitigation measures will reduce the scale of impacts arising from the scheme will be evaluated, and unavoidable residual impacts identified. The measures will be incorporated in the Environmental and Social Management Plan (ESMP).

6.1 Positive Impacts

Positive impacts of this project are various and diverse in nature. They include new employment opportunities, wealth creation, improved services, technology transfer, and national capacity building. Enhancement measures are proposed to ensure the project is strengthening on positive impacts while mitigating the negative ones.

6.1.1 Socio-Economic Benefits

It is mentioned in section 4 that on average the urban areas have 46.1% of household using electricity as their main source of lighting, compared with only 4.8% in rural areas and 10.8% at national level. Therefore, the anticipated impacts of the Symbion Power Lake Kivu Ltd Project on the socioeconomic development of Rwanda and its people include: new access to cheaper electricity (notably, new power resources could significantly improve healthcare and education services), effective use of a potentially dangerous national natural resource, the creation of new jobs for related services as well as for the project's direct workers, and the acceleration of investments in the region. This project will amount to a $173 million investment, one of the largest projects in Rwanda's history, and it can serve as a model for further investments to the region. Notably, the project is expected to promote further infrastructure development, as the additional power feeds new industrial businesses and as Rwandans acquire technical know-how in working on the project.

Other services that will be supplied locally will include materials and labour, transport, car hire, accommodation and restaurant, telephone, internet and travel services. Whilst the exact value of these services is not yet determined there is the potential for a significant boost to the local economy. There will also be increased demand for local produce and the project may be a catalyst to improve the local products especially if tourism is to increase as a result of the electricity provision.

6.1.1.2 Employment Opportunities

The overall employment rate of Rubavu District is 79.6% of the resident population aged 16 years and above and it is certainly higher around the project area. The construction of gas exploitation facilities and the power plant is expected to increase and create employment opportunities among the local communities, which will mainly be unskilled laborers. It is anticipated that approximately 600 jobs will be generated during construction of which approximately 500 will be local jobs and this is bound to improve the local economy. Unskilled laborers during the construction who will mainly offer manual labour will be paid around 4,000 Rfw daily. During the operational phase, additional employment opportunities will be generated. It is expected that 80 full-time workers will be needed to operate the gas extraction and treatment facilities and the gas/power plant on a twenty-four-hour basis. Employment will also be created or maintained indirectly for REG, the parastatal company responsible for the transport and distribution of the electric power produced.

Employment opportunities

Criteria	Assessment
Nature	Positive
Component value	Major
Intensity	Major
Extent	Local
Duration	Long term
Significance of impact	Major

Enhancement measures

- Preference for casual labourers should be given to local people but the local councils officials and local leaderships in Rubavu should be involved in recruitment processes.
- SPLKL can make it a contractual obligation for the contractors to hire a specific percentage of women.
- SPLKL can make it a contractual obligation for the contractors not to hire children for any work to be performed at onshore and offshore sites.

The following enhancement measures will be applied to manage labor and working conditions during construction and operation phases of the Project including the health and safety of the employees:

An ESMS that considers OHSAS 18001:2007 requirements will be developed for both construction phase and operation phase.

An HR policy for SPLKL will be developed.

Workers will have contracts in place prior to commencement setting out working conditions, terms of employment and EHS responsibilities.

All applicable national health and safety legislation and international regulations will be followed.

All the health and safety risks of each activity during construction and operation will be identified followed by identification of the appropriate mitigation measures/personal protective equipment. These issues will be detailed in an Occupational Health and Safety Management Plan that will be separately prepared for both phases of the Project.

A grievance mechanism will be developed for employees and included in the ESMS. Employees will be informed about this mechanism at the time of hiring. Grievance mechanism will be extended to non-employee workers in future.

Subcontractors will also be required to follow the requirements of IFC PS2 and EBRD PR2. Contracts to be signed with subcontractors will include EHS requirements. A Subcontractor Management and Monitoring Plan will be prepared and implemented.

All workers (including subcontractors) will be trained on health and safety, and Emergency Preparedness and Response Plan to respond timely to the incidents.

All workers will be insured under Social Security Institution.

All accidents and incidents will be recorded. The efficiency of health and safety practices will be monitored through internal and external audits and corrective actions

will be taken if required.

6.1.1.3 Capacity building and technology transfer

In Rubavu District, agriculture has for a long time been a core sector of economy in terms of its contribution to domestic income and employment. With SPLK Ltd project, local candidates will be trained and will acquire new technical skills. Job opportunities will increase over time and SPLK Ltd has a plan to gradually replace the expatriate staff over time. SPLK Ltd is recommended to propose an extensive training programme to be instituted by the local university for engineers and other roles for the operation of the plant and production facilities.

After six years of operation and the implementation of Phase II, local staff numbers will be 100 out of a total of 120. Local staff will be employed in the following additional roles:

- Mechanical engineers and technicians.
- Control and instrumentation engineers and technicians.
- Operations supervisors and technicians.
- Gas Extraction Facility (GEF) operations supervisors and technicians.

Of these 100 local jobs, 12 will be in management or administration, 34 in engineering, 14 in Power Plant operations and 44 on GEF's and boat crew. Given the poor educational levels of the local community the training programmes will be extremely important and it is possible that some senior staff will have to be brought in from elsewhere, e.g. Kigali or other regional centers.

Capacity building and technology transfer	
Criteria	Assessment
Nature	Positive
Component value	Moderate
Intensity	Moderate
Extent	Local
Duration	Long term
Significance of impact	Moderate

<u>Enhancement measures</u>

- Employ as much as possible locals and engage employees in skills development

6.1.1.4 Electricity

During public consultation, the project team was advised that local businesses are affected by frequent power outages that impact on their working hours and a secure supply is considered to provide an important boost to local business. Energy supply will also be critical to the development of the tourism industry that is developing around the lake.

The project aims to provide an additional 50MW, very significant new capacity for Rwanda's western region and the country in general. With the additional electricity supplied to the national grid through the environmentally friendly and sound exploitation of the gas reserves in Lake Kivu, the country is expected to attract further investments, as the energy deficit is met and price of electricity becomes cheaper.

More immediately, Rwandans will be able to enjoy a higher standard of living, as electricity will enable improvements to healthcare and education services.

Electricity	
Criteria	Assessment
Nature	Positive
Component value	Major
Intensity	Major
Extent	Local
Duration	Long term

Significance of impact	Major

Enhancement measures

- The GoR and so REG should consider connecting the populations and social services around the site in the objective to ensure they benefit from a project that is developed closed to their homes.

6.1.1.5 Improved Road Access

The planned construction of project facilities has involved the construction of a new 6km tarmac road from Bralirwa Brewery to the site, to facilitate the transport of equipment during all project phases. This will fast the trade within the area and ease access to different social services.

Improved access road	
Criteria	Assessment
Nature	Positive
Component value	Medium
Intensity	Medium
Extent	Local
Duration	Long term
Significance of impact	Major

Mitigation measures

- Regular maintain of the road and its associated infrastructures including the drains
- Regular monitoring of safety along the road

6.1.2 Environmental Benefits

6.1.2.1 Reduction of GHGs emissions

The operation of the methane gas project will reduce reliance on biomass – specifically, wood – as a source of fuel in the country. The project will thus help conserve vegetation in Rwanda and thereby curb soil erosion.

This project, as compared to standard diesel power plants, will not be run on petroleum products, and so will effectively reduce GHGs emissions by displacing the need for diesel generation. The project will thus help to minimize climate change by displacing GHGs emissions. The project also reduces GHG emissions by extracting methane from the lake and combusting it in the reciprocating engines, thereby reducing the possibility of a lake turnover and release of methane, which, as a GHG is some twenty times worse than CO2 to the atmosphere in general and specifically, to that around Lake Kivu.

When the phase 2 is completed, the project's installed capacity and projected yearly average generation is 50MW and 265.920GWh. Assuming the load factor is 59.4%. The Project is expected to displace 144,654 tCO2e per year, which accounts for 1,012,604 tCO2e for the first crediting period (7 years)

The reduced emissions stemming from the Symbion Power Lake Kivu Ltd project may generate carbon credits that could be sold through international markets.

Reduction of GHGs emissions	
Criteria	Assessment
Nature	Positive
Component value	Major
Intensity	Major
Extent	Regional
Duration	Long term
Significance of impact	Major

Mitigation measures

SPLKL will ensure:

- Emissions do not result in pollutant concentrations that reach or exceed relevant quality guidelines and standards by applying national legislated standards or in their absence the current WHO Air Quality guidelines (table **n** in annexes)[32] or other international recognized sources (WB EHS guidelines).
- Emissions do not contribute a significant portion to the attainment of relevant ambient air quality guidelines or standards. As a general rule, this Guideline suggests 25 percent of the applicable air quality standards to allow Significant sources of point and fugitive emissions are considered to be general sources which, for example, can contribute a net emissions increase of one or more of the following pollutants within a given air shed (WB EHS guidelines)

6.2 Adverse Impacts.

Adverse impacts of the Symbion Power Lake Kivu Ltd project are the unintended negative effects that the project could have on Rwanda's sustainable socio-economic development and the environment.

Onshore installations

6.2.1 Gas and power plants construction

6.2.1.1 Impacts on Physical Environment

Impacts on the physical environment are those impacts that may affect the non-living environment, including the water, soil, air quality and topography.

Geology and Soils

[32] **Available at World Health Organization (WHO). http://www.who.int/en**

As mentioned in section 4, the project site is occupied by metasedimentary sequence of Mesoproterozoic age consisting of Gishwati complex comprising micaschists with muscovite and biotite and metaquartzites with chlorite and biotite, as well as small pegmatitic granitic inclusions and doleritic sills.

As a result of this project, and especially during construction, when excavation activities will be conducted to install the gas and power plants and arrange the marine landing site, the soil and the geological make-up of the surrounding area may be disrupted to some extent.

Geology and soils	
Criteria	Assessment
Nature	Negative
Component value	Moderate
Intensity	Moderate
Extent	Local
Duration	Short term
Significance of impact	Moderate

Mitigation measures

- Minimization of the disturbances to the soil and earth should be encouraged and promoted during the construction period. The area surrounding the project should be reforested to prevent soil erosion.
- Construction should proceed in the dry season if possible to minimize soil erosion. Where construction is required in the rainy season, potentially unstable slopes should be avoided.

Residual impact: If the mitigation measures are implemented, risk related to Geology and soils will be minimized. The component value will stay at major and sensitivity or intensity will be reduced to minor resulting to minor significance.

Ground and surface water

Minor short-term lowering of the groundwater table may occur in the vicinity of Busoro site during dewatering of foundation excavations.

This site has the advantage of being flat and relatively spacious to accommodate both of the gas and power plants and there are no dwellings on site. However, due to its low-lying nature it is also wet and marshy in areas which would almost certainly require extra drainage and civil works to infill the area to above the lake elevation. The groundwater resources in this area are limited and the groundwater is not typically used for domestic drinking use or for other purposes. Therefore, the limited drawdown from dewatering activity is not expected to have a significant impact on the community.

There are no surface water drainages that run through the site, and storm water discharges will be managed to minimize adverse water quality impacts on Lake Kivu.

A site grading and drainage plan will be required by the construction contractor to manage the flow of water offsite in a responsible manner. Sediment control measures such as retention can be used as necessary to minimize sediment transport offsite. Measures such as seeding and silt fencing may also be implemented to minimize erosion of soil stockpiles.

The developer proposed to encroach the established 50 buffer zone from the edge of the lake. This being the only solution to install the gas and power plant pipes as they cannot be away from the lake. This is in contradiction of the ministerial order on protection of lakeshores.

In this context, accidental spills of fuels or other materials could potentially cause contamination. Precautions should be taken to prevent spills, and all workers should be trained in the proper handling, storage, and disposal of hazardous or toxic materials. A written emergency response plan should be prepared and retained on site, and the workers should be trained to follow specific procedures in the event of a spill. There must be proper equipment available for workers to contain and treat a spill in the event of an emergency.

Groundwater and surface water	
Criteria	Assessment
Nature	Negative
Component value	Moderate
Intensity	Moderate
Extent	Local
Duration	Long term
Significance of impact	Moderate

Mitigation measures

- Minimization of the disturbances to the soil and earth should be encouraged and promoted during the construction period.

Residual impact: If the mitigation measures are implemented, risk related to ground and surface water will be minimized. The component value will stay at moderate and sensitivity or intensity will be reduced to minor resulting to minor significance.

Encroachment into Lake buffer zone

As per the proposed onshore site plan, the gas and power plant will be constructed within the lake 50m buffer zone and considerable earthworks will be required to make the site suitable for construction of the plant. The high rainfall has the possibility to impact the construction schedule. Although every effort will be made to schedule the bulk earthworks and soil compaction in the drier part of the year, this will be impacted on when the Project can start. The construction of the onshore facilities has the potential to pollute Lake Kivu water if appropriate measures are not considered to contain the generated waste and the soil that could be washed away to the Lake.

Encroachment into Lake buffer zone	
Criteria	Assessment
Nature	Negative
Component value	Major
Intensity	Major
Extent	Local

Duration	Long term
Significance of impact	Major

Mitigation measures

All possible measures should be considered to protect the pollution of Lake Kivu from project activities and through different phases. During construction, the measures include:

- Install soil traps at the lower end of the site to retain the soil that could be washed away to the lake and from the construction site.
- Replant vegetation and keep green the non-built area for the protection of Lake Kivu water and prevention of pollution from the project activities
- Construction waste management plan which will identify areas where waste minimization measures can be employed. Construction waste through over-ordering, cut off and general wastage.
- An innovative approach to disposal could be to grade and sort waste on site into different categories and make this available at no cost to the local community to take away and reuse.
- All waste metals generated on site during the construction phase should be collected separately and stored in a suitable, secure location prior to disposal. Contaminated waste metals will require recovery by a suitable waste contractor for decontamination. "Clean" waste metals can be recycled within the community.
- Wherever possible, uncontaminated building rubble will be utilized within the site for hardcore or other land reclamation purposes. Contaminated building rubble will be sent off site to a suitable disposal facility capable of treating or disposing of the material without the loss of contamination at the disposal site, either by leaching or other mechanism.
- Mitigation must be taken to prevent run-off from the stockpiles of building rubble on site.
- Wherever possible, the top soils will be utilized for land reclamation purposes within the site. The top soils and excavation wastes can be re-used for landscaping, screening and filling purposes without prior treatment. Mitigation must be taken to prevent run-off from the stockpiles of top-soil and excavation materials on site.
- Waste oils and lubricants will be temporarily stored in oil drums placed in a sealed container which has a bund wall built into it. The container itself will be located in a bunded area of hard standing, to prevent leaks and spillages from entering the ground and the groundwater.
- The waste oil, lubricants and containers will be taken from site and disposed of at the nearest suitable recycling facility.
- Wherever possible, waste wood can be recycled in the community. However, where disposal is required, waste wood that is not contaminated by, or has not been treated with, halogenated organic compounds or heavy metals can be recovered for use as fuel.

- Electrical cabling and components should be recycled. Spent batteries will need to be stored in a suitable storage facility on site prior to transport to a suitable disposal facility.
- Wherever possible plastics, paper and glass will be separated at source and recycled. If recycling is not possible then the materials will be disposed of to a suitable disposal facility.
- Portable showers should be used. They should be emptied by suitably licensed operators who will dispose of the effluent to a suitable treatment facility. Alternatively, temporary facilities with a septic tank shall be constructed. Shower and wash facilities should drain to a septic tank until suitable treatment facilities are provided on site.
- Once available permanent washing and toilet facilities shall be utilized and shall drain to a septic tank and thence to a package treatment facility capable of meeting IFC standards prior to discharge to the Lake, preferable via a tertiary reed bed type treatment system.
- Within the GEFs, effluents from toilet and washing facilities shall be treated by an onboard package treatment facility to suitable standards, with respect to BOD, COD, ammoniacal nitrogen, and microbiological organisms, prior to discharge to the lake.
- Wherever possible, biodegradable food wastes shall be composted on site.

Residual impact: If the mitigation measures are implemented, risk related to encroaching into Lake buffer zon will be minimized. The component value will stay at major and sensitivity or intensity will be reduced to minor resulting to minor significance.

Traffic-Generated Dust
People will be settled on high altitude when looking to the topography of the onshore site. Dust may spread easily around the site. During construction of the gas and power plant, generation of dust along off-site access routes during importation of construction materials and staff travel is of concern, particularly during the dry season periods of June to August and December to February. Areas covered by earth, such as those near the power plant site, can yield large amounts of airborne particulates during dry weather, but there is no potential for nuisance levels, as there won't be nearby settlements once the government has availed the land for the project and hands it over to SPLKL.

Traffic-generated dust	
Criteria	Assessment
Nature	Negative
Component value	Moderate
Intensity	Moderate
Extent	Local
Duration	Short term
Significance of impact	Moderate

Mitigation measures

Dust will be controlled by following standard good site practices, including:

- During dry conditions, access roads will be wetted or treated with a biodegradable (e.g. lignin-based) road sealing products to prevent dust generation;
- Surrounding vegetation should be maintained on the site for as long as possible before being cleared to act as a windbreak, which will keep dust from spreading long distances.
- As a precautionary measure, workers on the site should be issued dust masks during dry and windy conditions.

Residual impact: If the mitigation measures are implemented, risk related to traffic generated dust will be minimized. The component value will stay at moderate and sensitivity or intensity will be reduced to minor resulting to minor significance.

Noise and vibrations

As the same for dust, noise will easily spread around the project site to higher altitude where people are settled. Construction activities generally result in high noise levels. The development of this project will result in increased ambient noise levels. However, there are no other construction developments currently being undertaken in the area, so the project will not be adding to already increased noise levels.

The simulations have shown that noise levels on the contours of the symbion project site will not affect the populations living outside the 4.08hectares availed as they are almost similar of the noise levels before construction and operation of the Symbion power project of the LAeq and LZpeak.

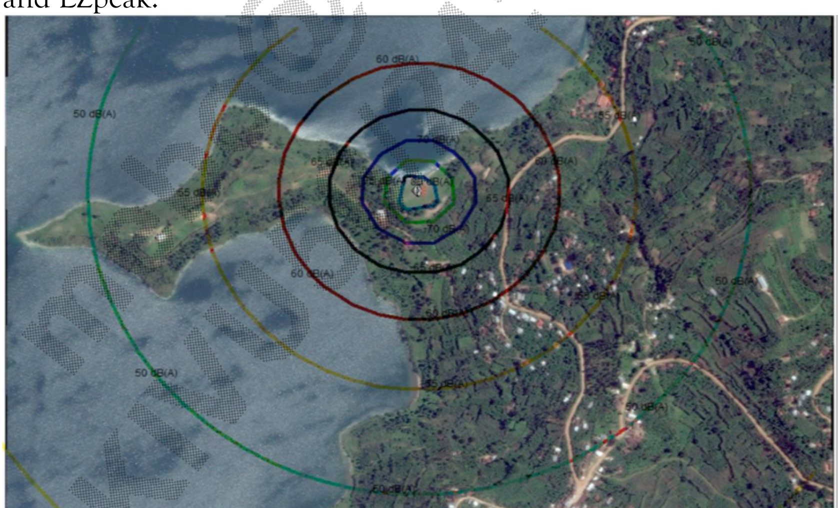


Figure 49: Simulated noise levels during operation

The predicted noise levels across the project area domain vary from 80 dB(A) at the proposed power plant site and dissipates outwards to about 46 dB(A) at 700m radial distance from the source.

Noise pollution	
Criteria	Assessment
Nature	Negative
Component value	Major
Intensity	Major
Extent	Local
Duration	Long term
Significance of impact	Major

Mitigation measures

- Utilize low noise machinery for the construction to the extent possible (Noise levels be below 70dBA to the nearest receptors by days).
- Provide all construction workers with relevant safety gear including ear masks Workmen should be provided with suitable protective gear (such as nose masks, ear muffs, helmets, overalls, industrial boots, etc at all times while at work and enforce application.
- Working at night within settled and built up areas will be upon issuance of necessary permits from the National Environment Management Authority (REMA)
- Noise reduction options that should be considered include:
  - Selecting equipment with lower sound power levels;
  - Installing silencers for fans;
  - Installing suitable mufflers on engine exhausts and compressor components;
  - Installing acoustic enclosures for equipment casing;
  - Radiating noise;
  - Improving the acoustic performance of constructed buildings, apply sound insulation;
  - Installing acoustic barriers without gaps and with a continuous minimum surface density of 10 kg/ to minimize the transmission of sound through the barrier. Barriers should be located as close to the source or to the receptor location to be effective;
  - Installing vibration isolation for mechanical equipment
  - Limiting the hours of operation for specific pieces of equipment or operations, especially mobile sources;
  - Reducing project traffic routing through community areas wherever possible;
  - Noise impacts should not exceed the levels presented in Table 22, or result in a maximum increase in background levels of 3 dB at the nearest receptor location off-site.

Table 22: IFC Noise Level Guidelines

	One hour LAeq (dBA)	
Receptor	Day time	Night time
	07:00-22:00	22:00-7:00
Residential, institutional and educational	55	45
Industrial and commercial	70	70

Road Hazard and Safety

Transport of the gas and power plant parts will result in increased heavy traffic from Bralirwa brewery through the road being constructed to the power plant site. The main effect of increased traffic volumes is additional safety risks to road users, who must compete for road space.

Pedestrians and pedal cyclists, regarded as especially vulnerable road users, currently constitute a substantial proportion of traffic on the project site. A shift in the main road's traffic composition, characterized by an increase in the number of trucks and construction vehicles, could increase the risk of accidents involving more vulnerable road users.

Similarly, pedestrians in settlements surrounding the project area would be exposed to an increased risk of traffic accidents. Concern for pedestrian safety was raised as regard to consultation activities.

Road Hazard and Safety	
Criteria	Assessment
Nature	Negative
Component value	Moderate
Intensity	Minor
Extent	Local
Duration	Short term
Significance of impact	Minor

Mitigation measures

A traffic management plan should be developed. It should include:

- Appropriate speed limits for vehicles indicated by road signs;
- Vehicle safety classes in the affected villages, in particular for pedestrians and bicyclists.

Residual impact: If the mitigation measures are implemented, risk related to road hazard and safety will be minimized. The component value will stay at moderate and the intensity and significance of impact will stay minor. The minor significance and intensity of impact is explained by the fact that the surroundings areas will be cleared with resettlements. People in the immediate surroundings of the site will be compensated and relocated.

Soil erosion

As earlier mentioned in the baseline section, the soil on site is covered by little vegetation. The natural vegetation" is comprised of secondary disturbed vegetation, primarily shrubs, herbaceous plants and several species of grasses, including razor grass, *Pennisetum* and *Paspalum* species. A number of exotic tree species including bamboo, *Bambusa vulgaris*, *eucalyptus* and *Euphorbia* species, guava and Mango trees can be seen on the project site.

Soil erosion will result from the removal of vegetation cover during construction phase of the project. During the land preparation, the soil will be exposed to erosion agents like wind and water. During rainy season, rain will carry topsoil downwards causing erosion. The movement of heavy equipment and other traffic is also bound to create erosion, which will be further added to by wind. In addition, loose surfaces created by such movements during rainy spells could lead to rill and gulley erosion. The topographic profile of the project area (like most of Rwanda) is dominated by young soils, which makes it very susceptible to soil erosion. The construction will be undertaken in phases, so only sections of the site will be bare at any given time, which will reduce the surface area open to these erosive agents at any given time.

Ultimately, the soil erosion impact should be only short-term and should cease with the end of the construction phase. However, if the area is left bare after construction, erosion could continue.

Soil erosion	
Criteria	Assessment
Nature	Negative
Component value	Moderate
Intensity	Moderate
Extent	Local
Duration	Short term
Significance of impact	Moderate

Mitigation measures

- Soil movement and excavation activities will be carried out in small sections so that at any given time, a minimal area is disrupted. Excavation activities may be carried out close to the time of construction so as to reduce the time period during which the excavated regions are exposed.
- The site engineer will ensure that soil traps in the form of rock bankers are installed on the lower edge of the construction sites on both sides of the road so as to trap any soil carried away by water. Water use will be properly managed so as to ensure that no running water is left unattended leading to erosion;
- Movement of traffic within the site will be limited as much as possible to appointed routes so as to ensure a minimal area is subject to the traffic of vehicles, which could loosen the soil and cause further erosion;
- Control of storm water movement will be undertaken through the installation of storm drains.
- Access roads will be designed to ensure majority of their length is approximately along

contours so as to reduce incidences of rill erosion on road surfaces that are along the slope direction.

Residual impact: Following implementation of mitigation measures, the risk related to soil erosion will be minimized. The component value will stay at moderate and sensitivity or intensity will be reduced to minor resulting to minor significance.

Solid waste management
Different types of waste will be generated with the construction activities as detailed below.
Waste Hierarchy
SPLKL, during all phases of the Project, will seek to apply the waste hierarchy as part of the waste prevention and management policy.
The waste hierarchy consists, in order of preference, of:
a Prevention;
b Re-use;
c Recycling;
d Other recovery (e.g. energy recovery); and
e Disposal.
The use of this hierarchy will be incorporated in the ESMP for the Project; all contractors / suppliers will be required to prepare their specific CESMP with due regard to this guiding principle.
This approach will allow SPLKL and its contractors to establish waste management priorities at the outset of activities based on an understanding of the potential risks and impacts and considering waste generation and its consequences.

The IFC General EHS Guidelines provide guidance on the approach to waste management that is expected for new projects. The Guidelines apply to any facility that generates, stores or handles any quantity of waste. The correct / preferred methods for dealing with wastes is dependent upon the nature of the waste, particularly whether the waste can be classified as hazardous or non-hazardous. The ESMP will provide for the submission of construction method statements and a Waste Management Plan (as part of the CESMP) for approval by SPLKL and relevant stakeholders (that may include Rubavu District Authority and REMA, as appropriate), prior to commencement of construction.
Specific measures could include, amongst others, the stockpiling of excavated sediment and testing for waste acceptance criteria, to determine whether it can be re- used on- or off-site, and the testing and removal, as appropriate, of any water encountered on-site where contamination is suspected which will be handled by a suitably licensed waste contractor.
The ESMP will ensure that all construction waste will be dealt with in a manner that complies with the regulations and (upon leaving the site) waste will be treated and disposed of by suitably licensed contractors. Where hazardous waste is transported from the Project, it will be handled in accordance with the relevant regulations, and, where necessary, be transported in sealed tankers. Application of waste classification will also apply as set out below.

The project will result in solid wastes during demolition and construction phase of onshore installations. The types of wastes that are anticipated to emanate from the project are as follows.

Table 23: Type of solid waste

Demolition and construction phase	Decommissioning phase
• Residue of tarmac • Debris (concrete and bricks) • Soil • Timber • Metal • Reinforcement bars • Ballast • Sand • Cement • Packaging material and containers e.g. paint pails, cement bags and metallic straps. • Nails • Glass • Ceramic tiles • Plastic piping • Excavated soil and rocks	• Debris (concrete) • Nails • Metal scrap and cut-off • Building blocks/bricks and concrete rubble • Waste timber • Wire • Piping • Plastic • Roofing tiles • Reinforcement bars

If not properly disposed, these wastes will result in the pollution of soil, wetland, groundwater and air (paint). Materials consisting of chemicals e.g. paints, cement and thinners will alter the chemical composition of these regimes.

Lake Kivu is a water body in the immediate surroundings; poor management of wastes in the site could lead to its contamination. Inadequate treatment of sewage and wastewater emanating from the project could lead to contamination of water resources. Assuming a modest consumption rate of 15 metric tons per day from the site, this is a substantial amount and where treatment is not adequate, it could result in contamination of Lake Kivu and other water resources from effluent directed to river channels.

Solid waste management	
Criteria	Assessment
Nature	Negative
Component value	Major
Intensity	Minor
Extent	Local
Duration	Short term

Significance of impact	Major

Mitigation measures

- At the project site there will be a refuse pit where all solid waste will be deposited. The pit will be constructed to segregate paper wrappings, empty oil canisters, plastic, metal straps and other waste. The items deposited here will be examined to identify those that can be re-used, and these will be sold off or given away for re-use elsewhere or recycling. Clean-up exercises will be regularly undertaken at the end of every business day so as to retain cleanliness within the site. Workers at site will also be clearly briefed on proper disposal of solid waste and the disposal area will be clearly marked.

Residual impact: Following implementation of mitigation measures, the risk related to solid waste management will be minimized. The component value will stay at major and sensitivity or intensity will be reduced to minor resulting to minor significance.

6.2.1.2 Impacts on Biological Environment

Impacts on the biological environment include effects on living parts of the environment, including flora, fauna, rare or endangered species, sensitive habitats, significant natural sites, species of commercial importance, and species with potential to become dangerous.

- **Impacts on Flora**

The onshore site is covered by little vegetation which has been altered by human intervention for agricultural and touristic purposes. The most observed crops are banana plantations of Musacae family and *Zea mays and* the surrounding "natural vegetation" is comprised of secondary disturbed vegetation, primarily shrubs, herbaceous plants and several species of grasses, including razor grass, *Pennisetum* and *Paspalum* species. A number of exotic tree species can also be seen on the project site. They include bamboo, *Bambusa vulgaris*, *eucalyptus* and *Euphorbia* species, guava and Mango trees.
Land clearing activities on site before construction commences will contribute to vegetation cover loss. A certain amount of vegetation and trees will be uprooted to create space for the project facilities.

Impacts on Flora	
Criteria	Assessment
Nature	Negative
Component value	Moderate
Intensity	Minor
Extent	Local
Duration	Long term
Significance of impact	Moderate

Mitigation measures

- Uprooting trees in the area proposed for the project facilities is unavoidable.

Symbion Power Lake Kivu Ltd should therefore undertake a reforestation program to restore the wood mass felled during project development

Residual impact: Following implementation of mitigation measures, the risk related to impacts on fisheries will be minimized. The component value will stay at moderate as well as sensitivity or intensity of impact resulting to minor significance.

- **Impacts on Fauna**

During the site visit, a number of bird's species could be observed and two endemic Congo clawless otter and Ruwenzori otter shrew have been reported around Lake Kivu even if none of them has been observed in the project area.
The project area and the study scope do not have any known species of fauna and avifauna that will or could be displaced due to the project.

Impacts on Fauna	
Criteria	Assessment
Nature	Negative
Component value	Minor
Intensity	Minor
Extent	Local
Duration	Short term
Significance of impact	Minor

<u>Mitigation measures</u>

- Activities that will create significant disturbances to the environment should be avoided or kept to a minimum in areas with wildlife and birds. Such activities include clearing of vegetation, traffic diversions, haulage routes, workmen's camps and chemical spills.
- To reduce the possibility of vehicle and wildlife collisions vehicle speed shall not exceed posted speed limits and wildlife warning signs shall be installed where appropriate.
- Wildlife is attracted to untidy campsites. Cleanliness, proper storage of food and garbage and common sense are the best avoidance practices.
- Wildlife shall not be fed or harassed. Project personnel will be prohibited from hunting, fishing, feeding or harassing wildlife around the project site.
- Awareness campaign on no disturbance of migratory birds
- Areas with migratory birds should temporary restricted for any construction activity

Residual impact: Following implementation of mitigation measures, risk related to impact on fauna will be minimized. The component value will stay at minor as well as the intensity of impact and significance of impact.

- **Impacts on Fisheries**

As earlier mentioned, fishermen are active with fishing activities. Although we note a moderate fishing activity in that area, it is sustaining the livelihoods of some households. There are two types of fishing activity, the artisanal and individual fishing. Of the current socio-economic uses of the lake the most prominent is fishing. The current catch is estimated at around 2,800 Mt per year and the overwhelming majority of the catch (2,800Mt) comprises the small freshwater herring *Limnothrissa miodon*, known locally as isambaza[33]. This species was introduced from Lake Tanganyika around 1960 and exploits the open waters of the lake. The remainder of the catch is riparian in nature and is dominated by *Tilapia*. Fish farming is underdeveloped around the lake although there are proposals to increase the contribution of farmed fish in the coming years. The near shore fishery, although less important economically, is still an important source of protein and provides a degree of food security for the local community.

In order to prepare for the Symbion Power Lake Kivu Ltd project and its associated infrastructure, the project will have to acquire land for the power plant and Kitraco Jetty used as marine landing site. Laying pipes and the land acquisition could disturb fishermen's activities and impact fishing as a commercial activity in the project area. The issue was also raised during the early consultation with the stakeholders, especially the fishermen having the fishing activity in Bwishura sector, in the surroundings of the project site.

Impacts on Fisheries	
Criteria	Assessment
Nature	Negative
Component value	Major
Intensity	Major
Extent	Local
Duration	Short term
Significance of impact	Major

Mitigation measures

- Relocation of fishery activities must be undertaken before any land acquisition occurs.
- The developer to consider engaging an awareness campaign on limited impact on fisheries. The impact is confined only on the area where will be located the gas plant. The pipes are to installed at -20m and so this should be seen as an impact to fishing activities
- As corporate responsibility, undertake training programme for fishermen that could improve their livelihoods

Residual impact: If the mitigation measures are implemented risk related to impacts on fisheries will be minimized. The component value will stay at major and sensitivity or intensity will be reduced to minor resulting to minor significance.

6.2.1.3 Socio-economic impacts

[33] ESIA Kivuwatt Project 2009

Cultural impact

The proposed onshore site and Kitraco Jetty for barges installation are located in areas that are defined as industrial areas under the Rubavu Master Plan. There are no notable cultural artifacts on the site. Given the planned activities, the current landscape of the area will likely change from bring rural and natural to being industrialized. However, this change conforms to the planned land use of the area. No adverse cultural impacts are anticipated, considering Rubavu Master Plan and the present status of the area.

Inevitably, the construction and other related activities onshore would affect the local culture, in particular, the constructing company, if foreign, could have a cultural influence on or a cultural with the local people.

Cultural impacts	
Criteria	Assessment
Nature	Negative
Component value	Minor
Intensity	Minor
Extent	Local
Duration	Short term
Significance of impact	Minor

Mitigation

- The contractors should be familiar with the culture of the local people so that they understand local norms and values. Additionally, the contractor should use local labor on the project to as great an extent possible to ensure the integration and involvement of local Rwandans. Including locals in the project will reduce cultural friction and the associated impacts.

Residual impact: If the mitigation measures are implemented risk related to cultural impacts will be minimized. The component value will stay at minor and sensitivity or intensity will also stay to minor with minor significance.

Loss of land and assets (including crops)

The proposed gas and power plant will have adverse impacts in terms of activities that will trigger off resettlement of the local communities living or utilizing the land for different reasons in the selected project area. Through the Purchase Power Agreement (PPA), the GoR has committed to avail land for the SPLKL gas to power project. It is estimated 6.5 hectares will be needed for SPLKL to fully operate from its onshore installations. This means the project will lead to acquisition of the land that is in actual facts owned by individuals including farmers. Therefore, the implementation of the project will require economical displacement of some of the households living in the land availed for SPLKL project.

The process of acquiring the land from current owners could create squatters if compensated landowners fail to resettle. If the people who have been compensated for use of the land do not resettle, they would become squatters. The fact that landowners were compensated does not necessarily means they have resettled. The absence of a concrete, well-focused resettlement plan for displaced persons could result in a situation where displaced persons build informal structures nearby on unoccupied land.

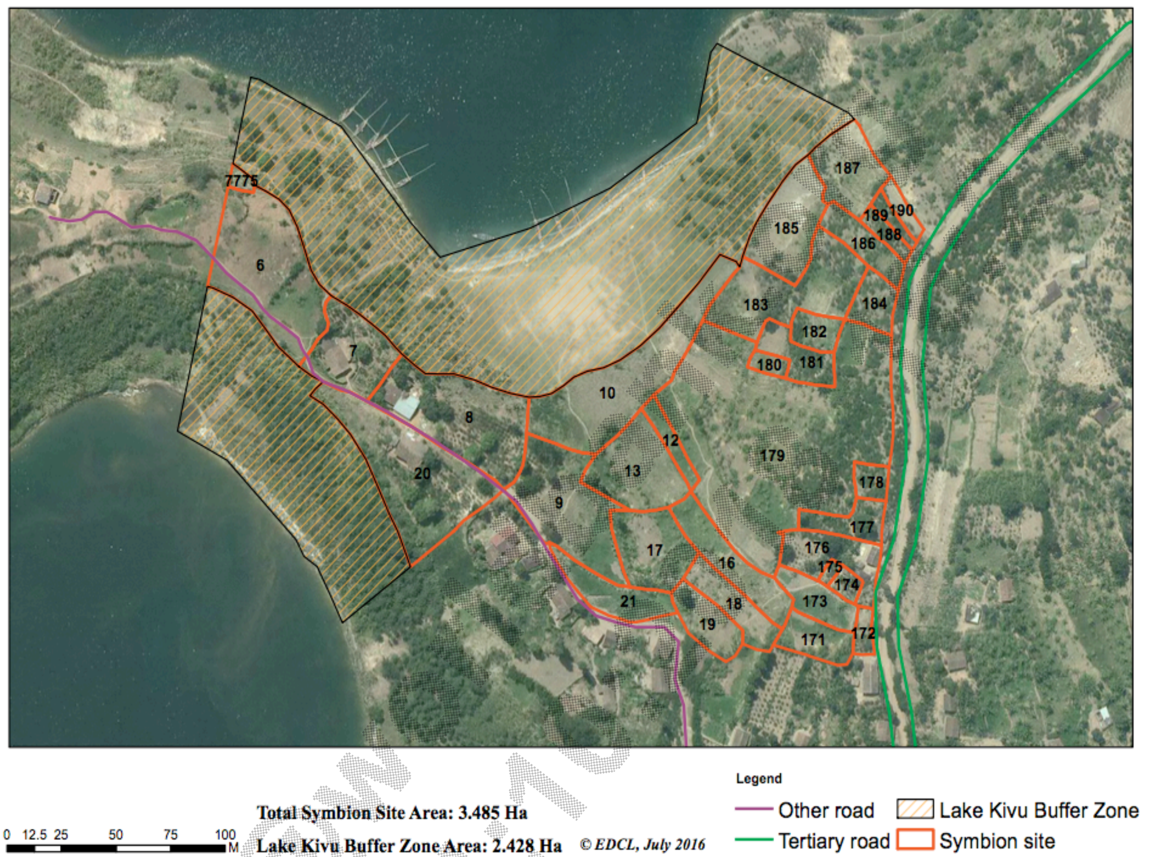


Figure 50: Parcels of land to be affected by the project

It was estimated 4 houses that belong to four households will be affected by the project, occupying approximately 1270m2. 27 households will be economically displaced as they lose their land. The land to be acquired has in total 4.08hectares.
In total, the GoR will spend USD122.731 for the compensation of economically and physically displaced PAPs.

Area	Environmental element	Impact	Criteria	Assessment
Loss of land and assets	Resettlement and change in land use	Land use and displacement	Nature	Negative
			Component value	Major
			Intensity	Major
			Extent	Local
			Duration	Permanent
			Importance impact	Major

Mitigation measures
• Those affected will be compensated according to the official compensation rates. • The acquisition of the land and private properties will be carried out in accordance with Rwanda Expropriation law for public interests, PS5, World Bank OP 4.12, RAP and entitlement framework for the project. • Early identification of entitlement for compensation planning of Resettlement and Rehabilitation Action Plan to compensate the losses. • The compensation will be paid in accordance with Expropriation law and will decided by competent authorities. • All the affected people will be compensated as per regulation before commencement of Construction works • Restoration of land after gas and power plant construction must be done. • Landowners should be assisted in their efforts to improve their livelihoods and standards of living or at least to restore these standards in real terms. It may therefore be necessary to offer them support upon losing their land. This being a government responsibility.

Residual impact: If the mitigation measures are implemented risk related to loss of land will be minimized. The component value will stay at major and sensitivity or intensity will be reduced to moderate resulting to minor significance.

HIV/AIDs and Sexually Transmitted Diseases

This section examines concerns for public health related to HIV/AIDS and other sexually transmitted diseases (STDs) as well as the project's potential impacts on available healthcare facilities in the project area.

The spread of HIV/AIDS is identified as a key public health issue. Concern has been expressed that the already high prevalence of HIV found in Rwanda could be exacerbated by an influx of construction workers, truck drivers and prostitutes attracted by workers. Additionally, an influx of construction workers from other regions could introduce new diseases to the local population or increase the local incidence of existing diseases – a particular concern with sexually transmitted diseases, such as HIV/AIDS.

Impact will however not be very significant as the developer has no intention to construct on site a worker camp. Given the Site's close proximity to Rubavu, which is a sizeable town with large amounts of accommodation, Symbion does not anticipate building construction camps. Once the manning curves are complete during detailed design, various accommodation sourcing strategies will be explored with the goals of both minimizing costs to the Project and maximizing benefits to the local community.

Consistent with this strategy, local buses will be used to transport the workforce to and from the Site each shift. A local catering company will be employed to provide meals during the working day at a mess hall onsite (including at the Kitraco work front).

Sexually Transmitted Diseases	
Criteria	Assessment
Nature	Negative

Component value	Major
Intensity	Major
Extent	Local
Duration	Long term
Significance of impact	Major

Mitigation measures

- The risk of an increase in STDs/HIV/AIDS should be minimized as a result of the project. For this reason, the following human resource management policies should be adopted:
- The construction camp will meet the reasonable requirements of the workers only;
- Unskilled workers (laborers) will be recruited, as available, from the local population and particularly from the villages affected by the project. Therefore, these workers will remain resident in their homes, which will reduce the need for accommodation for single male unskilled workers;
- An STD/HIV/AIDS awareness and prevention program will be incorporated into the training package for all workers;
- In coordination with the Rwandan health authorities, a program designed specifically for promoting safe sex for the construction workforce will be developed, condoms will be made available to workers upon request; and,
- An STD/HIV/AIDS awareness and prevention program will be delivered to local communities. The measures outlined above are intended to minimize the risk of an increase in STDs as a result of the project.

Residual impact: Following implementation of mitigation measures risk related to HIV/AIDs and Sexually Transmitted Diseases will be minimized. The component value will stay at major and sensitivity or intensity will be reduced to minor resulting to minor significance.

6.2.2 Gas and power plants operation

The major sources of potential environmental impacts that could result from operation of the plant include air quality impacts from fuel combustion, and surface water quality impacts from the discharge of low volume wastes from plant operation and storm water handling. Other potential sources of environmental impacts include small volume of solid and hazardous waste generation.

6.2.2.1 Physical Environment

- **GHGs emissions**

Gas emissions will result from combustion of fuel gas and fuel oil for power generation only enough for black starts generator operations and when required. The emissions to the ambient air from combustion include sulfur dioxide (SO2), nitrogen oxides (NOx), carbon monoxide (CO), carbon dioxide (CO2), particulate matter of less than 10 microns (PM10) and total suspended particulate (TSP). The particulates may contain small amounts of trace metals that

are also emitted to the atmosphere. The generation facility will be designed to comply with European Union (EU) and World Bank ambient air quality impact limits.
Rwanda does not currently have emission standards for thermal power plants. The applicable emission standards are summarized in the table below.
The emission of unburned hydrocarbons and NOx may contribute to ground-level ozone formation. These pollutants participate in atmospheric reactions to form ozone in the presence of sunlight.

Modelling air emissions
The assessment of impacts to air quality, was done considering the requirements of the East Africa Standard- Air Quality Specification (EAS 751:2010 and the WHO/Air Quality Guidelines (IFC 2007), which provide guidance to financial institutions for managing environmental and social risk in project financing. The project site can be classified as rural and other residential area according to the East Africa Air Quality Standard.

Emission parameters
Atmospheric emissions associated with the proposed Lake Kivu Power generation plant would arise from seven Wartsilla engine generator sets (Wärtsilä 20V34SGC2), each with its own stack. All the individual stacks will be collected to one cluster. The stacks will be located as close to each other as practical possible and form one-stack construction for efficient plume rise.
Emission parameters as supplied by the proponent are as indicated below.

Table 24: Power plant design emission parameters

Stack Parameter	
Exit Temperature (°C)	393
Exhaust gas volume flow for each engine (m^3/s)	32.3
Exit diameter each stack (m)	1.2
Exit diameter -7 engines equivalent (m)	3.17
Stack Height (m)	28, 40, 50
Emission Rate- NOx (g/s)	3.7
Emission Rate- CO (g/s)	5.8

Project site base map compilation
The project area base map as developed from high resolution satellite imagery as primary geographic data source. Specifically, IKONOS 1-meter resolution images of the project area scene were used in ESRI ArcGIS software to capture the relevant man-made and natural features across the project spatial domain. The following geographic layers were digitized and overlaid on the site satellite image as part of the base map:

1. Settlements/institutions
2. Roads
3. Lake Kivu
4. Field noise data measurement sites

For the third dimension, National Aeronautics & Space Administration (NASA) Shuttle RADAR Topographic Mission (SRTM) digital elevation models were used in GIS software to interpolate the height topography across the project spatial extent (1.5km X 1.2km). The sea level height contours were generated and classified to illustrate the undulation of topography across the project area extent (see **Figure below**).

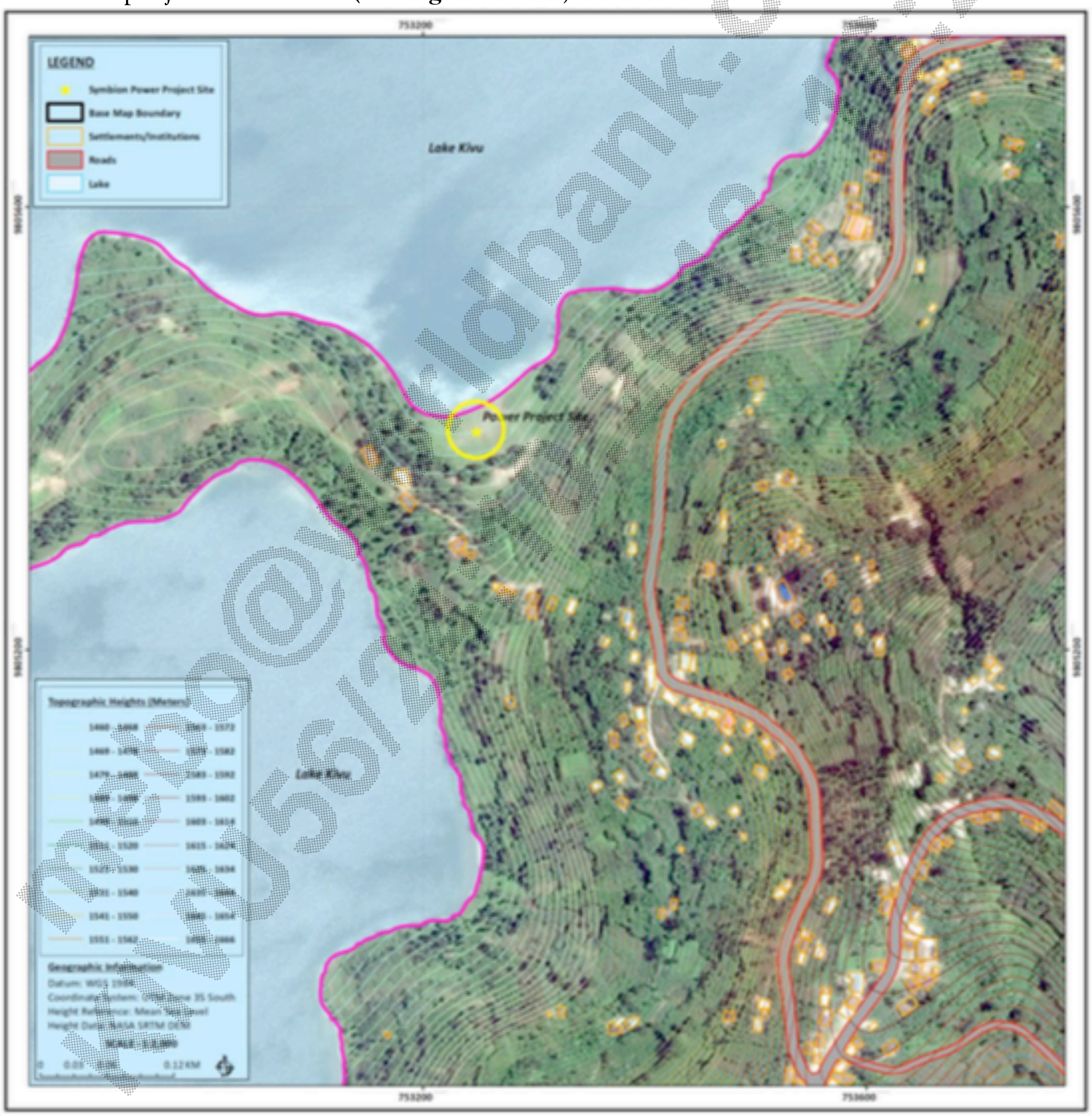


Figure 51: Project site base map
Source: ED&P, 2016

Dispersion Simulation domain definition

The dispersion of pollutants was modelled across an area covering 4.8 km by 4.8km centered in the proposed posed plant site. A uniform Cartesian network of receptors was adopted for pollutant concentration predictions. For this purpose, a total of 169 receptors across the modelling spatial domain were created with the parameters in the following table (see **Table below**).

The topography of the domain was generated as described in section 4.1.1.5 and figure 21.

Table 25: Pollutant concentration domain receptor grid definition

Grid	Size (Km)	Resolution (m)	No. of receptors
1	4.8 X 4.8	400	169

Wind roses

The model has been prepared with surface data schedules for one full year (temperature, wind speed and direction), considering in this case records from the period of January to December-2015 as the most appropriate for modeling of the dispersion of pollutants. Wind roses comprise 36 spokes, which represent the directions from which winds blew during a specific period. Annual wind rose is presented in section 4.1.1.2, figures 22 and 23 and annex 5. The prevailing direction of winds is SWW.

The colors used in the wind roses in the figures reflect the different categories of wind speeds and directions. Most of the duration, winds blew from SWW direction at 5.7-8.8 m/s.

Air Quality criteria used in the Assessment

The primary pollutants of concern for the Project with regards to air quality will be Oxides of Nitrogen generated during the operation phase of the gas power plant- most relevant parameters associated with methane gas plant are likely to be NOx and CO. The East Africa Air Quality Standard (EAS 751:2010) and WHO Ambient Air Quality Guidelines (WHO AAQG) (2005) were used.

The WHO air quality guidelines (AQGs) are intended for worldwide use but have been developed to support actions to achieve air quality that protects public health in different contexts. Air quality standards, on the other hand, are set by each country to protect the public health of their citizens and as such are an important component of national risk management and environmental policies. For particulate matter (NOx) WHO guidelines represent the levels where effects are very small, and should be considered as goals for the future. WHO has established Interim Targets (IT-1, 2 and 3), realizing that in many developing countries the WHO guideline cannot be met in the short term.

Table 26: Ambient air quality tolerance limits

Pollutant	Averaging Period	Limit (µg/m³)	Source
Oxides of Nitrogen (NOx)	Annual Average		
	Annual	60	EAS 751:2010*
	24-Hours	80	EAS 751:2010*
	Month	0.3ppm	EAS 751:2010*
	1-Hour	0.8ppm	EAS 751:2010*
	Instant	1.4ppm	EAS 751:2010*
Carbon monoxide (CO)	8-Hours	2,000	EAS 751:2010*
	1-Hour	4,000	EAS 751:2010*

Table 27: Air emission standards

Pollutant	Thermal generation Facility Emission Standard		Estimated Symbion Power Lake Kivu Ltd Power Plant emissions
	World Bank	European Union	
PM_{10}	$50mg/Nm^3$	$50mg/Nm^3$ (dry @ 3% O_2)	0.032 µg/m3 (as dry dust)
NO_X	2000 mg/Nm^3 (dry @ 15% O_2)	2000 mg/Nm^3 (dry @ 3% O_2)	100.45 µg/m3 (dry @ 5% vol O2)
SO_2	0.20TPDMW 2,000mg/Nm^3 (dry @ 3% O_2) (NA)	1,700mg/Nm^3 (dry @ 3% O_2) (NA)	0.012 µg/m3

Sources:
Word Bank pollution prevention and Abatement Handbook, Thermal power: Guidelines for New Plants-July 2008;
Directive 2001/180/EC of the European Parliament and the council of 23 October 2001 on the limitation of emissions of certain pollutants into the air from large combustion plants.

Table 28: WHO Ambient guidelines

Pollutant	Averaging Period	Limit (µg/m³)	Source
NO_x	1-hour	200	WHO, 2005
	Annual	40	WHO, 2005
CO	10-Minutes	500	WHO, 2005

Simulating air quality results

One of the potential impacts of a gas and power would be impact on air quality as intallations and machines are operated to process gas and generate power.

Source input parameters

The proponent design of the power plant suggested there will be seven engines with a stacked exhaust system bundled as one source. The coordinates of the proposed power plant site were adopted for the point stack source. The following are the supplied design and other source parameters that were used as input in the air quality modelling for NOx.

Table 29: Pollutant concentration modelling source and location parameters

Sources Location Parameters	
X Coordinate	753244
Y Coordinate	9805392
Base Elevation	1466
Sources Release Parameters	
Exit Temperature (˚C)	393.0
Stack Inside Diameter (m)	3.17[1]
NOx Emission Rate (g/s)	12.95
NOx Flow Rate (m^3/s)	226.1[2]
CO Emission Rate (g/s)	40.6
CO Flow Rate (m^3/s)	226.1

Dispersion models simulate ground level ambient concentrations as a function of source configurations, emission strengths and meteorological characteristics, thus providing a tool to ascertain the spatial and temporal patterns in the ground level pollutants concentration arising from various source emissions. Dispersion modelling was undertaken to determine the highest hourly, highest daily and the annual average ground level concentrations. The averaging periods were selected to facilitate comparisons of the simulated ground level concentrations to the ambient air quality criteria set out in the East African Standard (EAS 751:2010) and the IFC World Bank Environmental Health & Safety Guidelines of 2007.
The results are provided in tabular form as discrete values simulated at the sensitive receptor locations. The isopleths are used selectively to present areas of exceedance of the assessment criteria. Ground level concentration isopleths presented the figures below depict interpolated values from the concentrations simulated by AERMOD 9.2.0 for each of the receptor grid points specified.

Project area simulated/Predicted CO ,NOx and SO2 concentration levels

Table 30: Simulated ambient NOx concentrations results

ID	Description	Stack Height (Meters)	Highest 1-hour ($\mu g/m^3$)	Highest 24-hour ($\mu g/m^3$)	Highest Monthly ($\mu g/m^3$)	Annual Average ($\mu g/m^3$)
RP 01	Peninsular Base	28	9.8	0.95	0.30	0.23
		40	7.0	0.79	0.28	0.22
		50	4.1	0.68	0.26	0.21
RP 02	RP 02	28	20	3.71	1.91	1.60
		40	15.8	2.98	1.59	1.20
		50	14	2.43	1.34	1.10
RP 03	Peninsular Top	28	8	1.24	0.51	0.38
		40	7	1.21	0.47	0.37
		50	6.4	1.02	0.46	0.34
RP 04	Homestead	28	7.5	1.48	0.62	0.43
		40	6.2	1.22	0.50	0.37
		50	6.1	1.09	0.44	0.32
RP 05	Homestead	28	18.6	3.48	0.98	0.63
		40	14.6	2.64	0.76	0.54
		50	11.1	2.11	0.63	0.46
RP 06	Bible Methodist Church	28	84.3	8.08	2.72	1.89
		40	69.2	6.39	2.22	1.56
		50	52.1	4.98	1.81	1.28
RP 07	RP 07	28	70.5	6.60	2.15	1.48
		40	48.5	4.69	1.63	1.15
		50	27.9	3.15	1.23	0.93
RP 08	Residential Home	28	16.4	3.14	1.03	0.56
		40	13.4	2.58	0.90	0.50
		50	10.1	2.19	0.78	0.45
RP 09	Rusisiro Shopping Centre	28	21.4	5.73	1.55	0.80
		40	16.8	4.41	1.28	0.69
		50	12.8	3.38	1.03	0.59
	Criteria		**200***	**80**	**-**	**60**

ID	Description	Stack Height (Meters)	Highest 1-hour Average (µg/m³)	Highest 8-hour Average (µg/m³)
RP 01	Peninsular Base	28	30.0	3.0
		40	22	2.5
		50	14	2.1
RP 02	RP 02	28	62	11.6
		40	48	9.4
		50	37	7.7
RP 03	Peninsular Top	28	27	3.9
		40	21	3.6
		50	19	3.1
RP 04	Homestead	28	25	4.6
		40	18	3.8
		50	17	3.4
RP 05	Homestead	28	58	11.0
		40	45	8.4
		50	36	6.7
RP 06	Bible Methodist Church	28	264	25.2
		40	216	20.0
		50	165	16.0
RP 07	RP 07	28	221	21.0
		40	153	14.9
		50	87	9.7
RP 08	Residential Home	28	51	10.0
		40	42	8.3
		50	33	6.7
RP 09	Rusisiro Shopping Centre	28	67	18.0
		40	51	14.1
		50	40	10.5
	Criteria	-	**4,000**	**2,000**

1. Predicted Ground Level Carbon Monoxide plots

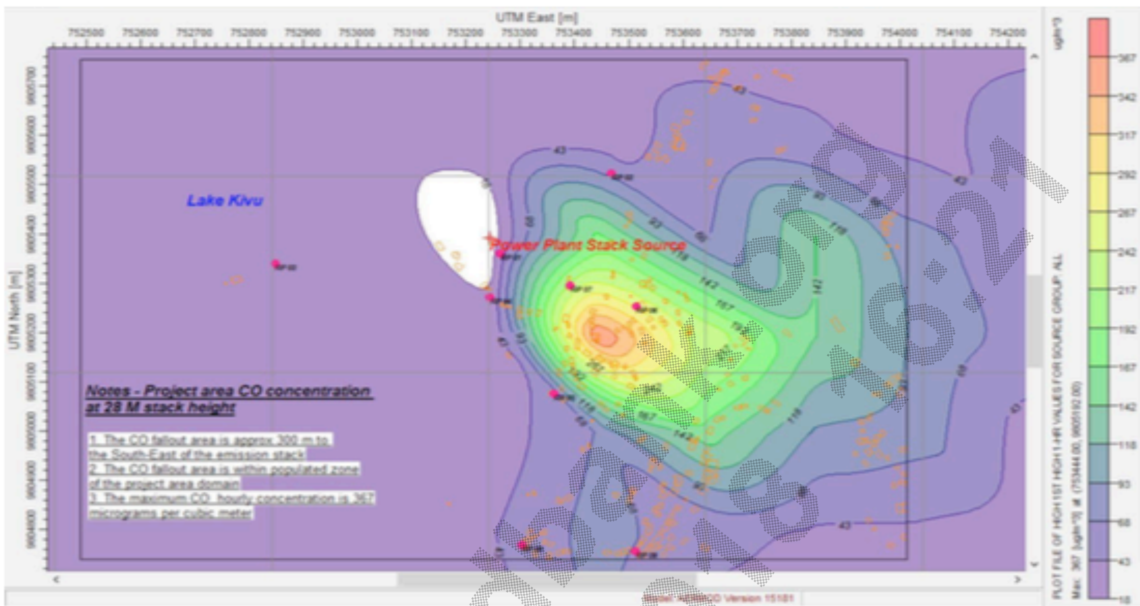


Figure 6: Predicted project area CO hourly concentration levels at 28m stack height

Discussion/Results

1. The CO fallout area is approximately 300 meters to the South-East of the power plant emission stack position.
2. The CO fallout area is within the populated zone of the project area domain.
3. The maximum CO hourly concentration at 28-meter stack height is 367µg/m³.
4. The predicated maximum ambient ground level concentration is below the East Africa Standards of 4,000 µg/m³

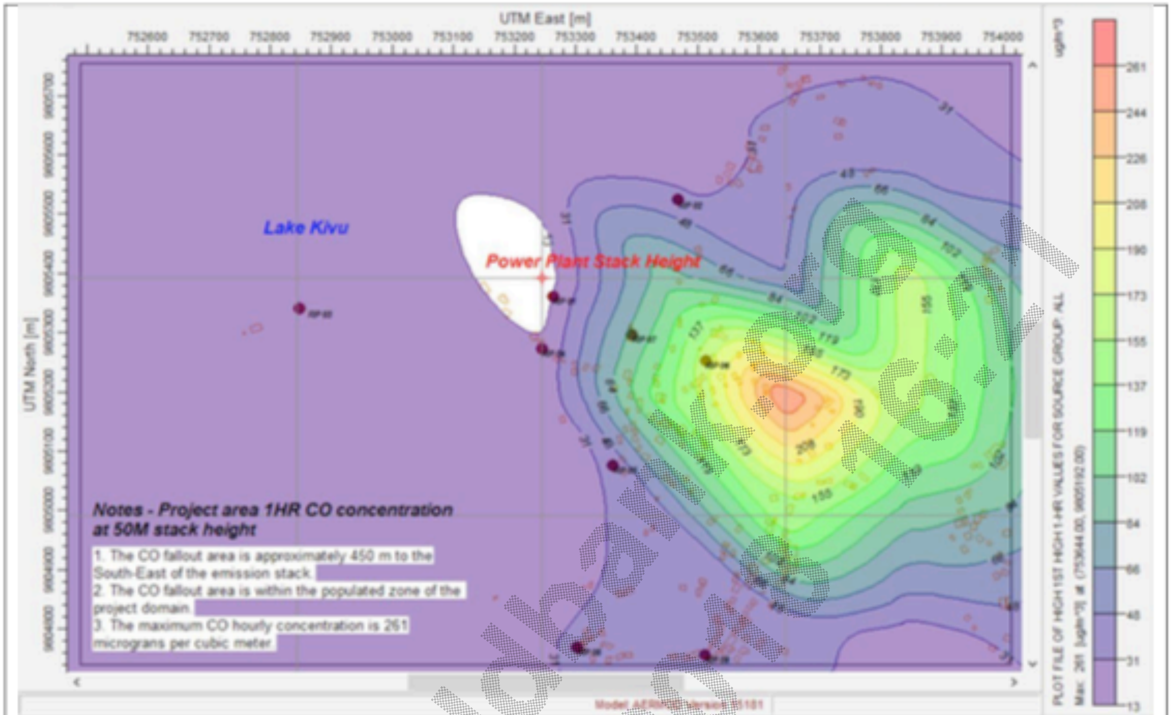


Figure 8: Predicted project area CO hourly concentration levels at 50m stack height

Discussion/Results

1. The CO fallout area is approximately 450 meters to the South-East of the power plant emission stack position.
2. The CO fallout area is within the populated zone of the project area domain.
3. The maximum CO hourly concentration at 28-meter stack height is 261µg/m^3.This is below the East African Air Quality Standard of 4,000µg/m^3

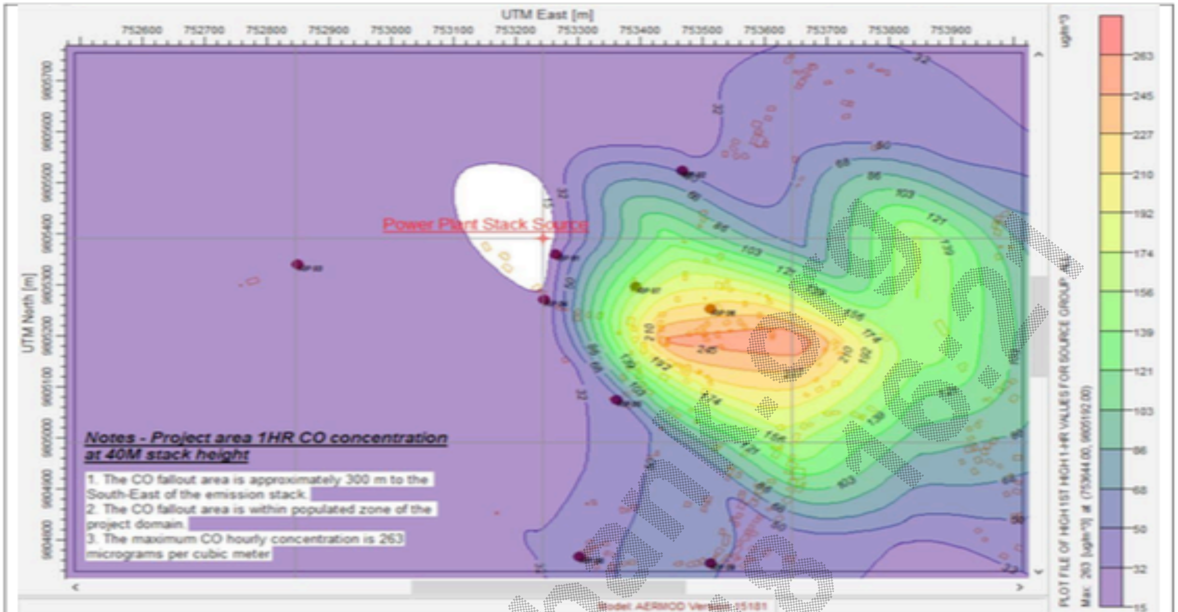


Figure 7: Predicted project area CO hourly concentration levels at 40m stack height

Discussion/Results

1. The CO fallout area is approximately 300 meters to the South-East of the power plant emission stack position.
2. The CO fallout area is within the populated zone of the project area domain.
3. The maximum CO hourly concentration at 40-meter stack height is 263μg/m³. This is below the East African Air Quality Standards of 4,000μg/m³

Carbon Monoxide (CO) Concentration

The highest predicted 1-hour and 8-hour CO concentrations at a sensitive receptor were 317.0 (μg/m³) and 28.8 (μg/m³) respectively, which is 3% the East African Standard ambient air quality limit value of 10,000 (μg/m³) and 5,000(μg/m³) respectively for the same period. The air quality assessment is forecast mainly SO_2, NOx and Respirable particulates that are associated thermal power plants. Further, carbon monoxide/ carbon dioxide emissions do not affect ambient air quality. The impact of CO_2 emissions is mainly on a global scale/issue with global warming.

2. Predicted Ground Level Nitrogen oxide (NOx) results

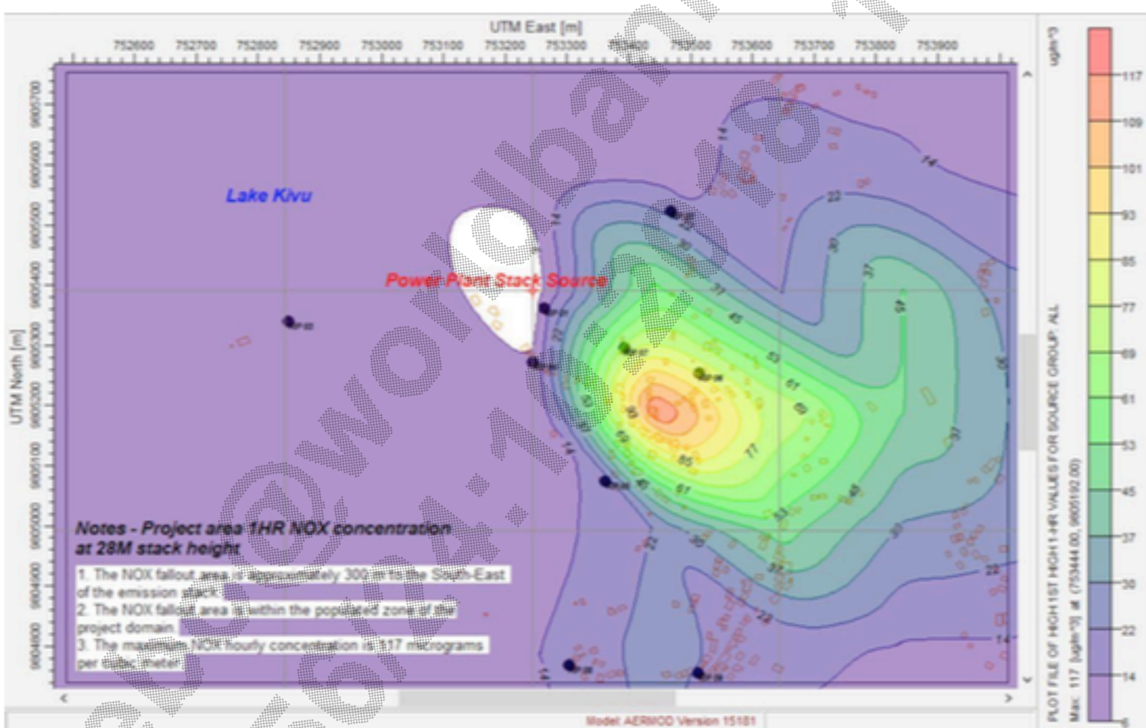


Figure 12: Predicted project area NOX hourly concentration levels at 28m stack height

Discussion/Results

1. The NOx fallout area is approximately 300 meters to the South-East of the power plant emission stack position.
2. The NOx fallout area is within the populated zone of the project area domain.
3. The maximum NOx hourly concentration at 28-meter stack height is 117µg/m^3.
4. This predicted ground level is in compliance with the WHO (IFC) Guideline value of 200µg/m^3

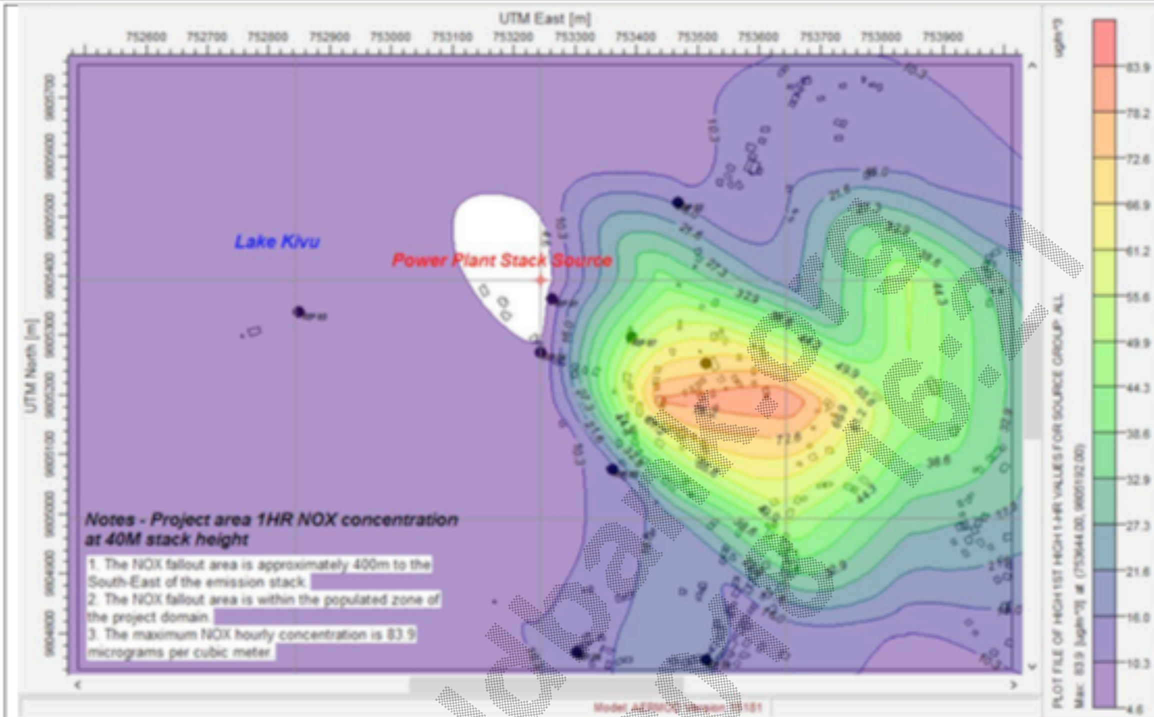


Figure 13: Predicted project area NOX hourly concentration levels at 40m stack height

Discussion/Results

1. The NOx fallout area is approximately 400 meters to the South-East of the power plant emission stack position.
2. The NOx fallout area is within the populated zone of the project area domain.
3. The maximum NOx hourly concentration at 40-meter stack height is 83.9µg/m^3. The predicated concentration is in compliance with the WHO (IFC) Guideline value of 200µg/m^3

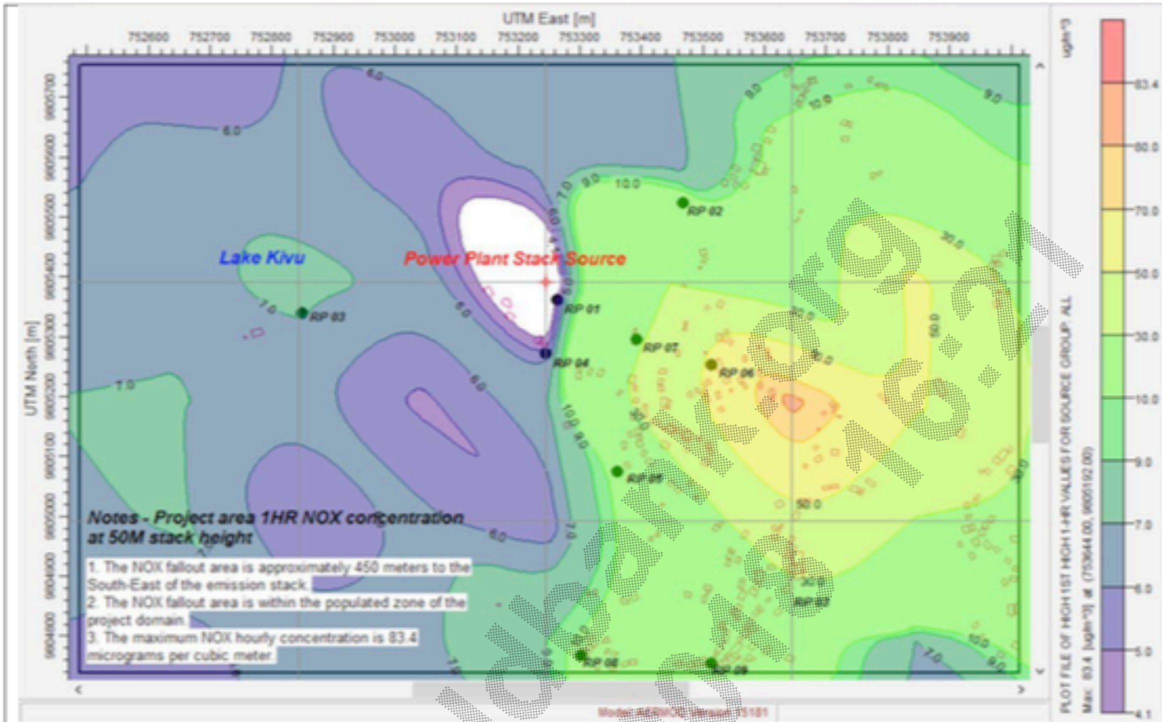


Figure 14: Predicted project area NOX hourly concentration levels at 50m stack height

Discussion/Results

1. The NOx fallout area is approximately 450 meters to the South-East of the power plant emission stack position.
2. The NOx fallout area is within the populated zone of the project area domain.
3. The maximum NOx hourly concentration at 50-meter stack height is 83.4μg/m³.
4. The ground level concentration is in compliance with the WHO (IFC) Guideline value of 200μg/m³

Oxides of Nitrogen (NOx) Concentration

The highest predicted average daily NOx concentrations at a sensitive receptor ranged from 6.51 to 9.19 (μg/m³) which is well within the daily EAS ambient air quality limit value of 150 (μg/m³). The IFC/World Bank Group Stipulates a maximum hourly limit of 200 (μg/m³) against the maximum simulated result of 117 (μg/m³) over the same period. It should also be noted that these predicted levels are based on a scenario where the existing power plant is on full load and all the three gensets are operating continuously over the 24hours with no reduction in load during the day. This represents the worst- case scenario as the gensets are not normally on continuous load and operation load always vary during the day depending on the dispatch requirements. The highest predicted annual average concentration ranged from 1.90- 3.10 (μg/m³) against the stipulated limit values of 40 (μg/m³) and 80 (μg/m³) for the IFC and EAS respectively.

3. Predicted Ground Level Sulfur Dioxide (SO2) results

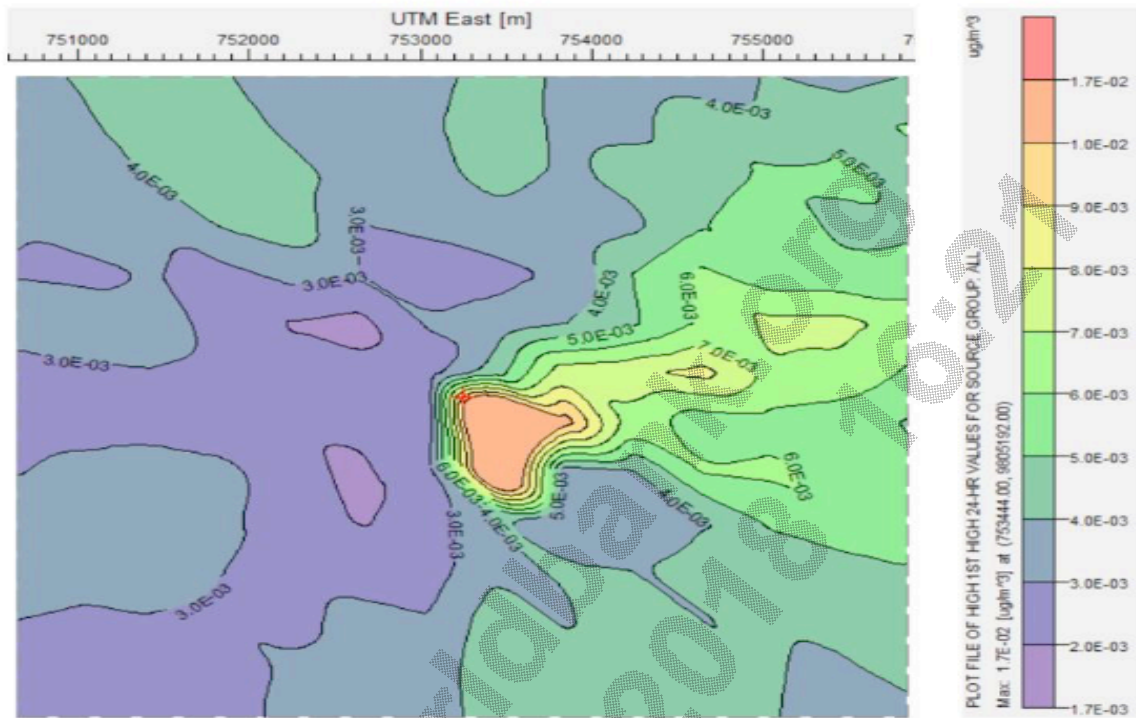


Figure 21:Ground Level 24hr SO_2 Concentration -28M Stack

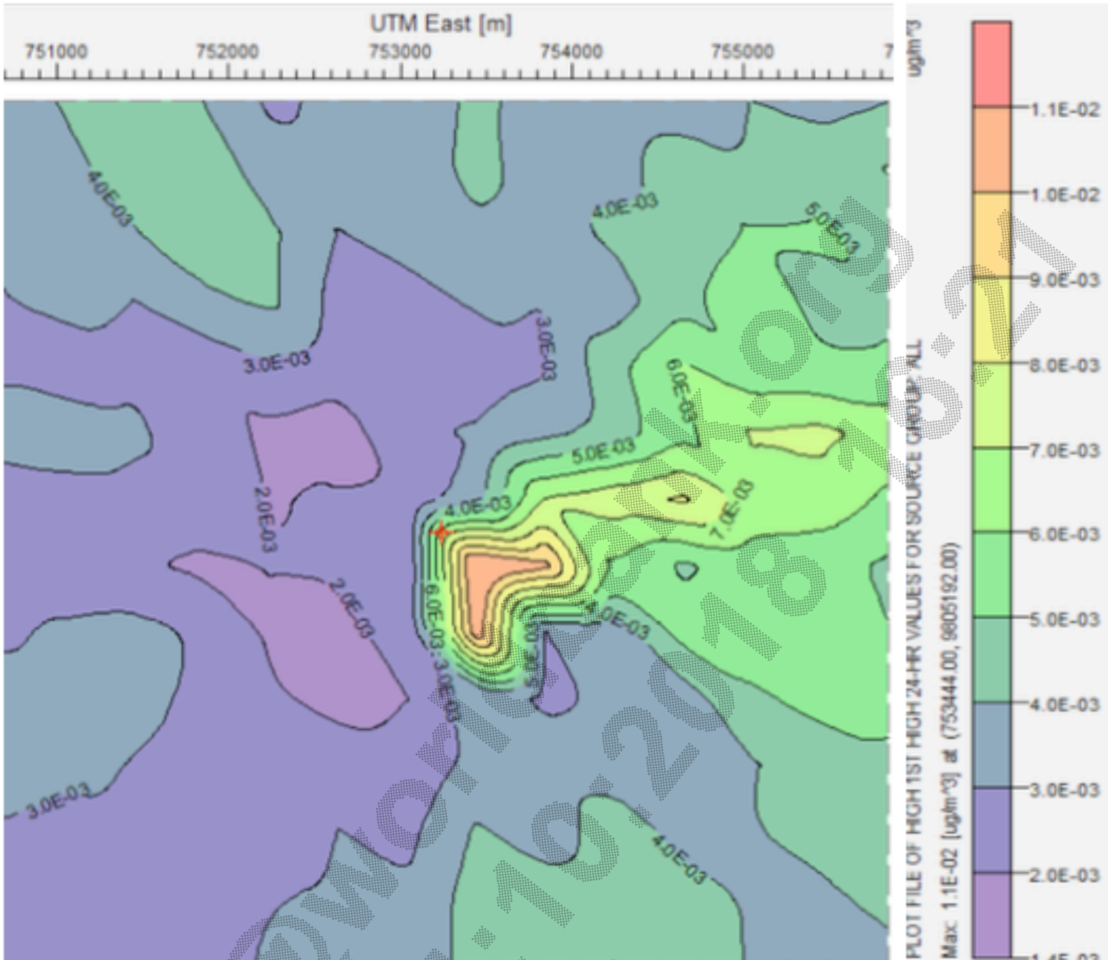


Figure 23: Ground Level 24h SO2 Concentration- 40M Stack

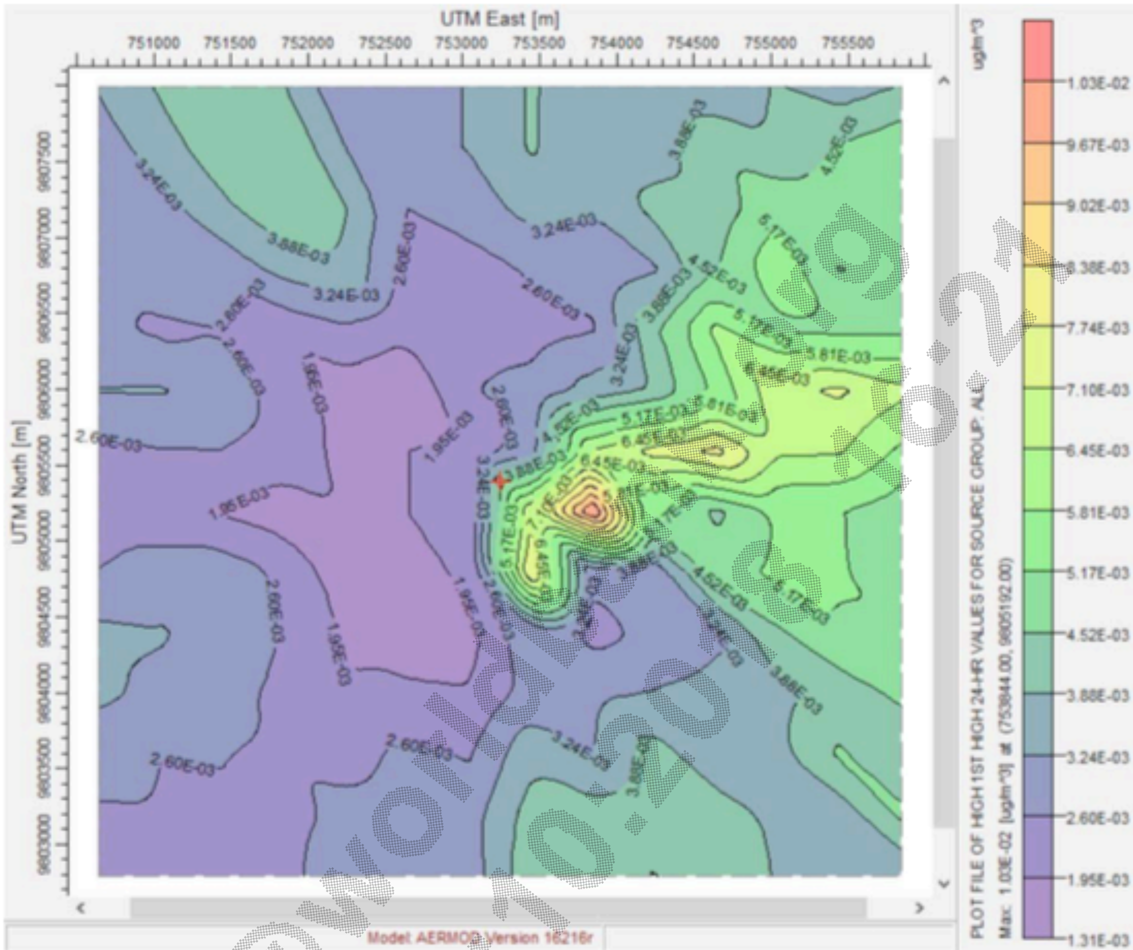


***Figure 25:** Ground level 24h SO2 Concentration -50M Stack*

The highest predicted average daily SO_2 concentrations at a sensitive receptor were 0.017 (µg/m³) which is well below the East African Standard daily ambient air quality limit value of 125 (µg/m³). IFC does not have limit values for SO_2 for gas fired thermal power plants. It should be noted that these predicted levels are based on a scenario where the existing power plant is on full load and all the three gensets are operating continuously over the 24hours with no reduction in load during the day. This represents the worst- case scenario as the gensets are not normally on continuous load and operation load always vary during the day depending on the dispatch demand.

The highest predicted annual average concentration was 0.0029 (µg/m³) with stack height of 28M. This predicted long-term ground level concentration seems negligible as compared to the EAS specified limit value of 80 (µg/m³).

Respirable Particulates (PM10) Concentration

The highest predicted average daily PM10 concentrations at a sensitive receptor were 0.042 (µg/m³) which is well below the daily EAS ambient air quality limit value of 150 (µg/m³) and the IFC Guide Value of 50 (µg/m³) with a 28M stack. The highest annual ground level concentration with the same stack parameters recorded was 0.007(µg/m³) against the stipulated limits of 20 (µg/m³) and 70(µg/m³) for both IFC and EAS respectively. It should also be noted that these predicted levels are based on a scenario where the existing power plant is on full load and all the seven gensets are operating continuously over the 24hours with no reduction in load during the day. This represents the worst- case scenario as the gensets are not normally on continuous load and operation load always vary during the day depending on the dispatch requirements.

1. Summary of simulated maximum ground level pollution concentration against EAS Limit Values 28M Stack Height

Pollutant	Sulphur Dioxide (µg/m³)		Oxides of Nitrogen (µg/m³)		Respirable Particulates (µg/m³)		Carbon Dioxide (µg/m³)	
	24hr av.	Annual av.	24hr av.	Annual av.	24hr av.	Annual av.	1hr	8hr
Maximum	0.017	0.0029	9.19	3.10	0.042	0.007	317.0	28.8
Limit Value	125	80	150	80	150	70	10,000	5,000

*Source: East African Air Quality Standard (EAS 751:2010)

2. Summary of simulated maximum ground level pollution concentration against EAS Limit Values 40M Stack Height

Pollutant	Sulphur Dioxide (µg/m³)		Oxides of Nitrogen (µg/m³)		Respirable Particulates (µg/m³)		Carbon Monoxide (µg/m³)	
	24hr av.	Annual av.	24hr av.	Annual av.	24hr av.	Annual av.	1hr	8hr
Maximum	0.011	0.0027	6.82	2.42	0.028	0.0066	283.0	21.1
Limit Value	125	80	150	80	150	70	10,000	5,000

*Source: East African Air Quality Standard (EAS 751:2010)

3. Summary of simulated maximum ground level pollution concentration against EAS Limit Values 50M Stack Height

Pollutant	Sulphur Dioxide (µg/m³)		Oxides of Nitrogen (µg/m³)		Respirable Particulates (µg/m³)		Carbon Monoxide (µg/m³)	
	24hr av.	Annual av.	24hr av.	Annual av.	24hr av.	Annual av.	1hr	8hr
Maximum	0.010	0.0025	6.51	1.90	0.025	0.0061	261.0	20.4
Limit Value	125	80	150	80	150	70	10,000	5,000

*Source: East African Air Quality Standard (EAS 751:2010)

4. Summary of simulated maximum ground level pollution concentration against IFC Limit Values 28M Stack Height

Pollutant	Sulphur Dioxide (µg/m³)		Oxides of Nitrogen (µg/m³)		Respirable Particulates (µg/m³)		Carbon Monoxide (µg/m³)	
	24hr av.	Annual av.	1hr av.	Annual av.	24hr av.	Annual av.	1hr	8hr
Maximum	0.017	0.0029	117.0	3.10	0.042	0.007	317.0	28.8
Limit Value	na	20	200	40	50	20	na	na

*Source: East African Air Quality Standard (EAS 751:2010)

5. Summary of simulated maximum ground level pollution concentration against IFC Limit Values 40M Stack Height

Pollutant	Sulphur Dioxide (µg/m³)		Oxides of Nitrogen (µg/m³)		Respirable Particulates (µg/m³)		Carbon Monoxide (µg/m³)	
	24hr av.	Annual av.	1 hr av.	Annual av.	24hr av.	Annual av.	1hr	8hr
Maximum	0.011	0.0027	83.90	2.42	0.028	0.0066	283.0	21.1
Limit Value	na	20	200	40	50	20	na	na

*Source: East African Air Quality Standard (EAS 751:2010)

6. Summary of simulated maximum ground level pollution concentration against IFC Limit Values 50M Stack Height

Pollutant	Sulphur Dioxide (µg/m³)		Oxides of Nitrogen (µg/m³)		Respirable Particulates (µg/m³)		Carbon Monoxide (µg/m³)	
	24hr av.	Annual av.	1hr av.	Annual av.	24hr av.	Annual av.	1hr	8hr
Maximum	0.010	0.0025	-	1.90	0.025	0.0061	261.0	20.4
Limit Value	na	20	200	40	50	20	na	na

*Source: East African Air Quality Standard (EAS 751:2010)

The same simulations were performed for CO, NOx and SO2 monthly concentration levels at 28m, 40m and 50m stack height (see annex 6). Based on the findings of the predicted results, it can be concluded that no violation of the regulatory limits is expected within the modeling domain and the area of influence of the proposed project. The values are below the tolerance limits and guideline values stipulated in the East Africa Air Quality Standard (EAS 751:2010) and WHO (IFC 2007) respectively.
However, it is recommended that the simulated values be validated by way of actual measurements during the operational phase of the plant.

It can also be concluded that the plant will have no impact on local ozone levels and a small, if any, impact on far-field ozone concentrations. Rwanda has ratified the Kyoto Protocol. As a

consequence, Rwanda has an obligation to work to avert the human activities, which are believed to cause changes to the atmosphere and climate.
Because of limited data and the lack of nearby emission sources, the facility should be considered the baseline facility and the only emission source during monitoring.

GHGs emissions	
Criteria	Assessment
Nature	Negative
Component value	Major
Intensity	Moderate
Extent	Local
Duration	Long term
Significance of impact	Moderate

<u>Mitigation measures</u>

- Gas washing will control, CO, NOx and SO2 emissions.
- Particulate emissions can be reduced through good combustion control to minimize the products of incomplete combustion.
- Gas extraction plants must be designed so that they do not emit methane and hydrogen sulphide to the atmosphere during regular operations. Limited, short-term emissions are acceptable when plant safety considerations are paramount.

Residual impact: If the mitigation measures are implemented, risk related to GHGs emissions will be minimized. The component value will stay at major and sensitivity or intensity will be reduced to minor resulting to minor significance.

- **Ambient Air Quality**

The World Bank air quality standards for thermal generating plants also require that the project cannot result in reducing the air quality to the "poor air quality" classification for NOx, SO2, and PM10. Table 9 lists the *Handbook* criteria for air quality classifications.

Table 31: Air quality classifications

Pollutant	Moderate Air Quality ($\mu g/m^3$)	Poor Air Quality ($\mu g/m^3$)
NO_X	> 100	> 200
PM_{10}	> 50	> 100
SO_2	> 50	> 100

Ambient air quality may be affected by air pollutant emissions such as SO_2 and NO_X. There is no regular monitoring system for air pollution in Rwanda. Therefore, it is difficult to find accurate baseline data regarding background air quality. No industries exist that contribute to the ambient pollutant concentrations. Data from monitoring during operation of the power plant will be considered baseline data (with option of getting baseline data from air quality monitoring before exploitation).

As per the project design characteristics, the gas plant is to supply a very clean methane stream to the Power Plant and the gensets proposed for this Project have very high efficiency (over 46%). The proposed Wärtsilä 34SG engines will be associated with low peak combustion temperature and so the emissions of nitrogen oxides (NOx) will be relatively low. In these conditions, no emissions of particulate matter or sulphur dioxide (SO2) and the fuel gas from the gas plant will have no sulphurs or particulates. There are no expected significant releases of CO2 emissions considering the main source will only be methane and no other longer chain alkanes.

Based on the situation of settlement around the project site (higher altitude compared to the site), one can assume the height of the plume from the exhaust stack will be of moderate concern.

Ambient Air Quality	
Criteria	Assessment
Nature	Negative
Component value	Moderate
Intensity	Moderate
Extent	Local
Duration	Short term
Significance of impact	Major

Mitigation measures

- The concentrations of pollutants in the exhaust gases are a function of engine characteristics, operating practices and fuel compositions. Poor operating or maintenance procedures can increase pollutants emissions. A comprehensive maintenance, monitoring and reporting system will be followed throughout the operational life of the power plant.
- Symbion will ensure emissions do not result in pollutant concentrations that reach or exceed relevant ambient quality guidelines and standards by applying national legislated standards, or in their absence, the current World Bank Air Quality Guidelines (table 24) or other internationally recognized sources.

Residual impact: Following implementation of mitigation measures, risk related to ambient air quality will be minimized. The component value will stay at moderate and sensitivity or intensity will be reduced to minor resulting to minor significance.

➢ **Noise and vibrations**

The individual gas engines will produce up to 120 dB at 1 m. The project-related environmental noise impact will be at its peak during the operational phase and will be limited to the areas immediately surrounding operational activities. Cumulative predicted noise levels from the Project and individual Project activities should be below the target PSL of 50 dBA Leq nighttime and 70 dBA Leq daytime for permanent facilities, at a distance of 1000m.

Cumulative Effects Assessment

There are no other activities around the power plant site, producing noise. Therefore, the Project will not result in significant increases in noise levels from the baseline conditions. It is predicted that the Project will result in significant (operation phase) effects on environmental noise. Given that the effects are expected to be significant and to be localized, appropriate mitigation measures and monitoring are required.

Noise pollution	
Criteria	Assessment
Nature	Negative
Component value	Moderate
Intensity	Moderate
Extent	Local
Duration	Long term
Significance of impact	High

Mitigation measures

- It is anticipated that the normal work practices and equipment maintenance practices will keep noise within the assumed levels of this analysis. Equipment maintenance practices (e.g., mufflers on diesel engines, adherence to occupational health and safety procedures) are recommended.
- The developer must consider optimizing the plant layout and orient away from nearest receptors elements emitting high noise levels.
- The developer must consider optimizing wall structures of the power plant
- Use silencers to attenuate the charge air intake and exhaust outlet

Simulation of noise emissions is required to determine the exclusion zone and populations to be relocated from the surroundings if need be and before operation of the gas and power plants.

Residual impact: Following implementation of mitigation measures, risk related to noise and vibrations will be minimized. The component value will stay at moderate and sensitivity or intensity will be reduced to minor resulting to minor significance.

- **Solid waste management**

The IFC General EHS Guidelines 1.6 (Waste Management) state: "Wastes may [...] be defined as "hazardous" by local regulations or international conventions, based on the origin of the waste and its inclusion on hazardous waste lists, or based on its characteristics."

The revised Waste Framework Directive (rWFD) (2008/98/EC) provides, for Europe, a definition of hazardous waste as, "a waste possessing one or more of the 15 hazardous properties set out in Annex III of the rWFD," and requires the correct management and regulation of such waste. Waste classification is based on the European List of Waste

(Commission Decision 2000/532/EC) (formerly the European Waste Catalogue) and the 'hazardous properties' provided in Annex III of the rWFD.

There are three categories of entries in the List of Waste (LoW):

a. Absolute entries are automatically considered hazardous;

b. Mirror entries are linked entries that are considered hazardous (or non- hazardous) if they contain "dangerous substances" and the waste possesses properties specified in Regulation (EC) 1272/2008 on the classification, labelling and packaging of substances and mixtures; and

c Non-Hazardous entries are neither absolute or mirror entries.

For the purposes of this Section, as relevant, consideration is given to the LoW for the determination of the nature of identified wastes (given that specific compositions are not currently known).

Project Wastes

A feature of the gas turbine technology, on which the proposed Project is based, is that the discharges to the land are minimal and would be restricted to the following:

a Used gas turbine air intake filters (typically replaced annually);

b Separated oil / sludge from oil / water separators;

e Sludge from the Light Crude Oil (LCO) pre-treatment equipment;

f Used oil or chemical containers; and

g General office waste.

For the wastes identified above, the relevant entries of the LoW are presented in Table below.

These wastes would be returned to the original supplier where possible or removed by an appropriate licensed contractor for disposal in an appropriate manner.

Disposal of all such solid wastes will be carried out under a service agreement between the Project, REMA and Rubavu District.

A hazardous waste disposal agreement will be signed with Rubavu District and all such disposals will be monitored by SPLKL.

Table 32: European list of waste (LoW)

Project Waste	LoW Waste Code	Waste Descriptor	Type of Entry
General Office Waste	20 03 01	Mixed municipal waste	Non-Hazardous
Demineralisation Media	19 08 06*	Saturated or spent ion exchange resins	Absolute Hazardous
	19 08 08*	Membrane system waste containing heavy metals	Mirror Hazardous
Oily Water	13 05 02*	Sludges from oil/water separators	Absolute Hazardous
	13 05 03*	Interceptor sludges	Absolute Hazardous
	13 05 04*	Oil from oil/water separators	Absolute Hazardous
	13 05 05*	Oily water from oil/water separators	Absolute Hazardous
Waste Mineral Oil	12 01 06*	Mineral-based machining oils containing halogens (except emulsions and solutions)	Absolute Hazardous
	12 01 07*	Mineral-based machining oils free of halogens (except emulsions and solutions)	Absolute Hazardous
Compressor Wash Fluid	20 01 29*	Detergents containing dangerous substances	Mirror Hazardous
	20 01 30	Detergents other than those mentioned in 20 01 29	Mirror Non-Hazardous

Project Waste	LoW Waste Code	Waste Descriptor	Type of Entry
Used Antifreeze	16 01 14*	Antifreeze fluids containing dangerous substances	Mirror Hazardous
	16 01 15	Antifreeze fluids other than those mentioned in 16 01 14	Mirror Non-Hazardous
Laboratory Waste	16 05 06*	Laboratory chemicals, consisting of or containing dangerous substances, including mixtures of laboratory chemicals	Mirror Hazardous
Discarded Chemicals	16 05 07*	Discarded inorganic chemicals consisting of or containing dangerous substances	Mirror Hazardous
	16 05 08*	Discarded organic chemicals consisting of or containing dangerous substances	Mirror Hazardous
	16 05 09	Discarded chemicals other than those mentioned in 16 05 06, 16 05 07 or 16 05 08	Mirror Non-Hazardous
Scrap Metal	02 01 10	Waste metal	Non-Hazardous

Solid waste management	
Criteria	Assessment
Nature	Negative
Component value	Major
Intensity	Major
Extent	Local
Duration	Long term
Significance of impact	Major

Mitigation measures

- Using the above LoW (or any updates to the list, based on the continuous monitoring and review cycle that will form part of the implementation of the ESMP), all wastes will be assessed and classified such that hazardous and non-hazardous wastes are segregated and appropriate storage / containment facilities are provided to minimize the environmental, health and safety risks associated with the storage of such substances.

- Secondary containment will be considered for the pre-disposal storage of all potential wastes for the Project. The implementation of such measures will be as appropriate to the potential magnitude of impact associated with loss to the environment.

- For hazardous substances (e.g. sludge from the LCO pre-treatment), specific management measures will be prepared and relevant and suitable training will be provided to employees that will include:

- Appropriate sharing of information regarding compatibility of substances;
- All storage will be clearly labelled to allow for the easy and rapid identification of the substances contained therein and the associated environmental risks;
- Control of access to areas where hazardous substances will be stored;
- Where necessary, emergency procedures in the event of a release will be prominently displayed in the relevant areas of the site;
- All hazardous substances will be stored above ground; and
- Frequent inspections of all storage facilities.

Monitoring

- In order to verify adherence to the documented procedures regarding storage and handling of waste and that these procedures are fit for purpose, SPLKL will frequently monitor, review and update (as necessary) all policies and training. SPLKL/ its contactor will:
- Undertake regular visual inspections of the integrity of all waste storage facilities; Require regular audits of waste segregation and collection / removal practices; Prepare periodic reports (to be made available to relevant stakeholders, on request)

regarding the generated amounts of each waste and measures taken to reduce waste;

- Maintain records of all waste removed from site and details of the ultimate disposal methods; and
- Undertake periodic monitoring off all waste removal contractors used by the Project.

Disposal

- Disposal of all solid wastes will be carried out under a service agreement between the Project, the VRA Takoradi Power Plants and the Shama District Assembly Waste Management Department.
- A hazardous waste disposal agreement will be signed with the Shama District Assembly and all such disposals will be monitored by SPLKL

Residual impact: If proposed mitigation measures are implemented, risk related to solid waste management will be minimized. The component value will stay at major and sensitivity or intensity will be reduced to minor resulting to minor significance.

- **Wastewater Discharge**

Discharge of sewage can cause some water quality degradation in the vicinity of the gas and power plants. The low flow wastewater discharge from the Project's SWTP is expected to meet international discharge criteria and is not expected to significantly impact the surrounding aquatic environment.

Wastewater discharges will be designed to comply with the World Bank standards as per the table below. There will be no adverse impacts on the Lake Kivu water from the wastewater of the plant.

Table 33: World Bank General Effluent guidelines

Parameter	Effluent guidelines (mg/l, except for the pH)
Ph	6-9
BOD_5	50
COD	250
Oil and Grease	10
Total residual chlorine	0.2
Temperature increase	<3%
TSS	50
Coliform	400 MPN/100ml
Sulfide	1.0
P	2
F	20
Cl	0.2
N	NH_3: 10

Wastewater Discharge

Criteria	Assessment
Nature	Negative
Component value	Moderate
Intensity	Moderate
Extent	Local
Duration	Short term
Significance of impact	Major

Mitigation measures

- A sewage treatment facility will be provided on site. It is recommended that appropriate on site procedures concerning wastewater treatment are included in the normal operation instructions of the gas and power plants.
- Oily sludge from all water treatment stages should be collected to a sludge tank, and the tank should be emptied regularly. The sludge and oily water should be transported by truck to be disposed of according to national regulations or practices, as currently there is no existing centralised sewerage system in Rubavu.

Residual impact: If proposed mitigation measures are implemented, risk related to wastewater discharge will be minimized. The component value will stay at moderate and sensitivity or intensity will be reduced to minor resulting to minor significance.

➢ **Gas exploitation and depletion**

The quantity of methane that will be extracted annually with Symbion Power Lake Kivu Ltd Project is averaging 313.1 M Nm^3 per year when we reach the second phase. The project will reverse the rate of accumulation of methane and carbon dioxide in the Lake Kivu. This should not be considered as depletion or an unsustainable exploitation of the resources as it could probably increase the rate of accumulation of reserves. Whether the maximum production rate should be limited to 120 M Nm3 per year (amount generated per year by different processes in the lake, this will depend on the policy set by the government as regard to Lake Kivu gas resources.

Gas exploitation and depletion	
Criteria	Assessment
Nature	Negative
Component value	Minor
Intensity	Minor
Extent	Regional
Duration	Long term
Significance of impact	Minor

Mitigation measures

- Compliance with the MPs will ensure medium scale gas exploitation project doesn't deplete the gas reserve from Lake Kivu

Residual impact: If proposed mitigation measures are implemented, risk related to gas exploitation and depletion will be minimized. The component value will stay at minor and sensitivity or intensity will be reduced to minor resulting to minor significance.

Offshore installations

6.2.3 Construction off-shore

6.2.3.1 Physical environment

- **Handling, Storage and Disposal of Hazardous Materials**

Materials used during construction may result in the generation of hazardous wastes including cleaning solvents, paints, and spent lubricating oils. Other potentially hazardous materials include the fuel for the construction equipment.

Handling Storage and Disposal of Hazardous Materials	
Criteria	Assessment
Nature	Negative
Component value	Major
Intensity	Major
Extent	Regional
Duration	Long term
Significance of impact	Major

Mitigation measures

- Hazardous wastes and other waste should be collected, stored separately and disposed of appropriately. Care should be taken to prevent accidental oil and chemical spills into Lake Kivu.

Residual impact: If proposed mitigation measures are implemented, risk related to Handling Storage and Disposal of Hazardous Materials will be minimized. The component value will stay at major and sensitivity or intensity will be reduced to minor resulting to minor significance.

6.2.3.2 Biological environment

Impacts on Fisheries

Lake Kivu has fishery resources can be negatively impacted by the construction of gas extraction facilities, the proposed marine landing site and installation of the pipeline. These fish species could be impacted by reduced water quality and blocking of migratory path.

Impacts on Fisheries	
Criteria	Assessment
Nature	Negative
Component value	Moderate
Intensity	Moderate
Extent	Local
Duration	Long term
Significance of impact	Moderate

Mitigation measures
• Water construction activities associated with the pipelines should be performed during periods of low fishing activity. • Experienced marine contractors with environmental procedures in place should be contracted to perform all work.

Residual impact: If proposed mitigation measures are implemented, risk related to impact on fisheries will be minimized. The component value will stay at moderate and sensitivity or intensity will be reduced to minor resulting to minor significance.

6.2.4 Operation off-shore

6.2.4.1 Physical environment

➢ **Wastewater management**

During operation of the offshore facility, a few amount of wastewater will be generated offshore. The waste cannot be discharged to the Lake as it may cause pollution with cumulative impact.

It was estimated 3.9m3 of wastewater can be daily generated from the site.

Solid Waste Management	
Criteria	Assessment
Nature	Negative
Component value	Moderate
Intensity	Moderate
Extent	Local
Duration	Short term
Significance of impact	Moderate

Mitigation measures
• Wastewater generated during the operation phase of the gas extraction and treatment facilities will be collected, transported and disposed of from the onshore installations. • A small sewerage system will ensure that no human waste enters the lake.

Residual impact: If proposed mitigation measures are implemented, risk related to wastewater management will be minimized. The component value will stay at moderate and sensitivity or intensity will be reduced to minor resulting to minor significance.

➢ **Solid Waste Management**

The project could generate a certain amount of solid waste during the operation phase of the offshore facility. But only small amounts of waste will be produced such as packaging material and containers, empty oil canisters, rags, excess materials, etc.

Waste oil will be collected and disposed of in the same manner as the waste lubricating oil produced from the functioning of power plant.

Solid Waste Management	
Criteria	Assessment
Nature	Negative
Component value	Minor
Intensity	Medium
Extent	Local
Duration	Short term
Significance of impact	Minor

Mitigation measures

To mitigate negative environmental impacts that could be caused by solid waste, the following are recommended:

- The services of a reliable, certified contractor should be engaged for the timely and efficient removal of solid waste to an approved site;
- Solid wastes such as packaging material, containers, discarded and/or damaged pipe and drill bits, and leftover construction materials are to be taken ashore and appropriately recycled, reused or disposed.

Residual impact: If proposed mitigation measures are implemented, risk related to **solid waste management** will be minimized. The component value will stay at minor and sensitivity or intensity will be reduced to minor resulting to minor significance.

➢ **Eutrophication**

Eutrophication is an increase in chemical nutrients, compounds containing nitrogen or phosphorus in an ecosystem, and may occur on land or in water. However, the term is often used to mean the resultant increase in the ecosystem's primary productivity (excessive plant growth and decay), and further effects including lack of oxygen and severe reductions in water quality, fish, and other animal populations.

When human activity increases on lake banks and or on the lake catchment area, larger amounts of nutrients may be introduced in the waters inducing "anthropogenic" eutrophication.

Eutrophication with over-fertilization due to waste products may have a limited impact on the excess bloom sometimes vanished when the wind rises. The wind is then filling the superficial layers with oxygen balancing the trophic phenomenon. Lake Kivu is oligotrophic (an ecosystem or environment with very low nutrient levels).

Eutrophication	
Criteria	Assessment
Nature	Negative
Component value	Moderate
Intensity	Moderate
Extent	Local
Duration	Long term

Significance of impact	Moderate

Mitigation measures

- Although eutrophication will have a limited impact on Lake Kivu, not shallow with points of depth 405m, regular monitoring of H_2S concentrations is necessary to follow up the phenomenon happening in the Lake Kivu as Symbion Power Lake Kivu Ltd facility adds sulphur in the biozone.

Residual impact: If proposed mitigation measures are implemented, risk related to eutrophication will be minimized. The component value will stay at moderate and sensitivity or intensity will be reduced to minor resulting to minor significance.

➢ **Noise pollution**

The Project-related environmental noise impact will be at its peak during the operational phase and will be limited to the areas immediately surrounding operational activities. There are no possible cumulative predicted noise levels; there is no activity in the lake part that will be surrounding the project. Moreover, the platforms will be located at a distance of around 5 to 7kms form the lake shore. The Project will not result in significant increases in noise levels from the baseline conditions.

However, it is important that the noise is a kept at the minimum for the safety of Symbion Power Lake Kivu Ltd project employees.

Noise pollution	
Criteria	Assessment
Nature	Negative
Component value	Moderate
Intensity	Moderate
Extent	Local
Duration	Short term
Significance of impact	Moderate

Mitigation measures

- There is a requirement for a follow-up noise monitoring program for this Project. It is anticipated that the normal work practices and equipment maintenance practices will keep noise within the assumed levels of this analysis.

Residual impact: If proposed mitigation measures are implemented, risk related to noise pollution will be minimized. The component value will stay at moderate and sensitivity or intensity will be reduced to minor resulting to minor significance.

➢ **Risk of fire**

Fire safety concerns have resulted in numerous regulations limiting the materials that may be used in the design and construction of barges. As methane gas is combustible, special attention is needed during the operation phase of the barges. Fire is an environmental concern not only for large chemical process plants but also for gas extraction and treatment facilities. It is mandatory for employees and management to carry out fire risk assessments regardless of the size and complexity of their premises. Fire safety is similar in complexity to hazards within the particular workplace.

Risk of fire	
Criteria	Assessment
Nature	Negative
Component value	Major
Intensity	Major
Extent	Local
Duration	Short term
Significance of impact	High

Mitigation measures

- Plant personnel should be thoroughly trained in the emergency procedures required for fires, explosions or accidental spills.
- Each barge will have fire and gas detection systems and fire suppression systems.
- Platform evacuations must be posted;
- Cooperative liaison should be established between the platform officials and the firefighting authority for emergency planning and the exchange of information of mutual interest;
- Should a fire occur in the vicinity of the storage area, workers should maintain a cooling water spray over the outside of the containers to guard against overheating;
- Fires on the barge(s) should be extinguished with the usual firefighting equipment;
- Fire drills and inspections should be regularly scheduled;
- Plant personnel should be trained in the use of firefighting equipment and diving when necessary.

Residual impact: If proposed mitigation measures are implemented, risk related to fire during operation will be minimized. The component value will stay at major and sensitivity or intensity will be reduced to minor resulting to minor significance.

➢ **Lake Kivu ecosystem and stability**

An exceptionally strong heat input into the deep waters of the lake is necessary to trigger a gas outburst from Lake Kivu. This could only be caused by an eruption of magma into the deep waters of the lake.

Exploitation of the methane contained in the lake would lower the risk of a gas outburst from the lake. It was recommended that the methane be exploited, provided that it is done in a way that the ecosystem of the lake is not seriously affected. It is very important that the concentrations of dissolved gases are regularly monitored. Measurements indicate that the concentration of dissolved CH_4 has increased by 15-20% within the last 30 years. If the concentrations continue to increase in this way, they could approach saturation within less than a century, and the risk of a catastrophic gas outburst would steadily grow. It is therefore recommended that the gas concentrations in Lake Kivu be measured every 10 years, such that an approaching saturation would be observed in time for preemptive measures.

Symbion Power Lake Kivu Ltd is proposing to produce 50MW through two different phases. Start with an operating pilot of 14MW that will be upscaled to 3 additional units of 42MW each. With the relative confinement of the gases methane and CO_2 below the lower discontinuity the general concern is that eventually the solution of methane becomes supersaturated and would come to be released as bubbles on large scale across the lake. In doing so CO_2 would also be stripped into the bubbles and would contribute the greater volume to the released gas. Once the conditions have built up, this can happen very quickly and result in a physical-chemical rupturing of the stability layers of the lake. Such catastrophic events have been recorded at Lake Manoun in 1984 and Lake Nyos in 1986. Both are volcanic crater lakes in Cameroon. In Lake Nyos the initial eruption in a localized layer broke down other layers, which allowed more gas bearing layers to become involved as the density structure was destabilized. Large volumes of gas were released but in the aftermath one of the most obvious effects in the lake of the breakdown in structure was the bright ochre colour of the surface water. This was caused by the ejection of bottom water with its high-reduced iron content being oxidised to an iron-hydroxide floc. Such potential catastrophic events have been predicted for Lake Kivu. In the Cameroon lakes, where considerable volumes of CO_2 still remained.

It is also important to know during the considered exploitation of Lake Kivu gas, whether the water exchanges through the different stratified layers could modify the balance between the layers and more particularly if the water returned to the lake and sinking to a deeper layer after the methane extraction, could modify the presently identified natural migration of the nutrients through the layers.

The main effect on the Lake's ecosystem and stability is likely to arise from discharging the degassed and scrubbing water (to -280m and -60 m respectively) below the Lake biozone, which extends down to about –50m to –70m.

It may be pointed out here, that the possibility of a huge gas outburst from Lake Kivu where all or most of the gas dissolved in it would reach the atmosphere, is very low, but that the impact of such an event on the whole Lake Kivu region of about 10 000 km2 could be very strong. Naturally the possibility for small or medium gas outbursts with limited consequences is higher. Therefore, not only the monitoring of this lake but also an exploitation of its gas and thus its controlled degassing is absolutely necessary, as pointed out by Tietze since 1974. A systematic overview about these problems including the equilibrium and stability of Lake Kivu is given in Tietze (2000).

Dr Klaus Tietze and all reassure that once the plant is operating within the recommended technical and administrative operating characteristics (MPs), for example water density, gas concentration, flows and velocities the influence on the stratification is manageable as consequence the exploitation of the gas deposit will not be harmful to the stratification.

Exploitation of gas reserves will have a long run and positive effect on Lake Kivu by transforming the risky lake into a living one.
Impact on the ecosystem may be the following:
- Adding the gas to energy sources portfolio of Rwanda will reduce existing deforestation and thus will prevent further soil erosion and improve air quality.
- Degassing the lake will significantly will reduce the future risk of an uncontrolled gas eruption.
Lake Kivu gas extraction has to be controlled and monitored and must be carried out with consideration of the volume of gas extracted.

Lake Kivu Ecosystem and Stability	
Criteria	Assessment
Nature	Negative
Component value	High
Intensity	High
Extent	Regional
Duration	Long term
Significance of impact	High

Mitigation measures

- The natural buildup of methane gas will trigger a catastrophic event, which could occur within the next 50-200 years, and so the only viable solution is to extract and utilize the methane.
- The developer will ensure a very close monitoring of Lake Kivu's stability. To monitor the risk of a disruptive change, the absolute proportions of dissolved CH_4, CO_2 and H_2S per liter of water dissolved in the bottom layers will be periodically measured.
- Water Extraction and re-injection must be done horizontally to facilitate laminar flow. The same volumes of water are to be re-injected at the new density level caused by gas extraction, which is equivalent to the water at 280m. According to the first Mandatory Technical Requirement (MTR1), this must also be horizontal since a vertical re-injection may physically breakdown stratification[34].

- (MTR2) **Washing water must be withdrawn from the biozone, and returned to the lower part of the biozone**. Washing water will be taken from a depth of 20m and discharged at 60 m, which is close to the bottom of the biozone. Both of these depths conform to the mandatory requirements and provide sufficient mitigation to reduce the impact.

- **Water used to dilute degassed water before re-injection must not be taken from the**

[34] Expert Working Group 2006

biozone. The degassed water is not diluted prior to discharge so the design meets the requirements of MTR3.

- When extracting gas-rich water from the LRZ, and re-injecting degassed water into the URZ, the goal is to displace gas-rich water from the top of the upper zone and replace it with gas-poor water in order to reduce the risk of premature, uncontrolled gas eruption from the lake. (MTR5)
- If degassing water is re-injected into the main gradient layer, it must re-stratify below the lower limits 10 percent of the main density gradient (now at about 270m depth). It is intended to match the density of the re-injection water with the density of the receiving water at the return depth of 280m (MTR6).

- MTR8: Methane gas produced offshore must not be transported to the shore in a way that might affect the surface use of the lake, or risk a gas outburst below the biozone.

Gas export

- **MTR10:** The design of the deep-water extraction systems must prevent any self-sustaining gas lift effect should a pipe-break or rupture occur (e.g. in a riser pipe or return water line). There will be butterfly valves in the gas extraction loop to turn down or turn off the rate of flow of water and hence the rate of extraction of gas. Furthermore, the riser will be constructed of a double barrier. If the inner barrier (wall) fails gas will leak into the annulus between the two barriers causing a pressure increase in the annulus. Annulus pressure will be monitored to detect any pressure increase. The technology is adopted for standard oil and gas well practice offshore and on land. These measures should be sufficient to respond to emergency shutdown, thus reducing the risk and the associated impact. The design fully complies with MTR9 and reduces the impact to minor.
- **MTR10: Plant design must ensure zero gaseous emissions during normal operations**. The plant is designed to either utilize the extracted gases (methane) or to return the unwanted gases (CO_2 and H_2S) in the wash water to the base of the biozone. concentrations of gases will be well below saturation concentrations. Therefore, the dissolved gases are expected to remain in solution during normal operation. The exception is H_2S which will be oxidised to sulphate. There should be no air emissions under normal operation although there will be intermittent flaring for short periods e.g. during start up or when needed for safety reasons. This is normal practice and is not usually counted as operational emissions.
- The design fully complies with MTR10 and reduces the impact to minor.
- The wash water will be taken from a depth of -20m and the Management Guidelines state that the wash water should be taken from less oxygenated water from a depth of around -40m. Recognising the Expert Committee's concern about the potentially explosive nature of using wash water from the oxygenated level of the biozone about -40m, the design has been developed to operate the wash tower at 100 psig, which is higher than the lake's hydrostatic head pressure at 20 metres. This means that there will not be any free oxygen in the tower. This in combination with the high levels of $C0_2$ being introduced by the raw gas

stream will prevent an explosive atmosphere from forming.

- **Water extraction pipes should be located and designed to minimize potential problems with the intake of sediments**. The lakebed is known to consist of loose unconsolidated sediments with a significant proportion of clayey particles. Thus it might actually be quite difficult to determine the actual depth of the lakebed, particularly if the sediments are flocculants. Lakebed surveys will be undertaken and these will provide more robust data upon which to base the depth of the raw water riser.

Residual impact: If proposed mitigation measures are implemented, risk related to lake ecosystem and stability will be minimized. The component value will stay at high and sensitivity or intensity will be reduced to minor resulting to minor significance. However, cumulative impacts are possible due to other developments extracting gas from the Lake Kivu. An overall monitoring of Lake Kivu and specific monitoring at the plant site are required as per the Technical Mandatory Requirements (TMRs). Disturbance of the lake ecosystem and stability by natural disasters is also a possibility with a very weak probability.

- **Carbon dioxide (CO_2) management.**

The presence of the gas, mostly dissolved carbon dioxide and methane represents a considerable hazard. The lake gas outburst susceptibly is linked to the gas concentrations in deep layers.

As mentioned earlier, no expected higher chain carbon such as propane, it is only methane that is to be extracted from the Lake. The mixture of the extracted gas and water will be processed to increase the content of CH_4. There won't be significant releases of carbon monoxide. CO_2 emissions will be essentially related to the amount of CO_2 in the fuel gas as well as the genset efficiency. Of some concern will be the height of the plume from the exhaust stack. With the Power Plant located at the base of a cliff, and with people resident at the top of the cliff, it might be technically very difficult to ensure that the plume does not impact those people.

Risk related to carbon dioxide management	
Criteria	Assessment
Nature	Negative
Component value	Major
Intensity	Major
Extent	Regional
Duration	Long term
Significance of impact	High

Mitigation measures

- The management of the amount of carbon dioxide in the lake must balance the need to remove it for safety reasons with the need to maintain sufficient concentrations for sustaining lake stratification and gas lift forces for extraction operations.

- The degassed water must be re-injected and remain at the lower margin of the main density gradient (at -270 m in 2004). Meeting this objective will involve controlling the degassed water density through its CO_2 content (minimum 50 % removal), and sizing the plant to avoid short-circuiting between the re-injection and extraction points
- The amount of any gas released into the atmosphere must not be such as to result in atmospheric concentrations that would harm any person within the facility, or harm or cause a nuisance to any person nearby.

Residual impact: If the mitigation measures are implemented, risk related to CO2 management will be minimized. The component value will stay at major and sensitivity or intensity will be reduced to minor resulting to minor significance. However, gas outburst is not only related to the project activities, it can be caused by natural hazards or volcanoes eruptions although the probability of this to occur is almost uncertain.

➢ **Water quality**

A very small amount of hydrocarbons will be stored on the platform, mainly lubricants and a small amount of diesel for the emergency generator. These will be carefully contained in accordance with normal industry practice to prevent any hydrocarbon leaks into the lake. Although the barge will not normally be manned, a toilet will be provided for the use of maintenance and security personal. Sewerage will either be treated on the barge or brought back to shore for treatment, but will not be released into the lake.

In addition, if large volumes escape the water is very dense and will sink rapidly thereby producing a wider mixing and destabilization of the continuity layers.

Water quality	
Criteria	Assessment
Nature	Negative
Component value	Moderate
Intensity	Moderate
Extent	Local
Duration	Short term
Significance of impact	Major

<u>Mitigation measures</u>

- Measures must be taken to prevent leakages particularly bearing in mind the corrosive nature of the water to the engineering components.
- Regular monitoring of Lake water parameters so to ensure the impact of the project on water quality is within acceptable limits

6.2.4.2 Biological environment

➢ **Loss of fish**

As yet, this is an unknown factor. It is not anticipated that there will be a major change in fisheries. However, monitoring is required.

An exclusion zone of 100 m around each of the new barges will be maintained (subject to designation by the naval authorities). While this will reduce the area that can be fished by 6.28 hectares, this is a small portion of the overall area of the lake that is fished. Moreover, the positive benefit to fish by creating a marine habitat where fishing is not present may increase local fish populations (as has been seen at the Kivuwatt and KP1 existing platforms), thereby increasing the fish stocks in the lake. In consideration of these two factors, any negative impacts to fishing from maintenance of the exclusion zones are considered negligible.

It is however advised that the returning wash water should be discharged at the base of the biozone to minimize the risk of coming into contact with fish. This has been interpreted in the project design as re-injection at -80m. Since these waters are already deprived of oxygen they would encourage H_2S gas to remain in solution for longer or at least until the wind induced mixing occurs to refresh the oxygen. Monitoring of water quality in fisheries will be undertaken to assess the extent of any impacts that might occur and allow further mitigation measures to be developed.

6.2.4.3 Socio-economic environment

Health and Public safety

Extraction of methane gas from Lake Kivu has double benefit. It reduces the risks of gas outburst, but it can also be used to produce electricity (plus many other potential uses) and contributes to the socio economic development of the region. However, inadequate extraction of methane gas with this Symbion gas to power project can have many negative effects on the lake and its environment. This includes dilution of the resources, destruction of the lake's environment and stability ...

In developing the gas resources of Lake Kivu, ensuring public safety (workers included) should be a primary concern.

Health and Public Safety	
Criteria	Assessment
Nature	Negative
Component value	Major
Intensity	Major
Extent	Local
Duration	Long term
Significance of impact	Major

Mitigation measures

The following mitigation measures should be implemented by both the gas extraction company and the Monitoring Task Force:

- The total relative gas partial pressure must be monitored at all levels in the lake to reduce the risk of dangerous, uncontrolled gas outbursts;
- The overall density gradient of the lake, mainly determined by the salt content, must

not be significantly diminished;

- The management of the amount of carbon dioxide in the lake must balance between the need to remove it for safety reasons and the need to maintain it in sufficient concentrations to sustain the lake's stratification and the gas lift forces for extraction operations;
- The management of density gradient levels (-90 m and -260 m gradients) should aim to prevent the levels from rising. Managing the density gradient levels is essential to long-term safety and will help to preserve the feasibility of the gas extraction facilities that are essential for the continued removal of the gases accumulating in the lake;
- The Contractor and Symbion Power Lake Kivu Ltd will design an occupational health and safety program (OHSP), which addresses all aspects of worker health and safety relevant to the operation of gas plants. If deemed necessary by Symbion Power Lake Kivu Ltd, a facility-specific safety manual may be designed.

Residual impact: If the mitigation measures are implemented, risk related to Health and public safety will be minimized. The component value will stay at major and sensitivity or intensity will be reduced to minor resulting to minor significance.

6.3 Cumulative impacts

The cumulative impacts of this development fall into two categories. The first is associated with Phase 2 of Symbion gas to power project with generation of additional 42MW and the second refers to other developments of a similar nature. The principal impacts are associated with the stability of the lake.

Of particular importance is the effect of raising large volumes of water from the deep layers on the density gradient. The single GEF shows that the discharge of the degassed water remains in a very limited localized area. Given that the GEFs will be many kilometers apart they can in effect be considered as 4 separate entities and the de- gases water plumes will not mix with each other but remain as discrete plumes beneath each installation. Therefore, the stability of the density gradient should not be altered.

The risks associated with escaping gas and possible ruptures in the delivery pipeline, even if the maximum amount of gas were to escape simultaneously from all 4 GEFs (an extremely unlikely occurrence) the gas clouds would be unlikely to merge because they are so small and the resultant impact would be in the same order of magnitude as a single rupture.

Similarly, the effects in the wash water discharge are localized within the exclusion zone around each GEF and, there won't be no impact on the upper density layer from the discharge of the wash water, the stability of the lake should not be altered.

Finally, the impact of the wash water discharge on the water quality of the biozone is equally limited to the immediate vicinity of the GEF inside the exclusion zone and so the impact would be localized.

Details concerning other developments of a similar kind scheduled for development for either Rwanda or Democratic Republic of Congo (DRC) have to be considered. However, some assessment can be made with reference to the predicted volume of the resource expounded by the Expert Working Group. The Version 12c Guidelines actually provide for a 50:50 split of the resources between the Democratic People's Republic of Congo and the Republic of Rwanda. Furthermore, the IFC/World Bank (2009) report states that they anticipate that within 40-60 years most of the gas in the lake will have been harvested and so this suggests that the effect of the development on the resources is reasonable and that there will be sufficient additional resources available for exploitation by others.
Projects developed from any future concessions awarded will be required to assess cumulative impacts including the KP1 and KivuWatt Ltd development.

Cumulative impacts can also those to be generated with the construction of the access road. It was agreed through the Purchase Power Agreement (PPA) the construction will start once the road access construction activities have ended. This implies no cumulative impacts are expected for the road and power plant construction activities although very linked.

Access Road phases
GoR shall construct, make available and maintain the Access Road in three (3) stages, being:
Stage 1: sufficient access to allow heavy earthmoving machinery, concrete batching plant, semi-trailers carrying loaded 40" containers and 40-seat personnel buses to enter and exit the Site at the Site Entrance;
Stage 2: sufficient access to allow generating sets and step-up transformers to be delivered to Site at the Site entrance point; and
Stage 3: sufficient access for regular operational vehicular traffic including the vehicles described in Stage 1.

Stage 2 Access Road Requirements
For Stage 2, the Access Road shall have the following characteristics:
- Maximum uphill or downhill inclination of 11% or less;
- Asphalted or paved surface;
- Minimum width of not less than 6 m;
- Ground bearing pressure of not less than 2.5 tons per square metre;
- Turning radius of not less than 20.5; and
- Free height of not less than 6 m.

6.4 Project Decommissioning

6.4.1 Operational Life of the Facility

The contractual term of this project is 25 years from the entry into commercial service date for Phase 2. At this juncture in the life cycle analysis of the facility, it is difficult to predict the status of the Rwandan energy sector over such a long period. However, Symbion Power Lake

Kivu Ltd is contractually obligated to: operate the facility for the term of, and in accordance with, its PPA and GCA.

Closure/Decommissioning Plan

It would be very rare to abandon a gas extraction and electric power production project when that facility has operated for only one third of its design life. However, assuming that closure is required, decommissioning the facilities in a safe manner is a relatively simple procedure. The procedure depends on whether all traces of the project must be removed or whether the project only needs to be established as safe.

SPLKL obligations vis a vis Decommissioning are as follows:

Prior to the expiration of the agreements covering the gas concession and the production/sale of electrical energy to REG, Developer and the GoR shall negotiate in good faith to enter into a decommissioning agreement, which addresses the obligations of each with respect to decommissioning. Alternatively, the GoR is entitled to make separate arrangements for the decommissioning of the facilities at termination or expiration of the respective gas concession and power production agreements.

Expert Committee recommends that venting should follow extraction. Whenever the economically extractable quantities of gas have been all removed from the lake, the platforms should be used to vent the last parts of the gas from the bottom of the lake.

It is suggested, that any production platform located in the deepest parts of the lake should be made in such a way that at the end of its production life, it may be converted into a venting system functioning by auto-siphoning like in the lakes Nyos and Manoun, but in such a way that water degassed after venting still will be returned to the lake below the biozone.

6.4.2 Decommissioning Impacts

6.4.2.1 Positive impact

1. Lake stability

When comes time for decommissioning, extraction of the gas will have already reduced risks of eruption and the phase means there are no risks related to extraction of gas, transport through pipes that can destabilize the lake Stability. This is seen as a positive impact in terms of risks associated with the whole onshore and offshore installations.

Expert Committee recommended that venting pipes be put into the deeper part of the lake when extraction is complete to reduce the possibility of eruption.

6.4.2.2 Negative impact

The disassembling of the various extraction components should also be carried out in a way that potential impacts are minimised and wherever possible done on land in where contaminants can be fully contained

Care should be taken to ensure that there would be no leakages of accumulated waste products in the GEFs
Recommended measures are those of the construction phase for the same impact and whether it is onshore or offshore.

1. Air quality for the gas and power plants
Dust will be generated during demolition of the gas and power plants, machinery used on the site during the decommissioning Phase and traffic using roads in the vicinity of the development. Comparing with the construction Phase of the development, the impact of these emissions is expected to be very small.

2. Waste
The most significant waste generated in a decommissioning exercise is the marine growth from the jacket structures that it is preferable to be removed with water jets rather than onshore during the scrapping stage. The quantities of the organic matter will need to be estimated when the exact time of the abandonment is known.
Further to that, typical specific waste streams like: scrap metal, batteries, electrical and electronic equipment (WEEE) are expected, however those cannot be determined at this stage in terms of their quantities.
Specifically, with regards to the quantities of scrap metal (that is expected to be the bulk quantity) that will need to be managed will highly depend on the method of decommissioning (i.e. deep water disposal or towing onshore for dismantling).

3. Dust pollution
Dust twill be generated during demolition of the gas and power plants, machinery used on the site during the decommissioning Phase and traffic using roads in the vicinity of the development. Comparing with the construction Phase of the development, the impact of these emissions is expected to be very small.

7.0 Public Consultation and Disclosure Procedure

7.1 Introduction

This chapter describes the Public Consultation and Disclosure Plan (PCDP) activities that were undertaken during the preparation of the ESMP for the Symbion Power Lake Kivu Ltd Project.

The public was engaged in a dialogue concerning the project early on in the EIA process. The public consultation was thorough, transparent, and open. In accordance with the public Disclosure and Consultation Plan, direct invitations to interviews meetings were also sent to institutions and individuals.

Public consultation and disclosure procedures have been, and will continue to be, carried out in an ongoing, transparent, consistent, up-to-date and equitable manner. Relevant project information has been and will continue to be made accessible in a timely manner and in a language understandable to the groups being consulted. Information included as part of this process has been considered in the preparation of the ESMP Report and associated action plans.

Public participation and stakeholder engagement requirements will follow the IFC Good Practice Manual Doing Better Business through Effective Public Consultation and Disclosure (1998).

A Stakeholder Engagement Plan (SEP) has been prepared to record the methodology and outcomes of both the ESIA and wider project stakeholder engagement process. It will also set out proposals for future stakeholder engagement and participatory methods for communication and feedback.

7.2 Principles of consultation

Early and ongoing consultation, disclosure and meaningful stakeholder engagement is a key requirement for projects financed by IFC. The ESIA will be informed by the outcomes of consultation activities that will be guided by the SEP initially produced for the Project at the outset of the ESIA process.

The Project SEP has been designed to guide public consultation and disclosure activities up to the completion of the ESIA Report and through the construction and operational phases of the Project. It is a strategic document for planning meaningful and appropriate consultation with stakeholders that will be periodically updated as the Project progresses. Stakeholders are defined as persons and entities who are interested in, are affected by, or can affect the outcome of the Project. Specific objectives of the SEP are to provide a consultation strategy for the Project to:

- Ensure all legal and international finance requirements related to consultation are addressed

- Involve a full range of stakeholders in the planning of the Project to improve the acceptability of the Project design, implementation and monitoring
- Encourage an open dialogue with local communities and especially Project Affected Peoples (PAPs) where the Project is located
- Keep all interested and affected stakeholders informed of project progress

Provide a grievance mechanism for PAPs to raise complaints that are appropriately addressed by the Project. The SEP is underpinned by the principles that community engagement should be free of external manipulation, interference, coercion and intimidation and conducted on the basis of timely, relevant, understandable and accessible information. Consultation activities should always be well planned and based on principles of respectful and meaningful dialogue. Stakeholder engagement should be inclusive such that all members of society, including those from traditionally disadvantaged groups, have opportunities to participate. Regardless of personal characteristics, all community members will have equal opportunity to participate and influence decisions. As appropriate, special measures will be identified with regards to venue, content, literacy, and groupings to ensure that vulnerable stakeholders are included in stakeholder engagement activities.

7.3 Consultation requirements

7.3.1 National requirements

The GoR's Environmental Impact Assessment Regulations (2005) set out the minimum requirements for stakeholder consultation and engagement.

According to Article 47 of the EIA regulations, REMA should upon receipt of the developer's environmental impact report, arrange for a public hearing to take place within twenty (20) working days from the first day of public notification. At this public hearing relevant Lead Agencies, local governments, civil societies and concerned members of the public may comment on the environmental impact report and express views on the impact of the proposed development. The Authority shall cover all costs incidental to the public hearing. Article 48 further classifies all projects under Impact Level III to be subjected to a public hearing prior to the decision-making process.

7.3.2 IFC Consultation requirements

Public consultation, disclosure and stakeholder engagement are key requirements of the IFC's Policy and Performance Standards on Social and Environmental Sustainability (January 1, 2012).

The eight IFC Performance Standards (PS) are applicable to private sector projects in emerging markets. Each PS has specific consultation requirements and these are embedded in the general requirements specified in Performance Standard 1: Social and Environmental Assessment and Management Systems. These requirements specifically refer to the need for and means of achieving community engagement, disclosure of relevant project information, appropriate consultation processes and grievance mechanisms throughout the Project lifecycle. The requirements for stakeholder engagement in projects are:

- Start as early as possible in the project cycle
- Continue throughout the life of the project
- Be free of external manipulation, interference, coercion, or intimidation
- Where applicable enable meaningful community participation
- Be conducted on the basis of timely, relevant, understandable, and accessible information in a culturally appropriate format.

The IFC seeks to provide accurate and timely information regarding its investment and advisory activities as well as more general institutional information in accordance with its Access to Information Policy (January 1, 2012). IFC's Access to Information Policy states that for all Category A and B projects proposed for financing, a summary of its review findings and recommendations will be disclosed and include as a minimum, the following information:

- Reference to the performance standards and any applicable grievance mechanisms, including the compliance advisor/ombudsman;
- The rationale for IFC's categorization of the Project;
- A description of the main social and environmental risks and impacts of the Project; and;
- Key measures identified to mitigate those risks and impacts, specifying any supplemental measures;
- and actions that will need to be implemented to undertake the Project in a manner consistent with the PS;
- Electronic copies or web links to any relevant environmental and social impact assessment (ESIA) documentation prepared by the developer;
- Any additional documents such as Action Plans (APs), Stakeholder Engagement Plans (SEP), Resettlement Action Plans (RAPs) etc. In addition to the above, general financial and investment information will also be provide by the IFC. Project or investment information, once published by the IFC, will be disclosed through its Disclosure Portal at http://www.ifc.org/disclosure. Relevant environmental and social information must be made publicly available for at least 60 days prior to consideration of investment approval by the IFC's Board of Directors (or other relevant authority).

7.4 Methodology

Public consultations were organized as a way of collecting firsthand accounts from the people directly impacted by the Symbion Power Lake Kivu Ltd project. Visits to the project were undertaken by the ED&P Team between December 20015 and January 2016. The ED&P team made physical visits and observations of the project site and infrastructures (that were constructed by Government of Rwanda and Dane Associates) in order to verify and corroborate respondents' perceptions and descriptions. The objective of the public consultations with stakeholders is to garner information on their attitudes, perceptions and

reactions of the livelihood changes to be brought about as a result/consequence of Symbion Power Lake Kivu Ltd project.
Discussions involved stakeholder representatives from the following groups: individual fishermen, fishermen cooperatives; farmers, cooperative of transport in Lake Kivu as well as representatives of potentially affected homesteads.

Other contacted people and institutions included: government actors like Rubavu district officials, REG/EDCL, the Ministry of Infrastructures (MININFRA) and the private sector. All discussions were conducted in Kinyarwanda.

7.5 Introduction to the project

The Symbion Power Lake Kivu gas extraction project consists of extracting gas dissolved within a deep layer of water in Lake Kivu and processing it to remove water and other gases so as to concentrate the methane content until it is suitable for supplying gas-fired generators to produce electricity up to 220 KV grid.
Along this project, On August 7, 2014, after a competitive bidding process, Rwanda's Energy, Water and Sanitation Authority (EWSA, now REG) awarded Symbion Power a concession to finance, design, build, own, and operate a 50 MW methane gas fuelled power plant on Lake Kivu. In accordance with the Environmental Organic Law (2005), the implementation of any development project in Rwanda requires the respect of the right of every citizen to a clean, safe and healthy environment, and the right of access to environmental resources for recreational, educational, health, spiritual, cultural and economic purposes. In this framework, Symbion Power, assisted by Eco Design and Protection Ltd (ED&P), a local environmental consultant company, is embarking on the preparation of the prefeasibility Environmental and Social Impact Assessment (ESIA) for this specific project. As part of the ESIA preparation process, Symbion Power and Eco Design and Protection Ltd (ED&P) have organized a first public consultation meeting in Rubavu district on **February 24th 2016** to collect stakeholders' concerns and views about the project. In this meeting, representatives from Public and Private Institutions, Local government's representatives, Civil society organizations and opinion leaders, NGos and Religious denominations operating both in Rubavu and in Nyamyumba sector have attended the consultation meeting and provided their views about implementation together with plausible negative and positive impacts on the livelihoods of residents, ad hoc opportunities or hindrances to be encountered by already operating companies in the area etc. The relevance of the views of attendees is the enhancement of positive impacts; and the prevention, the reduction or mitigation of negative impacts allied to the project.

7.6 Meeting attendees, agenda and process

The meeting started at 10:30am sharp in the premises of Centre Culturel of Rubavu district. In total, around 90 people attended the meeting. The meeting chairing committee was composed of the Executive Secretary of Rubavu District, Ir. Kabuto Alexis, the Symbion General Manager, Mrs Jocelyn Wessling, the Symbion 50 MW water- methane extraction and gas-to-power production Program Manager, Mr. Cesar Niyonzima, a MININFRA Fossil Energy

Senior Engineer, Ir. Jean Clement Nshubijeho, the EDCL Methane, Peat and Oil Development Manager and Mr. Jean Paul Iyakaremye, the EDCL methane, peat and oil specialist, Mr. KARARA the RDB representative, Ir. Richard Ngendahayo, the Managing director of ED & P Ltd and Dr. Ignace Kabano, the ED&P Ltd Socio-economist expert. The rest of the meeting attendees was comprised of representatives from key public and private institutions such as REMA, BRALIRWA, ARCOS, ABAKIR, Lake Kivu Monitoring Project, K.K.N mining company, local development companies, representatives from local NGos, local development companies and fishery cooperatives such as KOMINYABU, KOABI, KOPILAK, and the Busoro cell people to benefit from or to be affected by the project. The meeting comprised the following key components and stages:

7.6.1 Introductory remarks

As an introduction, attendees introduced themselves one by one starting from the chairing members and the rest of attendees. After the introduction, attendees were introduced to the aim of the project and were encouraged to give their views and concerns for its better implementation. The Executive Secretary of Rubavu District, the Symbion General Manager and the ED&P Ltd team addressed the congregation about the relevance and objectives of the project vis-à-vis the development of Nyamyumba sector and Busoro Cell residents, Rubavu District residents and the country in general.

7.6.2 Summary of talks, anticipated negative and positive impacts

Talks were introduced by a description of the project by both Symbion General Manager and ED&P Managing Director. The Symbion General Manager informed the gathering that Symbion is an international company, working mainly in energy production area in USA and other African countries. In Rwanda, this company intends to operate a 55 MW methane gas fuelled power plant on Lake Kivu in a period of only 2 years, to which Symbion is committed to generate the first 14 MW in the first 14 months of gas exploitation and 42MW as the second phase after 36 months. Next was the explanation of the process of the project implementation, and the role of local residents and other potential stakeholders in this endeavor. In brief, the gathering was informed about the necessity of development projects for their welfare, and the government's role in protecting its citizens to ensure that they benefit from the project instead of it creating disastrous or negative impacts on their livelihood and the lake environment. The expropriation law and relocation principle were extensively explained to them before the discussions on positive and negative impacts were undertaken. Remy Norbert Duhuze from Rema recalled Consultants do the environmental and social impact assessment of the project, collect views and concerns from the stakeholders and at the end RDB and REMA on behalf of the government take the final decision. A project like the Symbion project can have very significant negative and positive impacts. It is in this context stakeholders were reminded they were not invited to applaud the project but to contribute in addressing the negative impacts and build on positive ones. Stakeholders were requested to contribute with no fear. Although the project will increase the power supply in the country but how do we address impacts related to fishing in the lake Kivu, lake stability and how do we restore the livelihoods of affected parties.

In this regards, the following is a summary of anticipated positive impacts:

1. Creation of employment and businesses (restaurants, bar, hotels etc.);
2. Easy movement of goods and people, increased safety to road users from Bralirwa to Busoro;
3. Availability of a good quantity of electricity and water in the area;
4. Proactive safeguard of the adverse outcome of unrestricted methane gas in Kivu Lake on residents of its neighborhood.
5. Anticipated negative impacts were expressed through residents and local business and cooperative operators concerns about the project, which are summarized in the following sub-section:

3. Main Issues/Questions raised during the consultation meeting

In regards to the project, a number of issues were raised from the public consultations as summarized in the below table.

Table 34: Issues raised during the consultative meeting

Main issue	How the issue will be addressed
1. When will the construction works begin so that the affected people begin to prepare?	The project is in the planning phase and the tentative month for implementation is June 2016. However people should continue to lead their normal lives, as adequate notice will be given to the project affected people in Busoro Cell.
2. Participants expressed the concern about where they would be relocated after moving from their current location following the project implementation.	Pursuant to the expropriation and compensation laws, Mr. Jean de Dieu Kara from RDB clarified the government recommends the relocation of displaced people as a result of any development project. In this regards, the developer, in collaboration with Rubavu district and Nyamyumba sector will make sure displaced people are relocated.
3. Residents of the shore of Lake Kivu also inquired safety assurance and were concerned about possible outcomes of the lake instability with gas extraction	Mechanisms have been put in place for a day-to-day management of the Lake. In these regards, Lake Kivu Monitoring Program (LKMP) has been created for the monitoring of the entire lake and the surroundings of the existing gas

Main issue	How the issue will be addressed
	plants and therefore to timely mitigate any related disturbance.
4. In the Lake's ecosystem, are fishes the only thing to protect?	Fish have been given a particular attention because of its impact on the socioeconomic livelihood of citizens. However, not only fish, but also the whole flora and fauna will be taken into account along the safeguarding of Lake Kivu Ecosystem.
5. There are some other projects being implemented on lake Kivu. How do you address the cumulative impacts	While undertaking the environmental and social impact assessment of the project, different developments being undertaken onshore and offshore will be identified and related cumulative impacts identified and analysed to understand whether they are reversible or nor, understand their significance and extent.
6. We noted there would be some related activities for which Symbion is not responsible. They include 7km access road and power lines. Is there a plan to assess cumulative impacts? Which institution is coordinating the three activities	Even though the construction of the 7km road and power lines is not undertaken by Symbion Power or is not the responsibility of Symbion Power, the cumulative impacts will be analysed to make sure related mitigation measures are proposed. It was agreed REG will be the institution coordinating the three different activities.
7. Knowing that Lake Kivu is shared by both Rwanda and DRC and that gas cannot be limited to move from one area to the other, what will happen if DRC also claims that Rwanda is exploiting both its resources and those of DRC?	The General Manager of Symbion explained to the gathering that lake Kivu methane gas resources can produce 700 MW in total and therefore Rwanda has the right to extract 350MW. The Lake Kivu Monitoring Program has the capacity to monitor gas extraction process and will warn

Main issue	How the issue will be addressed
	developers on the side of Rwanda whether the country has finished its gas share. It has been agreed between DRC and Rwanda that countries can initiate joint projects and each can decide to go for its own project as long as design, technical and administrative guidelines for the extraction of the gas are respected. The last proposed joint project was to generate 200MW to be equally shared between the two countries.
8. The Technical Director of BRALIRWA, after questioning the current carrying capacity of electrical wires from Bralirwa to Busoro cell, and after expressing the dire need of electricity for this brewery, wondered whether there might be any plan to invest in the upgrading of existing national grid, concomitantly to the new big project.	Yes, a new 220KV electricity grid is under construction in this perspective and therefore, the electrical wires carrying capacity will subsequently be upgraded (REG representative) to accommodate and additional 50MW to the national grid.
9. Given that this road crosses the Brewery's premises, how can BRALIRWA expect the impact of this project on the traffic movement of cars and trucks between Balirwa premises and Busoro?	During construction, we can expect heavy traffic of trucks carrying construction material, but in a longer run, this traffic will be significantly reduced during operation of the road (Mrs Jocelyn, the Symbion program manager).
10. Do you think the current status of existing road from the entrance of Rubavu city and the site will be sufficient to be used by big trucks transporting construction material to the site? Will the upgrading of the road cross the premises of the Brewery? What kind of road will be constructed between Bralirwa and Busoro?	From the entrance of Rubavu city to the site, upgrading of the road will be considered to allow Symbion's trucks to use it. Yes, if necessary, the road upgrading will cross the Brewery because even the part of the road crossing the Brewery is a public road and was not constructed by Bralirwa. Phase 1 of the road between Bralirwa and Busoro (site) will be a paved road. If

Main issue	How the issue will be addressed
	a need is felt to upgrade this road to a more improved status given the number of trucks using it, this road will be subsequently upgraded (MININFRA representative).
11. Ndirugiribambe, the agriculture advisor in Kabushongo village of Busoro cell wondered whether residents would be compensated if their crops are destroyed by the project.	Before the real project development, residents are given enough time to harvest their crops. In exceptional circumstance, if some specific crops are still in the farms such as trees, they will be compensated (EDCL representative).
12. What will happen to people whose land is in the buffer zone (50m) of the lake? Why can't the government connect us with the developer so as to undertake negotiation to buy the land located in 50m?	The REMA representative (Mr. Remy Norbert Duhuze) told the gathering that any land located in 50m zone buffering the lake does not belong to residents, but rather is a public land. The buffer zone ensures the lake is not polluted by all kinds of activities that can be developed within the 50meters buffer zone. In this perspective, even Symbion Power will have the right of exploiting the 50m buffer zone land only after the authorization of the Ministry of natural resources having the responsibility to protect natural resources including lakes.
13. What will happen to people who, after being compensated, remain with a small portion of land? Will the government again estimate the value of this land and paid for it (Abayisenga Emmanuel, local farmer)?	If the remaining portion of land is more than 30% of the total land initially owned by the resident, he/she would be given a new land registration for this remaining land. The exception will apply only if 80% of his/her initial total land is compensated because of a development project (EDCL representative).

Main issue	How the issue will be addressed
14. Nyamyumba area was the only remaining Lake section for fishing, in other parts of the lake; fishing activities were banned because of gas extraction projects (KP1 and Kivuwatt), how shall we survive since fishery is the main survival and income generating activity in this area?	The project will not prevent people to keep fishing at least beyond 1Km^2 distance and this distance will be reduced some time as the project comes to operation phase. Taking the example of KP1, people were not initially allowed to fish in less than 2Km^2, but now they can fish up to only 100m from the power plant. The fishing in the nearest distance from the power plant is beneficial because fish come to breed near the plant and go back to the lake (Symbion General Manager). Symbion Power has always considered its Corporate Social Responsibility (CSR). In other countries where we have different projects we have initiated complementary initiatives to assist the surrounding populations restoring their livelihoods but also participate in the country development. It is within this context that a stadium was constructed in one of the countries where we are operating. There is therefore a plan we participate in the country development
15. Economic operators in Nyamyumba sector such as RWACOF-a coffee treatment industry experience serious water and electricity shortage, is there any plan to tackle this issue with the coming of this new project? (Niyonshuti Eric, RWACOF representative)	In an attempt to put in place a conducive industry development environment, the government plans to bring a 55m^3 water pump and a 1.3MW at the Symbion Power Plant. This will not only benefit Symbion as a new investor but also other investors and the entire population in the area.

7.6.3 Conclusion and recommendations

The community members and representatives of various institutions operating in Nyamyumba and Rubavu districts who attended the meeting unanimously showed their support to the proposed project as it will bring a number of significant positive impacts specifically in the area but also for the country in general. Participants, however, insisted the following important observations related to the better implementation of the project and the safety of Busoro cell residents:

- Representatives of industries operating in Nyamyumba sector thanked the government of Rwanda for this project, which is to generate sufficient electricity for the good function of their industries. Some of these people said they had already ordered heavy machines but that they had not yet used because of shortage of power, but were confident to start using these macines once symbion Power has started generating sufficient electricity.
- They recommended that similar source of energy such as thermal energy be developed in this endeavor.
- Given that the road Rubavu city-Bralirwa is condensed with heavy traffic of brewery's trucks and that this road is closed from 7pm by the brewery management, they recommended a deviation of the road to allow a safer movement of individuals of Symbion's trucks to the power generation construction site or a clear communication with the brewery on a permanent use of this public road the population and any other individual willing to move from one point to the other
- In a bid to bring a panacea to the fishing restriction to some areas closer to the power plant, fishermen recommended the non-restriction of fishing activities in other areas of the Lake Kivu such as Buhoko and Kayove and in the entire territory of Rwanda.
- Lastly, fishermen agreed with the Symbion General Manager about putting into place some alternatives and projects in favor of the fishermen who will no longer carry out fishing activities to their entire satisfaction. These will include the so called corporate social responsibility-related activities such as offering tools and training in modern fishing techniques, putting into place some fish seedling cages to mention a few.

7.7 Consultations planned throughout the lifetime of the project

As part of the ESIA, an Environmental and Social Management and Monitoring Plan (ESMP) will detail specific monitoring and reporting requirements for environmental and social project performance. This will include ongoing stakeholder engagement and implementation of the grievance mechanism throughout the construction, operation and decommissioning stages.

7.8 Ongoing Community Liaison and Grievance Logging

SPLKL has designated a Community Liaison Officer (CLO) who will be responsible for day to day community engagement during the initial Project development phase. This individual will be suitably qualified and tasked to:

- Act as main point of contact for the local community e.g. local group leaders (for instance there are women's groups, youth groups, village elders, religious leaders) and the elected and appointed local authorities;

- Disclosure of Project employment opportunities and key project news and impact information, such as the commencement/completion of construction activities;
- Community consultation and disclosure events at key stages in the Project, for example at the beginning of construction;
- Organize local community meetings to provide a regular opportunity to discuss any issues or concerns.
- Receive and record written and oral comments;
- Receive and log stakeholder grievances according to the grievance mechanism detailed below (see Section 7.7);
- Dissemination of comments/meeting minutes to appropriate stakeholders; and
- Produce annual summaries that provide details related to community investment activities and the use of the grievance mechanism. SPLKL will also include clauses in the construction contracts to ensure that construction contractors and other sub-contractors appoint their own CLO's, who will report to SPLKL's CLO.

7.9 Community consultations events

Regular workshops will be a constructive way in which to involve key stakeholders throughout the duration of the operation phase, so that issues and any grievances can be raised and addressed as they emerge. Private meetings with individual stakeholders will also be organized as the need arises to discuss specific Project elements or concerns. These workshops will be held at a minimum prior to the start of construction; prior to the completion of construction; and prior to ceasing operations.

The importance of topics will change over time. Key topics for community consultation events should include:

- Women's rights. As part of SPLKL's social interaction, there will be efforts to increase women's participation in Project activities and to assist women in taking responsibilities in equal partnership with men. Consultation activities will advise women that their opinions and ideas count in equal measure to men and that women can make a difference in local society and wider;

- Education. SPLKL will promote the adherence to education regimes established by the GoR. Benefits to individuals and communities as a whole from education include potentially higher income which can directly affect families and local businesses such as shops, hotels and restaurants;

- Possible Project employment opportunities. Information will be provided about the possibilities and types of jobs that may arise as a result of the Project. Women of all ages will be encouraged to apply their skills to perceived 'men only' jobs.

7.10 Stakeholders Engagement Implementation

In order to comply with international finance standards, the Project will require public consultation and disclosure activities and mechanisms to continue beyond the ESIA process throughout the lifecycle of the Project. IFC PS 1 states that "The client will provide periodic reports to the Affected Communities that describe progress with implementation of the project Action Plans on issues that involve ongoing risks to or impacts on Affected Communities and on issues that the consultation process or grievance mechanism have identified as a concern to those Communities. The frequency of these reports will be proportionate to the concerns of affected communities but not less than annually". All of the project stakeholder engagement activities are guided by the SEP, which may be available from the Project website. The key activities are summarized in table below.

Table 35: Stakeholder Engagement Implementation Timescales and responsibilities

Activity	Timing	Responsibility
Construction phase engagement		
-Ongoing community liaison and grievance logging	-Appointment immediately in time for consultation and disclosure activities concerning the final ESIA report -Day to day interactions -Visiting local communities for informal consultation once a week at minimum -Weekly grievance reporting -Discussing progress of implementation of project action plans and issues that involve ongoing risks or impacts (as needed, but at least annually).	-SPLKL Community Liaison Officer and EPC -Contractors' CLOs, Project Manager
-Community consultation	-Prior to start of construction -Prior to the completion of construction -Project website to be regularly updated	-SPLKL CLO and EPC Contractors' Community events
-Media notifications of project progress	-At least two weeks prior to the community consultation meetings.	-SPLKL CLO

-Updating SEP	-Following each of the community consultation events	-SPLKL CLO
-Operation and decommissioning phases engagement		
-Open days	-Annualy	-CLO, Project Manager
-Grievance logging, resolution and reporting	-Ongoing logging and resolution -Bi-annual reporting	-CLO, Project Manager
-Decommissioning consultation event with affected staff and communities	-With staff prior to retrenchment proceedings -With communities prior to ceasing operations	-CLO, Project Manager
-Updating SEP	-Annually	-CLO and Project Manager

Stakeholder engagement activities will be documented and reported as part of sustainability reporting requirements. To the extent possible, profiles of the stakeholders being consulted will be established and as appropriate, disaggregated gender and other socially relevant data will be presented. Any special measures to include disadvantaged groups, for instance physically challenged persons from affected communities will also be documented.

7.11 Project Grievance Redress Mechanism

7.11.1 Overview

A grievance can be defined as an actual or perceived problem that might give grounds for complaint. As a general policy, SPLKL will work proactively towards preventing grievances through the implementation of impact mitigation measures and community liaison. A project performance grievance mechanism should be established prior to the commencement of construction activities and an ongoing grievance register will be maintained through construction and operation by the CLO. The sections below consider types of grievances, confidentiality and anonymity, and the Project's grievance resolution process.

7.11.2 Types of Grievances

Anyone will be able to submit a grievance to the Project if they believe a practice is having a detrimental impact on the community, the environment, or on their quality of life. They may also submit comments and suggestions. Grievances could include:

- Negative impacts on a person or a community (e.g. financial loss, physical harm, nuisance)
- Dangers to health and safety or the environment
- Failure of SPLKL, its Contractors and sub-contractors and their workers or drivers to comply with standards or legal obligations
- Harassment of any nature
- Criminal activity
- Improper conduct or unethical behaviour
- Financial malpractice or impropriety or fraud
- Attempts to conceal any of the above.

Grievances during construction will be investigated by SPLKL and their CLO to review the validity and responsibility of each grievance. There will be a separate grievance mechanism prepared for land acquisition and resettlement issues. There will also be separate grievance mechanisms prepared for workers.

7.11.3 Grievance Reporting and Resolution

A Grievance and Information Request Form has been produced and can be found in Appendix B of the Stakeholder Engagement Plan (which could be accessed through the Project website, for those wanting to make a complaint or comment. Provision will be made to do this directly to SPLKL or the contractor; through the CLO or through a community representative (e.g. through the community leaders). The procedure for lodging grievance and their resolution will be included in appropriate project communication materials such as the non-technical summaries.

A formal logging system will be developed and the CLO will be responsible for logging all grievances. Two tabulated standard forms will be prepared, one for recording any environmental grievances or comments and one recording community grievances or comments that are received from the public or government organizations by whatever medium i.e. visits to the site, telephone calls or correspondence. The form will concisely list the following information:

-Date of the grievance or comment

-Name and contact address of the complainant

-Brief description of the complaint, with a file reference to any correspondence from the complainant

-Brief description of the action taken by the Project Plant Management to investigate the cause of the complaint and bring about corrective action, if justified date of reply to the complainant, with a file reference to any correspondence.

In the first instance, grievances will be directed to the CLO who will classify grievance according to the table below.

Table 36: Grievance Classification Criteria

Grievance classification	Risk level	Validity	Response
Low	Negligible to low	Unsubstantiated	CLO will conduct investigation, document findings and provide a response
Moderate	Possible risk and likely one off event	Possible substantiation	CLO and an appropriate investigation team will conduct investigation. The Site Manager or OHS Manager may decide to stop work during the investigation to allow the corrective preventative actions to be determined. The CLO will provide a response.
High	Probable risk and could re-occur	Probable substantiation	CLO will get the contractor to organize a Major Investigation Team including the SPLKL for prompt investigation and resolution. Work will be stopped in the affected area. The CLO will provide a response.

The Project will aim to protect a person's confidentiality when requested and will guarantee anonymity in annual reporting. Individuals will be asked permission to disclose their identity. Investigations will be undertaken in a manner that is respectful towards the aggrieved party and the principle of confidentiality. The aggrieved party will need to recognise that there may be situations when disclosure of identity is required and the Project will identify these situations to see whether the aggrieved party wishes to continue with the investigation and resolution activities. There will be no costs or retribution of any kind associated with using the grievance mechanism.

A differentiation will be made on the Grievance and Information Request Form between grievances and comments. The CLO will log the receipt of a grievance, formally acknowledge it, track progress on its investigation and resolution, and respond in writing with feedback to the aggrieved party. They will initiate the investigation and ensure its speedy conclusion aiming to provide a response within ten working days, unless there are exceptional circumstances. If the Project receives a large number of unsubstantiated grievances, the process will be reviewed to define instances when no response is needed.

On the receipt of a comment, the CLO will log the receipt, formally acknowledge it, and track progress on its investigation and resolution. Some comments may take longer to answer, or not require a formal response. The response of a comment will be provided within twenty working days, unless there are exceptional circumstances.

Where investigations are required, Project staff and outside authorities as appropriate, will assist with the process. The CLO will collaborate with SPLKL to identify an appropriate investigation team with the correct skills to review the issue raised and to decide whether it is Project related or whether it is more appropriately addressed by a relevant authority outside the Project.

The investigation will also aim to identify whether the incident leading to the grievance is a singular occurrence or likely to reoccur. Identifying and implementing activities, procedures, equipment and training to address and prevent reoccurrence will be part of the investigation activities. In some cases, it will be appropriate for the CLO to follow up at a later date to see if the person or organization is satisfied with the resolution or remedial actions.

The CLO will summarize grievances to report on Project performance; weekly during construction and bi- annually during operation removing identification information to protect the confidentiality of the complainant and guaranteeing anonymity. Bi-annually grievance analysis and reporting will be undertaken where logs will be reviewed to identify repeat grievances.

7.11.4 Grievance Mechanism Disclosure

Prior to the start of the main construction activities, the CLO contact details and information material about the grievance redress mechanism will be disclosed in the local communities at group meetings, on the Project website and in any written information given to stakeholders.

8.0 Environmental and Social Management Plan for Symbion Power Lake Kivu Ltd Project

An Environmental and Social Management Plan (ESMP) has been developed and will be implemented during the construction, operation and decommissioning phases of the project.
The ESMP will comply with IFC PS 1: Social and Environmental Assessment and Management Systems The ESMP will also consider the operational environmental and health risks and hazards of the Project. An operations ESMP will be developed by SPLKL or its designated contractor in accordance with the principles and measures provided in the ESMP ahead of operations commencing. A decommission plan will also be drafted ahead of any decommissioning activities to the satisfaction of SPLKL.

The ESMP details the mitigation, monitoring measures and institutional responsibilities to be undertaken during the project's implementation.
It will be the task of the appointed contractors to further detail the issues addressed based on the details of construction.
It is advised that the environmental issues addressed in this ESIA report are used as the basis for detailing the environmental specifications in the tender documents for the construction contractors. The construction contractors will be contractually bound to follow good management and environmental practices during all construction work activities and to minimize damages to vegetation, soil, groundwater, surface water, landscape, and local noise levels.
Environmental hazard management will be a binding part of the contract conditions of the construction contractors. It is recommended that the contractors be required to implement an integrated Health & Safety and Environmental Management System, as in accordance with EN ISO 14001. Health & Safety and Environmental Coordination should be designated by the appointed contractors to ensure compliance with applicable legislation and the targets of their management system.
To ensure an effective implementation of the ESMP, Symbion Power Lake Kivu Ltd will designate staff to undertake environmental, health and safety supervision and monitoring during the construction and operation phases. Key responsibilities will be to ensure that environmental, health and safety requirements are properly implemented as per the terms and conditions of the approvals and permits.
This includes coordination with authorities and agencies involved.

This ESMP defines the measures needed to prevent, minimize, mitigate, or compensate for adverse impacts. These measures aim to improve the project's environmental performance, while ensuring compliance with applicable environmental standards during the planning and design phase, the construction and operation phase, and the eventual decommissioning of the plant.

The recommendations for main environmental mitigation measures include waste management and disposal planning, noise and air pollution abatement measures, emergency response planning as well as the purchase of necessary response equipment. These mitigation measures must be incorporated into the project's design and implementation.

In order to develop institutional capacity in implementing and enforcing the ESMP, training should be provided with adequate budgets to ensure satisfactory achievement of an environmentally sound performance. The training proposed here should include technical skills relating to environmental assessment, environmental mitigation plans, and environmental monitoring.

8.1 Responsibility of Institutions in Implementing the ESMP

The contractors or EPCs that will be awarded the contract to construct and install the barges, gas and power plants will remain the key responsible institution for undertaking the proposed mitigation measures as well as the monitoring activities/measures associated with this mitigation plan.

Upon successful installation, commissioning and handing over of the barges, gas and power plants to Symbion Power Lake Kivu Ltd by the contractor, Symbion Power Lake Kivu Ltd shall henceforth become the sole and lead institution responsible for ensuring proper mitigation measures and monitoring as indicated in the ESMP document.

Specifically, in the Monitoring and Evaluation, the following institutions will play the following roles:

8.1.1 Roles of Rwanda Environment Management Authority (REMA)

8.1.1.1 Oversight Monitoring

As the lead agency responsible for the protection of the environment in Rwanda, Rwanda Environment Management Authority (REMA) will play the leading oversight role in monitoring the activities of the project.

According to the Cabinet decision establishing RDB and its functions, it has the responsibility to establish the conditions of conducting the ESIA, to review and approve the ESIA findings, conclusion and recommendations through an EIA certificate. REMA at the other hand will contribute in enforcement of law and regulations.

8.1.1.2 Site Inspection Visits

REMA will also undertake regular site visits to inspect and verify the nature and extent of the impacts and to inspect and verify compliance with the mitigation measures proposed in the ESMP. Based on these findings, REMA will be expected to make recommendations to Symbion Power Lake Kivu Ltd.

8.1.1.3 Periodic Reports

REMA will prepare periodic consolidated environmental reports on the monitoring progress of the gas extraction and power plants.

8.1.1.3 Lake Kivu Monitoring

Lake Kivu Monitoring Program (LKMP) has been created for the monitoring of the entire lake and the surroundings of the existing gas plants and therefore to timely mitigate any related disturbance.

8.1.2 Role of the Contractor

8.1.2.1 Daily and Routine Monitoring

Symbion Power Lake Kivu Ltd will undertake the major role of ensuring that the mitigation measures in the ESMP are followed in details.

During construction, the contractors will undertake regular monitoring of all the activities occurring on the project site to ensure compliance with the ESMP.

The contractors will bear all the costs relating to monitoring activities during the construction and installation phase of the onshore and offshore facilities.

The construction contractor(s) will be solely responsible for ensuring that monitoring and adherence to the ESMP beginning from the construction phase up to the point where they install and commission the 50MW gas power project facilities. Thereafter, their responsibility of project monitoring ceases.

8.1.3 Role of Symbion Power Lake Kivu Ltd

Symbion Power Lake Kivu Ltd will remain the sole institution fundamentally responsible for the environmental, health and safety monitoring when the contactor hands over the project. It will be expected to ensure monitoring throughout the project's operational phase and until the term of its PPA and GCA are reached.

Table 37: Environmental and Social Management Plan Implementation Schedule

Impacts	Mitigation measures	Responsibility for implementation	Implementation schedule	Costs (USD)/an
1. Gas and power plants construction (onshore)				
Socio-cultural environment				
1a. Cultural impact	-The contractor should be orientated in the culture of the local people so that they understand the norms of the local people; -The contractor should use local labor for different project activities and as much as possible to ensure integration of the local people in the project. This will reduce cultural friction and its associated impacts.	Engineer, Contractor and SPLKL	Gas and power plants construction phase.	Included in the project cost
1b. Loss of land and assets (including crops)	-Those affected will be compensated according to the official compensation rates. -The acquisition of the land and private properties will be carried out in accordance with Rwanda Expropriation law for public interests, PS5, World Bank OP 4.12, RAP and entitlement framework for the project. -Early identification of entitlement for compensation planning of Resettlement and Rehabilitation Action Plan to compensate the losses. -The compensation will be paid in accordance with Expropriation law and will decided by competent authorities. -All the affected people will be compensated as per regulation before commencement of Construction works -Restoration of land after gas and power plant construction m done.	REG/EDCL, Rubavu District and SPLKL	Before construction starts	Government budget

Impacts	Mitigation measures	Responsibility for implementation	Implementation schedule	Costs (USD)/an
1c. HIV/AIDs and STDs	-The construction camp will meet the reasonable requirements of the workers only; -Unskilled workers (laborers) will be recruited, as available, from the local population and particularly from the villages affected by the project. Therefore, these workers will remain resident in their homes, which will reduce the need for accommodation for single male workers; -An STD/HIV/AIDS awareness and prevention program will be incorporated into the training package for all workers; -In coordination with Rwandan health authorities, a program designed specifically for promoting safe sex for the construction workforce will be developed, and condoms will be made available to workers upon request, ; and, -An STD/HIV/AIDS awareness and prevention program will be delivered to local communities. The measures outlined above are intended to minimize the risk of an increase in STDs as a result of the project. -Encourage workers for voluntary testing on HIV/AIDs -Free distribution of condoms on site	Engineer, Contractor and SPLKL. The Contractor will design an occupational health and safety program (OHSP), which addresses all aspects of worker health and safety relevant to the operation of the facilities. If deemed necessary, a facility-specific safety manual may be designed	Gas and power plants construction and design phases.	25,000 Should be included in the project cost (training of personnel)
1d. Effects on Land	-Landowners should be assisted in their efforts to retain their livelihoods and standards of living. It may therefore be necessary to offer landowners support in the event of displacement.	MINALOC and Rubavu District	Power plant design phase	NA
Physical environment				
1e. Geology and Soils	-Minimal disturbance of the soils and earth should be	Engineer,	Gas and power	Included in the

Impacts	Mitigation measures	Responsibility for implementation	Implementation schedule	Costs (USD)/an
	encouraged and promoted; -The catchment of the project should be reforested to prevent exposure to erosion; -Construction should proceed in the dry season if possible to minimize soil erosion and mass wasting; -Potentially unstable slopes should be avoided and appropriate drainage structures should be constructed on site.	Contractor and SPLKL.	plants construction phase	project cost
1f. Ground and surface water	-Precautions should be taken to prevent spills, and all workers should be trained in the proper handling, storage, and disposal of hazardous or toxic materials; -A written emergency response plan should be prepared and retained on site; Prevent the release of liquid materials that can potentially contaminate surrounding surface water or groundwater resources, mainly Lake Kivu, the following mitigation measures should be employed: i) Segregate all waste oils and lubricants from maintenance of construction equipment and dispose of these wastes properly; ii) Construct secondary containment structures for all storage tanks using an impermeable material; iii) Inspect secondary containment areas and other sumps regularly; iv) Construct and maintain facilities to remove rainwater from the secondary containment structures and properly remove oil from the surface of the accumulated material. -An offsite disposal contractor or a small package sewage	Engineer, Contractor and SPLKL.	Gas and power plant construction and design phases.	Included in the project cost

Impacts	Mitigation measures	Responsibility for implementation	Implementation schedule	Costs (USD)/an
	treatment system can be employed to treat sanitary wastes. Under no circumstances should untreated sewage be discharged into local watercourses.			
1g. Encroachment into the buffer zone	-Install soil traps at the lower end of the site to retain the soil that could be washed away to the lake and from the construction site - Replant vegetation and keep green the non-built area for the protection of Lake Kivu water and prevention of pollution from the project activities -Construction waste management plan which will identify areas where waste minimization measures can be employed. -Construction waste through over-ordering, cut off and general wastage. -An innovative approach to disposal could be to grade and sort waste on site into different categories and make this available at no cost to the local community to take away and reuse. -All waste metals generated on site during the construction phase should be collected separately and stored in a suitable, secure location prior to disposal. Contaminated waste metals will require recovery by a suitable waste contractor for decontamination. "Clean" waste metals can be recycled within the community. -Uncontaminated building rubble will be utilized within the site for hardcore or other land reclamation purposes.	Engineer, Contractor and SPLKL.	Gas and power plant construction	Cost of mitigating waste and soil erosion impacts

Impacts	Mitigation measures	Responsibility for implementation	Implementation schedule	Costs (USD)/an
	-Contaminated building rubble will be sent off site to a suitable disposal facility capable of treating or disposing of the material without the loss of contamination at the disposal site, either by leaching or other mechanism. -Prevent run-off from the stockpiles of building rubble on site. -The top soils will be utilized for land reclamation purposes and re-used for landscaping, screening and filling purposes without prior treatment. -Prevent run-off from the stockpiles of top-soil and excavation materials on site. -Waste oils and lubricants will be temporarily stored in oil drums placed in a sealed container to prevent leaks and spillages from entering the surface and the groundwater. -The waste oil, lubricants and containers will be taken from site for recycling -Waste wood can be recycled -Electrical cabling and components should be recycled. Spent batteries will need to be stored in a suitable storage facility -Plastics, paper and glass will be separated at source and recycled. -Portable showers should be used and emptied by suitably licensed operators and dispose of the effluent to a suitable treatment facility. -Shower and wash facilities should drain to a septic tank until suitable treatment facilities are provided on site. -Permanent washing and toilet facilities shall be utilized and			

Impacts	Mitigation measures	Responsibility for implementation	Implementation schedule	Costs (USD)/an
	shall drain to a septic tank and thence to a package treatment facility capable of meeting IFC standards prior to discharge to the Lake, preferable via a tertiary reed bed type treatment system. -Biodegradable food wastes shall be composted on site.			
1h.Traffic-Generated Dust	-During dry conditions, access roads will be wetted or treated with a biodegradable (e.g. lignin-based) road sealing product to prevent dust generation; -Surrounding vegetation should also be maintained on the site for as long as is possible before it is cleared -Workers on the site should be issued dust masks during dry and windy conditions.	Engineer, Contractor, REMA, Rubavu District and SPLKL.	Gas and power plants construction phase	18,000
1i. Noise and vibrations	-Preferred noise levels as per World Bank Standards should be 70 decibels during daylight hours and 50 decibels during nighttime in order to reduce negative impacts on surroundings especially during sleeping hours.	Engineer, Contractor, REMA, Rubavu District and SPLKL.	Gas and power plants construction phase	6,000
1j. Road Hazard and Safety	-A traffic management plan should be developed; -Appropriate speed limits should be established with road signs for vehicles; -Vehicle safety classes will be held in the affected villages, in particular for pedestrians and bicyclists.	Engineer, Contractor and SPLKL.	Power plant design and construction phases	30,000
1k. Soil erosion	-The site engineer will ensure that soil traps in the form of rock bankers are installed on the lower edge of the construction sites on both sides of the road; -Earth movement and excavation activities will be carried out	Engineer, Contractor and SPLKL.	Power plant design and construction phases	Included in the project cost

Impacts	Mitigation measures	Responsibility for implementation	Implementation schedule	Costs (USD)/an
	in small sections at a time so that at any given time minimal areas are being excavated; -Control of storm water movement through adequate and correctly constructed storm drains will be undertaken so as to reduce the impact of soil erosion; -Roads will be designed in such a way as to ensure the majority of their length is approximately along contours so as to reduce incidences of rill erosion on road surfaces that are along the slope direction.			
1l.Solid waste management	-At the project site there will be a refuse pit where all solid waste will be deposited. The pit will be constructed so as to segregate paper wrappings, empty oil canisters, plastic, metal straps and other waste -The items deposited here will be examined to identify those that can be re-used, and the rest will be sold off or given away for re-use elsewhere or recycling; -Clean-up exercises will be regularly undertaken every end of business day so as to retain cleanliness within the site; -Workers at site will be briefed on proper disposal of solid waste and the disposal area will be clearly marked.	Engineer, REMA, Contractor and SPLKL.	Gas and power plants construction phase	9,000
Biological environment				
1m. Impacts on Flora	-Symbion Power Lake Kivu Ltd should undertake a revegetation program to restore the vegetation felled during the project development.	Engineer, Contractor and SPLKL.	Gas and power plants construction phase	12,000
1n. Impacts on Fisheries	-Relocation of fishery activities must be undertaken before	Engineer,	Power plant	Included in the

Impacts	Mitigation measures	Responsibility for implementation	Implementation schedule	Costs (USD)/an
	any land acquisition occurs.	Contractor and SPLKL.	design phase	project cost
2. Gas and power plant operation				
Physical environment				
2a. GHGs emissions	-SO2 emissions will be controlled by limiting the sulfur content of the fuel gas; -NOx emissions will be controlled through burner management and water injection. -Particulate emissions can be reduced through good combustion control to minimize the products of incomplete combustion. -Gas extraction plants must be designed for no emissions of methane and hydrogen sulphide to the atmosphere during regular operations, though limited, short-term emissions are acceptable when plant safety considerations are paramount.	SPLKL and REMA	Power plant design and operation phases	75,000
2b. Ambient Air Quality	-A comprehensive maintenance, monitoring and reporting system will be followed throughout the operational life of the power plant.	SPLKL and REMA	Power plant operation phase	25,000
2c. Noise vibrations	-Normal work practices and equipment maintenance practices will keep noise within the standard levels cited in this analysis. -Equipment maintenance practices (e.g., mufflers on blackstart diesel, adherence to occupational health and safety procedures) are recommended.	SPLKL and REMA	Power plant construction and operation phases.	45,000
2d. Wastewater Discharge	-A sewage treatment facility will be provided at the plant -It is recommended that appropriate on site procedures	SPLKL and REMA	Gas and power plant plant	82,000

Impacts	Mitigation measures	Responsibility for implementation	Implementation schedule	Costs (USD)/an
	concerning wastewater treatment are included in the normal operation instructions of the power plant.		construction and operation phases.	
2e. Gas exploitation and depletion	Depletion is a good thing if done in an environmentally responsible manner.	SPLKL and LKMP	Has been planned and will be implemented	Included in the project cost
3. Offshore installations and construction of barges from Kitraco Jetty				
Physical environment				
3a. Handling, Storage and Disposal of Hazardous Materials	-Hazardous wastes and other waste should be collected, stored separately and disposed of appropriately. Accidental oil and chemical spills into Lake Kivu should be avoided.	Engineer, Contractor and SPLKL.	Gas and power plants construction phase	Included in the project cost
3b. Gas conveying Failure of gas conveying pipeline may cause uncontrolled gas liberation.	The pipeline should not be situated on lakebed where such failure in the pipeline may trigger spontaneous water degassing at the lake surface.	Engineer, Contractor and SPLKL.	Gas and power plants design and construction phases.	Included in the project cost
Biological environment				
3c. Impacts on Fisheries	-Water construction activities associated with the pipelines should be performed during periods of low fishing activity; -Experienced marine contractors with environmental procedures in place should be contracted to perform all work.	Engineer, Contractor and SPLKL.	Gas plants design and construction phases.	Included in the project cost
4. Operation off-shore				
Physical environment				
4a.Wastewater management	Wastewater generated during the operation phase of the gas	SPLKL and	During operation	Included in the

Impacts	Mitigation measures	Responsibility for implementation	Implementation schedule	Costs (USD)/an
	extraction and treatment facilities will be collected, transported and disposed of from the onshore installations. A small sewerage system will ensure that no human waste enters the lake.	REMA	phase	project cost
4b.Solid waste management	The services of a reliable, certified contractor should be engaged for the timely and efficient removal of solid waste to an approved site; Solid wastes such as packaging material, containers, discarded and/or damaged pipe and drill bits, and leftover construction materials are to be taken ashore and appropriately recycled, reused or disposed.	SPLKL and REMA	During operation phase	15,000
4c.CO2 management	-The management of the amount of carbon dioxide in the lake must balance the need to remove it for safety reasons with the need to maintain sufficient concentrations for sustaining lake stratification and gas lift forces for extraction operations. -The degassed water must be re-injected and remain at the lower margin of the main density gradient (at -270 m in 2004). Meeting this objective will involve controlling the degassed water density through its CO_2 content (minimum 50 % removal), and sizing the plant to avoid short-circuiting between the re-injection and extraction points	SPLKL and LKMP	During operation phase	Included in the project cost
4d. Lake Kivu ecosystem and stability	-The developer will assure a very close follow up for monitoring of Lake Kivu stability -For the monitoring of the risk, the absolute proportions of dissolved CH_4, CO_2 and H_2S per liter of water dissolved in the bottom layers will be periodically measured.	SPLKL and LKMP	-Design and operational phases.	0.2 M

Impacts	Mitigation measures	Responsibility for implementation	Implementation schedule	Costs (USD)/an
	-Start with an operating pilot of 14MW that will be upscaled to 3 additional units of 42MW each. Development of the gas resource needs to be carried out incrementally to test extraction locations, technologies and their ability to adapt to the structure and behavior of the resource. Observe the technical management prescriptions for compliance ad follow: -Water Extraction and re-injection must be done horizontally to facilitate laminar flow. -Washing water must be withdrawn from the biozone, and returned to the lower part of the biozone. Washing water will be taken from a depth of 20m and discharged at 60 m, which is close to the bottom of the biozone. -Water used to dilute degassed water before re-injection must not be taken from the biozone -The design of the deep-water extraction systems must prevent any self-sustaining gas lift effect should a pipe-break or rupture occur. Methane gas produced offshore must not be transported to the shore in a way that might affect the surface use of the lake, or risk a gas outburst below the biozone. Gas export -Plant design must ensure zero gaseous emissions during normal operations -Water extraction pipes should be located and designed to minimise potential problems with the intake of sediments			
4e. Eutrophication	-Although eutrophication will have a limited impact on Lake Kivu, regular monitoring of nutrients concentrations is	SPLKL and LKMP	Gas plant operational phase	NA

Impacts	Mitigation measures	Responsibility for implementation	Implementation schedule	Costs (USD)/an
	necessary to follow up the phenomenon happening in the Lake Kivu during exploitation (N,P,..etc).			
4f. Water quality	-Monitoring Lake Kivu water quality (pH, To, Turbidity, DO, BOC, COD, Fecal coliforms, TSS,)	SPLKL and LKMP	Gas plant design and construction phases	30,000
4g. Noise vibrations	-There is a requirement for a follow-up noise monitoring program for this Project; -It is anticipated that the normal work practices and equipment maintenance practices will keep noise within the assumed levels of this analysis; -Equipment, maintenance practices (*e.g.*, mufflers on diesel engines, adherence to occupational health and safety procedures) are needed; -A noise barrier or acoustic shield reduces noise by interrupting the propagation of sound waves.	SPLKL	Gas plant design and operational phases	25,000
4i. Fires	-Platform evacuation plan must be posted; -Each barge will have fire and gas detection systems, an automated fire suppression systems and portable class (A-B-C) fire extinguishers in and around the barge deck. -A cooperative liaison should be established between the platform officials and the local fire authorities for emergency planning and the exchange of information of mutual interest: -In the event that a fire occurs in the vicinity of the storage area, operators should maintain a cooling water spray over the outside of the containers to guard against overheating;	SPLKL	Gas plant design, construction and operation phases	Included in the project cost

Impacts	Mitigation measures	Responsibility for implementation	Implementation schedule	Costs (USD)/an
	-Fires in the manufacturing area should be extinguished with standard fire-fighting equipment; -Fire drills and inspections should be regularly scheduled; -Plant personnel should be trained in the use of fire fighting equipment and diving when necessary.			
Biological environment				
4j. Loss of fish	-Continuous monitoring is required	SPLKL and LKMP		20,000
Socio-cultural environment				
4k. Health and safety	-The overall density gradient of the lake, mainly determined by the salt content, must not be significantly weakened; - The management of the amount of carbon dioxide in the lake must balance the need to remove it for safety reasons and the need to maintain sufficient concentrations of it for sustaining lake stratification and gas lift forces for extraction operations; -The Contractor and Symbion Power Lake Kivu Ltd will design an occupational health and safety program (OHSP), which addresses all aspects of worker health and safety relevant to the operation of gas plants. If deemed necessary by Symbion Power Lake Kivu Ltd, a facility-specific safety manual may be designed.	SPLKL	Gas plant design and operation phases	Included in the project cost

8.2 Monitoring Plan

Symbion Power Lake Kivu Ltd is the project sponsor and will have overall responsibility for owning and operating the Symbion Power Lake Kivu Ltd project facility throughout its lifetime. As project sponsor, the ultimate responsibility for the project's compliance with Rwandan and international lender legislation and guidelines for environmental and social performance will lie with **Symbion Power Lake Kivu Ltd**l. This responsibility includes the day-to-day implementing of environmental mitigation measures, compensation and monitoring actions. The ESMP addresses both the construction and operations phases of the gas extraction and power plant facilities over project period.

Symbion Power Lake Kivu Ltd will remain committed to the creation and implementation of programs to reduce the probability of the occurrence of deleterious environmental incidents. Contingency plans will be developed for dealing with such incidents should they occur. **Symbion Power Lake Kivu Ltd** will require the same level of environmental performance from its agents, suppliers, and sub-contractors and will stipulate this in any legally binding agreements with these parties.

In order to fulfill its commitments with respect to managing the biophysical impacts of the project, **Symbion Power Lake Kivu Ltd** will have to designate a suitably qualified and experienced Environmental Manager.

The ESMP proposes parameters to be monitored during preparation, operation and decommissioning of the plant.

Table 38: Environmental Monitoring Plan

Impacts	Indicators	Responsibility for implementation	Targets	Frequency
1. Gas and power plants construction (onshore)				
Socio-cultural environment				
1a. Cultural impact	-Number of complaints from locals on employee's behavior; -Number of locals employed versus the non-locals	Engineer, Contractor and SPLKL	Zero complains from the locals. Maximum number of locals employed by the project (90%)	Weekly
1b. Loss of land and assets (including crops)	-Number of PAPs compensated versus not compensated -Areas restored after construction and areas not restored -Number of complains on expropriation -Number of PAPs not compensated after the start of construction	RED/EDCL, SPLKL and local government	Zero complains from the locals. All PAPs (100%) compensation before the start of construction activities.	Daily
1c. HIV/AIDs and STDs	-Number of non-locals employed -Number of awareness campaign and trainings conducted on HIV/AIDs and STDs -Number of new	Engineer, Contractor and SPLKL.	No new infected of HIV/AIDs following implementation of the project	Daily

Impacts	Indicators	Responsibility for implementation	Targets	Frequency
	HIV/AIDs infections			
1d. Effects on land	-Number of people displaced and settled	MINALOC and Rubavu District	No new squatters cause of displacement	Weekly
Physical environment				
1e.Geology and soil	Compacted area; Vehicle numbers and weights	Engineer, Contractor and SPLKL.	Maximum compaction of 50% of total area.	Daily
1f.Ground and surface water	Symbion Power Lake Kivu Ltd employees trained in the proper handling, storage, and disposal of hazardous or toxic materials; Secondary containment structures for all storage tanks constructed; Presence of a small package sewage treatment system can be employed to treat sanitary wastes, and; All waste oils (if applicable) and lubricants from maintenance of construction equipment	Engineer, Contractor and SPLKL.	-Zero contamination of ground and surface water	Daily

Impacts	Indicators	Responsibility for implementation	Targets	Frequency
	segregated for disposal;			
1g. Encroachment into the buffer zone	-Amount of retained soil by soil traps -Amount of solid waste generated on site (kgs) -Types of waste sorted on site (number) -Amount of waste recycled and reused -Number of portable showers and volume of effluent -Percentage of revegetated non built area (%)	Engineer, Contractor and SPLKL.	Zero pollution of lake water from the onshore site 80% of non-built area is revegetated.	Daily
1h.Traffic-Generated Dust	Dust amount	Engineer, Contractor, REMA, Rubavu District and SPLKL	Low level of dust on site	Daily
1i.Noise vibrations	Large equipment with mufflers; Noise measurements from traffic and heavy Machinery; Operation schedule; Workers with ear muffs;	**Contractor**	Noise levels of below 70dB immediately outside the project site. Sensitive receptors like schools offices and clinics around should register below 65 dB.	Daily
1j.Road hazards and Safety	-Number of accidents	Engineer, Contractor	Zero accident during the	Daily

Impacts	Indicators	Responsibility for implementation	Targets	Frequency
	recorded monthly -Number of sign posts warning on speed limits	and SPLKL.	phase	
1k.Soil erosion	Areas eroded (sqm).	Engineer, Contractor and SPLKL	Improved soil conservation within site and along access road.	Daily
1l.Solid waste management	Silt amounts from site; Leakage of sewage or waste water; Refuse pit on site where all solid wastes are deposited; Retained cleanliness within the site	Engineer, Contractor, REMA and SPLKL	Zero siltation from site. Cleaned site. Wastewater to meet international discharge criteria.	Weekly
Biological Environment				
1m. Impacts on Flora	-Area newly vegetated vs areas cleared of vegetation -Number of trees planted	Engineer, Contractor and SPLKL.	100% of cleared vegetation replanted	Monthly
1n. Impacts on Fisheries	-Complains from fishermen on continuous of their activities	Engineer, Contractor and SPLKL.	No single complain from fishermen about their activities	Monthly
2. Gas and power plant operation				
Physical environment				

Impacts	Indicators	Responsibility for implementation	Targets	Frequency
2a. GHGs emissions	Quantity of SO2, CO, CO_2, particulates and NOx emitted.	SPLKL and REMA	Acceptable limits	Daily
2b. Ambient Air Quality	- Concentrations of pollutants in the exhaust gases; Engine characteristics, operating practices and crude gas compositions	SPLKL and REMA	No impact on air quality during operation of the power plant. No increase of the background values (air pollutant emissions).	Daily
2c. Noise and vibrations	-Noise levels (db) -Number of equipment emitting noise above acceptable levels	SPLKL and REMA	Noise maintained at acceptable levels	Daily
2d. Wastewater Discharge	-Monitoring effluent of the wastewater system (BOD, COD, TSS, N, P coliforms,..etc) in mg/l	SPLKL and REMA	-Wastewater appropriately treated	Daily
2e. Gas exploitation and depletion	Amount of gas extracted from the Lake annually (m3/day of CH4 and CO2)	SPLKL and LKMP	Amount extracted is in conformity with TMPs	Annualy
3. Offshore installations and construction of barges from Kitraco Jetty				
Physical environment				
3a.Handling, Storage and	-Hazardous wastes and	Engineer, Contractor	No hazardous waste on	Daily

Impacts	Indicators	Responsibility for implementation	Targets	Frequency
Disposal of Hazardous Materials	other waste collected, stored separately and disposed of appropriately (m3/d). Oil and chemical spills into Lake Kivu (m3)	and SPLKL.	the site; Zero contamination of Lake Kivu by oil and chemical spills	
3b.Gas conveying pipeline	Amount of gas degassing at the lake surface (sqm covered).	Engineer, Contractor and SPLKL.	At least the pipeline located on -10m	Monthly
Biological environment				
3c. Impacts on Fisheries	-Water construction activities frequency during low fishing activity; -Number of experienced marine contractors with environmental procedures performing the work	Engineer, Contractor and SPLKL.	Minimum disruption of fishing activity	Weekly
4. Operation off-shore				
Physical environment				
4a.Wastewater management	Amount of wastewater discharged onshore and the effluent parameters	SPLKL and REMA	Acceptable effluent wastewater quality	Weekly

Impacts	Indicators	Responsibility for implementation	Targets	Frequency
	Amount of wastewater that enters the lake			
4b.Solid waste management	Amount of solid waste dumped at approved site; Solid wastes appropriately recycled, reused or disposed from offshore to onshore	SPLKL and REMA	No solid waste retained on site weekly	Weekly
4c.CO2 management	-Management of CO2 discharged and extracted. - Degassed water density through its CO_2	SPLKL and LKMP	(Minimum 50 % removal),	Daily
4d.Lake Kivu ecosystem and stability	-Proportions of dissolved CH_4, CO_2 and H_2S per liter of water dissolved in the bottom layers periodically measured. -Water Extraction and re-injection type.	SPLKL and LKMP	-	Daily
Comments: Regular site visits to monitor the activities of the contractor will ensure that work is carried out in full compliance with the environmental specifications and provisions. This will be done by the appointed person, responsible for environmental issues. The Contractor will prepare a monthly environmental management report for Symbion Power Lake Kivu Ltd and the GoR (through REMA) for follow-up and actions.				
2. Operation phase				

Impacts	Indicators	Responsibility for implementation	Targets	Frequency
	.		of the background values (air pollutant emissions).	
Lake Kivu stability	Changes in balance between the Lake Kivu layers and the presently identified natural migration of the nutrients through the layers; Measurements of the absolute proportions of dissolved CH_4, CO_2 and H_2S per liter of water dissolved in the bottom layers will be permanently measured.	**Third party appointed by the GoR**	Regular monitoring of proportions of dissolved CH_4, CO_2 and H_2S per liter of water dissolved in different layers following the planned exploitation.	
4e. Eutrophication	-Nutrients concentrations in the Lake Kivu during exploitation (N,P,..etc).	SPLKL and LKMP	Acceptable levels	Monthly
4f. Water quality	-Monitoring Lake Kivu water quality (pH, To, Turbidity, DO, BOC, COD, Fecal coliforms, TSS,)	SPLKL and LKMP	Record	Daily
4g. Noise and vibrations	-Noise level (db);	SPLKL	Gas plant design and	Daily

Impacts	Indicators	Responsibility for implementation	Targets	Frequency
	-Equipment with non-acceptable noise levels (number) -A noise barrier covering which area		operational phases	
4i. Fires	-Evacuation plan; -Barge with fire and gas detection systems, -Fire drills and inspections should be regularly scheduled (frequency); -Plant personnel trained on firefighting equipment and diving (number).	SPLKL	-Very short time to evacuate in case of fire -Personnel regularly trained	Weekly
Biological environment				
4j. Loss of fish	-Continuous monitoring is required (number of fish catch per day)	SPLKL and LKMP	Zero impact on fishing	Daily
Socio-cultural environment				
4k. Health and safety	Occupational health and safety program (OHSP), implemented on site on daily basis -Number of accidents or disease cases on site	SPLKL	No accidents or disease case on site	Daily

Impacts	Indicators	Responsibility for implementation	Targets	Frequency
Comments: The offshore plant performance will be also regularly monitored as well as gas plant performance (flow, gas composition, gas concentration, water conductivity, pressure, temperature, etc. Monitoring of the lake area surrounding will be undertaken and other locations in the lake for comparison (gas composition, gas concentration, water conductivity, pressure, temperature, wind stress, water velocity, density,..etc.) Modeling to predict the general trend of Lake Kivu's characteristics and stability will be performed.				

8.2.1 Contractor's Action Plans

The controlling documents for all of the Contractor's activities (including environmental responsibilities) will be its Action Plans. This framework is described in the sections that follow. It is intended that the Contractor will take this framework and developed it into a self-standing Action Plan, which will form a component of the overall ESMP for the project. The Contractor's Action Plan will be comprised of a set of method statements covering all critical construction and environmental management tasks. The key components of the Contractor's Action Plan are outlined in the following sections.

8.2.2 Traffic/Access Management Plan (TMP)

The Contractor will produce a Traffic Management Plan (TMP) that contains appropriate strategies for moving materials and persons to, from and within construction areas, including abnormal loads. It will also contain provisions for management of connection points between site access roads and the main public highways, and for any upgrading work to be carried out. Specific traffic management measures will include, but not be limited to, those provided in ESMP Report.

The TMP will also specify the procedures for monitoring construction-generated traffic movements, and associated environmental problems.

8.2.3 Waste Management Plan (WMP)

The Contractor will produce a Waste Management Plan (WMP), for dealing with waste generated as a result of construction. The WMP will specify provisions for disposal, re-use or recycling of solid waste, hazardous waste, foul and process water. Specific waste management measures will include, but not be limited to, those provided in the ESMP Report.

8.2.4 Pollutant Spill Contingency Plan (PSCP)

The Contractor will produce a Pollutant Spill Contingency Plan, which will set out the procedures for proper handling of potential pollutants and procedures to be taken in the event of a pollutant spill. It will also specify equipment procurement and training of construction personnel. Specific pollution management measures will include, but not be limited to, those provided in ESMP Report.

8.2.5 Contractor's Labor Force Management Plan

The contractor will ensure that labor standards are respected during the project, by taking into account the capacity of sub-contractors to achieve sound labor management in its assessment of potential sub-contractors.
The contractor will:

- Commit, where requested, to providing a copy of employment registers and records, including details of hours/overtime worked, wages paid and the employment status of workers, both those employed directly and indirectly;

- Assume primary responsibility for day-to-day monitoring of the implementation of labor standards requirements placed by project financiers on the and thereby designate a manager who is responsible for ensuring compliance with labor and health and safety legislation, both in the direct and indirectly-employed workforce (namely, sub-contracted labor);
- Provide or ensure that training is carried out on health and safety issues with regard to all workers, direct and indirectly employed;
- Put in place a mechanism for checking the age of workers;
- Carry out risk assessments in relation to all employees who are under the age of 18;
- Put in place a worker grievance mechanism and details of any complaints lodged under the procedure;
- Undertake to inform Symbion Power Lake Kivu Ltd of all serious accidents that take place in relation to the project.

8.2.6 Hazardous Materials Management Programme

A Hazardous Materials Management Programme will be prepared to comply with the relevant IFC Environmental, Health and Safety Guidelines. This will set out the methods for screening the characteristics and threshold quantities of hazardous materials, managing the risks associated with their transportation, storage, use and disposal, and for informing the potentially affected community (if relevant).

8.2.7 Health and Safety Management Plan

A Health and Safety Management plan will be prepared, which shall address all Rwandan Health and Safety Standards, as well as the Health and Safety guidelines of the international lenders (such as the IFC June 2003 Occupational Health & Safety Guidelines), including:

- Workplace noise;
- Workplace air quality;
- Electrical safety in the workplace;
- Working at height;
- Working in confined spaces;
- Handling hazardous substances;
- General workplace health and safety; and,
- Personnel training.

Health and safety management procedures will include internal incident tracking and a corrective action program to prevent recurrence of any such incidents. The Contractor will be responsible and accountable for the actions of its company and employees. These responsibilities will be incorporated into the contract documents consistent with the recommendations of the ESIA.
Worker grievance mechanism will be put in place for both construction and operation so that workers can raise reasonable workplace concerns and for the monitoring and resolving of such concerns. Personnel will be informed of this mechanism at the time of being hired.

8.2.8 Contractor's Environmental Mitigation and Monitoring Plan (EMMP)

Within this plan, the Contractor will specify the 'biophysical' mitigation and monitoring measures to be implemented in relation to construction of gas extraction and power plant facilities.

The monitoring component of the EMMP will identify:

- Environmental issues;
- Parameters to be monitored;
- Monitoring methodology including locations, equipment, frequency, etc;
- Threshold limits that trigger corrective action;
- Reporting procedures; and,
- Responsibility for monitoring.

The Contractor will monitor the parameters set out in the ESMP to ensure that the performance of the work complies with the threshold limits, which trigger intervention, including relevant Rwandan standards (e.g. noise limits) and performance standards of key lender and internal corporate performance standards.

8.2.9 Responsibilities and Costs for Environmental Mitigation Measures

Table on ESMP outlines the overall package of environmental mitigation measures that will be implemented in relation to the Symbion Power Lake Kivu Ltd project (as outlined in detail in ESMP). The table also assigns general responsibilities for implementing each group of mitigation measures.

9.0 Conclusion and Recommendations

9.1 Conclusion

In undertaking such a study, it is important to take into account the importance of the project to the nation of Rwanda as well as impacts of the project on the environment. Energy projects are national projects that are significant to the development of the country, but ultimately a sustainable environment is also crucial for the country's long-term development.

Demand for electricity in Rwanda continues to outstrip supply. For industrial, commercial, and domestic electricity growth additional generation is required to promote economic growth and poverty alleviation. The Symbion Power Lake Kivu Ltd project will provide Rwanda with an additional 50 MW to 56MW of electricity that will meet the shortfalls during peak times, with the two phases.

The study report has proposed mitigation measures to combat the potentially adverse impacts of the project. Based on the findings of this study, we believe that the project's benefits outweigh the risks of adverse impacts.

The main potentially adverse environmental impacts identified include: disturbance to Lake Kivu's stability, a disruption of fisheries, gas reserve depletion, GHGs emissions, diminished air quality, wastewater from the gas and power plant and poor land use practices in the catchment areas. These impacts can be mitigated subject to recommendations for final design, monitoring and mitigation made in this ESIA.
We believe the project is viable. The identified impacts can be effectively mitigated through technological means, monitoring of inputs used, and capacity building. Potential hazards can be prevented through implementation of the EHS strategy.

The possibility of a huge gas outburst from Lake Kivu, where all or most of the dissolved gas would reach the atmosphere is very low, but the impact of such an event on the whole Lake Kivu region of about 10,000 km^2 could be profound. There is a greater likelihood of small or medium gas outbursts with limited consequences. Therefore, not only the monitoring of this Lake but also its controlled degassing is absolutely necessary. And so, the importance and necessity of a monitoring system for Lake Kivu during the gas exploitation is evident.
The long-term exploitation of the Lake Kivu gas will expand the biozone and harness the gas in Lake Kivu, thereby making the Lake safe for continued gas exploitation. The risk of accidents and disasters can be reduced through adequate monitoring and policy enforcement. The project's impact on the environment can be contained by effective action.
The Project (including ancillary development) has been categorized as a Category A, according to IFC Performance Standards (PS). However, with effective mitigation, as outlined in the ESMP, residual negative impacts can be reduced ensuring compliance with all necessary standards.

Mitigation measures that are proposed include developing an employment management plan, a retrenchment plan (ahead of decommissioning / site closure), a health, safety and environment plan (including waste and dust), a traffic management plan, an oil spill response and management plan, working conditions to comply with IFC standards for accommodation if they are developed, worker induction training and a worker grievance mechanism.

The inclusion of these mitigation measures will ensure that potential adverse impacts resulting from the Project are minor or insignificant.

The gas emissions dispersion model and the simulation of noise levels has confirmed there is no significant impact if there are no populations living within the 4.08 hectares that the government has availed and allocated for Symbion onshore installations. The gas emissions and noise levels are within the limits established by IFC and East African community.

According to this ministerial order determining the length of land on shores of lakes and rivers transferred to public property - N° 007/16.01 of 15/07/2010, the land within a distance of fifty (50) meters from the lakeshore is reserved as natural vegetation. The proposed site plan doesn't comply with this Ministerial Order as the gas and power plant is proposed to be constructed within the lake buffer zone. Technical reasons are related to optimization of gas production, installations of offshore and onshore installations unavoidable for the proposed technology. Some pipes conveying the gas to the gas plant are to be installed on the lakeshores and the optimum processing of the gas and power generation have to take place on the shore of the lake.

Locating the gas and power plant outside the 50m buffer zone will have as disadvantage the drop of pressure as the altitude of the site and distance from the edge of the lake increase. The drop of pressure will seriously affect the optimum utilization of the power plant generators and the project profitability.

In the context of having the gas and power plant generator, mitigation measures were proposed to protect the lake from pollution and degradation of its resources and biodiversity but it is up to the decision makers to appreciate whether an exemption to this ministerial order is relevant after analyzing the limited options for the gas processing and power generation.

9.2 Recommendations

While insisting the project must be in conformity with the Management Prescriptions (MPs), this study recommends that the project be implemented with the proposed measures in place to mitigate and reduce some of the impacts identified above. The study recommends that:

- An operating pilot plant of 14 MW should be built for Phase 1, which will be upscaled by 42 MW with three additional platforms for a total of 56MW.

- The pipeline should be situated at depth of -20 meters below lake level and avoided on lakebed.

- Regular monitoring of changes in balance between the Lake Kivu layers and the presently identified natural migration of the nutrients through the layers be undertaken by a third party (LKMP) for the GoR.

- Measurements of the absolute proportions of dissolved CH_4, CO_2 and H_2S per liter of water dissolved in the bottom layers be periodically measured.

- For health and safety risks, harmful and hazardous substances should be banned and avoided, in accordance with Rwandese legislation and international standards;

- Waste Management be carefully carried out;

- The contractor maximizes the utilization of the local labor for the project to ensure integration of the local people in the project and reduce cultural friction;

- The power plant and gas extraction facilities operate as stably and as efficiently as possible to keep emission figures at the lowest level;

- The persons responsible for environmental issues relating to the project make site visits regularly to monitor the activities at the power plant and gas extraction and treatment facilities during all phases of the project;

- Monitoring data be analyzed and reviewed at regular intervals and compared with specified requirements so that any necessary corrective actions can be taken.

- Records of monitoring results be reported to the responsible authorities and relevant parties, as required.

References

Biswas A. K. and Agarwala S. B. C., 1992. Environmental Impact Assessment for Developing Countries, Oxford.

Bull Agric Congo Belge 51(4):975–985 Muderhwa N, Matabaro L (2010)

Collart A (1960) L'introduction du Stolothrissa tanganicae (Ndagala) au lac Kivu.

Collart A (1960) L'introduction du Stolothrissa tanganicae (Ndagala) au lac Kivu. Bull Agric Congo Belge 51(4):975–985 Conservation plan for Kivu Islands

Descy , J.P, Guillard , J., MUZANA A., RUGEMA E.(2014). Biological Baseline Study of Lake Kivu ; Final Report.

Descy J.P., Darchambeau F., Guillard J., Schmid M., (2012).Limnology ad biogeochemistry of a tropical great Lake. Springer Dordrecht Heidelberg New York London.pge 130

Diego Shoobridge and Sachin Kapila, Environmental Impact Assessment of the Camisea Gas Project: the Importance of Local Participation. Peru, not published.

Dr.Klaus Tietze, Michel Halbwachs, Andreas Lorke and Alfred Wuest, Response of Lake Kivu stratification to lava inflow and climate warming. Limnol. Oceanogr., 49(3), 2004, 778–783.

DUSABE M.C and A. APIO (2014). The biological fresh water quality and diversity of Rwandan rivers draining into Lake Kivu Final report.

Eco Power Global 2006, Feasibility Study and Designs for Rukarara Small Hydro Power Project, Final Report.

Elmer KR, Reggio C, Wirth T, Verheyen E, Salzburger W, Meyer A (2009) Pleistocene desiccation in East Africa bottlenecked but did not extirpate the adaptive radiation of Lake Victoria haplochromine cichlid fi shes. Proc Natl Acad Sci USA 106(32):13404–13409

Environmental Protection Authority, LPG Extraction Plant, proposed modifications to extract ethane. Bulletin 332, Perth Western Australia, April 1998.

EPA (1992). *Screening Procedures for Estimating the Air Quality Impact of Stationary Sources, Revised,* EPA-454/R-92-019, US-Environmental Protection Agency, Research Triangle Park, North Carolina, 2711

EPA (1993). *AP42 Volume 1, Fifth Edition,* US-Environmental Protection Agency, Research Triangle Park, North Carolina, 2711

EPA (1993). *Users Guide to the Building Profile Input Program,* EPA-454/R-93-038, US-Environmental Protection Agency, Research Triangle Park, North Carolina

EPA (1995). *Screen3 Model User's Guide,* EPA-454/B-95-004, US-Environmental Protection Agency, Research Triangle Park, North Carolina, 2711

EPA (1995). *Users Guide for the Industrial Source Complex (ISC) Dispersion Models.* EPA-454/B-95-003a, US-Environmental Protection Agency, Research Triangle Park, North Carolina

EPA (2005) *Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions; Final Rulel.*40 CFR Part 51, US-Environmental Protection Agency, Research Triangle Park, North Carolina, 2711

Government of Rwanda (2007. Vision 2020, Ministry of Finance and Economic Planning).

Government of Rwanda Organic Law on Environment Protection and Management, 2005

Government of Rwanda REMA 2007 Guidelines and Regulations for Environmental Impact Assessment.

Government of Rwanda, 2002. Poverty Reduction Strategy Paper, Ministry of Finance and Economic Planning.

Government of Rwanda, 2004 Energy Policy, Ministry of Infrastructure.

Government of Rwanda, 2004, National Land Policy, Ministry of Lands, Environment, Forests, Water and Mines.

Government of Rwanda, 2006, Environmental Impact Assessment Regulations and Guidelines, Ministry of Lands, Environment, Forests, Water and Mines.

Government of Rwanda, 2006, Environmental Policy, Ministry of Lands, Environment, Forests, Water and Mines.

Gozlan RE (2008) Introduction of non-native freshwater fi sh: is it all bad? Fish Fish 9:106–115.doi: 10.1111/j.1467-2979

http://www.mmm.ucar.edu/mm5/

https://www.iucn.org/

IFC (2007). *Environmental Health and Safety Guidelines – General EHS Guidelines: Environmental Air Emissions and Ambient Air Quality* International Finance Corporation – World Bank Group [available from]

IFC (2008). *Environmental Health and Safety Guidelines – Thermal Power Plants* International Finance Corporation – World Bank Group [available from]

Institute of Natural and Regional Resources (INRR), Summary Environmental Impact Assessment of Oyong Gas and Oil Filed Development Project. Indonesia, February 2004.

Jorgen S. Stenfelt. Ticking Bomb of Rwanda Salvation. April, 2006.

Klaus Tietze, Mebus Geyh, Helmut Müller, Lothar Schröder, Wolfgang Stahl and Hermann Wehner, The genesis of the methane in Lake Kivu (Central Africa). International Journal of Earth Sciences. 452-472, Volume 69, Number 2 / June, 1980, September 2005.

Klaus Titze and all, Lake Kivu Gas Extraction: Mandatory Requirements and Guidelines for the Design and Operation of Gas Extraction Plants. May 2008.

Lake Kivu Monitoring Programme 2015. Stock assessment of *Limnothrissa miodon* in Lake Kivu. Monitoring Report.

Lake Kivu Monitoring Programme, 2016. Physico-Chemical parameters monitoring. CTD profiles report.

Martin Doevenspeck, Lake Kivu's methane gas: Natural Risk or Source of Energy and Political Security? GIGA Institute of African Affair. Hamburg Kurzbeiträge / Reports.

Martin Schmid, Michel Halbwachs and Bernhard Wehrli, Report of the scientific expeditions to Lake Kivu in November 2003 and February 2004. . An investigation of physical and chemical properties of Lake Kivu as a base for gas outburst risk assessment. 2004.

Michel HALBWACHS, Klaus TIETZE and Andreas LORKE, Specific study of the impact of the sub-water lava inflow on the lake stability. March 2002.

MM5. *The PSU/NCAR Mesoscale Mode.* Pennsylvania State University / National Centre for Atmospheric Research [available from]

MMW Consulting, Final Environmental Impact Assessment Vlore Combined. Albania, October, 2003.

Natasha Pasche, How does nutrient cycling influence methane production in Lake Kivu? Unpublished.

Reinoud Post, Monitoring Strategy and Monitoring Action Plan for Lake Kivu Gas Extraction. Februarary 2008.

Sarmento H.(2007). Ecologie du Phytoplankton du Lac Kivu (Afrique de l,Est).PhD thesis, Universoty of Namur, Belgium.

Sarmento H.(2007). Ecologie du Phytoplankton du Lac Kivu (Afrique de l,Est).PhD thesis, Universoty of Namur, Belgium

Snoeks J, De Vos L, van den Audenaerde DT (1997) The ichthyogeography of Lake Kivu. South Afr J Sci 93:579–584.

The introduction of the endemic fish species, *LamprichthysTanganicanus* (Poeciliidae), from Lake Tanganyika into Lake Kivu: possible causes and effects.Aquat Ecosy Health Manag 13:203–213

WHO (2005). *WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulphur dioxide.* WHO/SDE/OEH/6.02, World Health Organization, 20 Avenue Appia, 1211 Geneva 27, Switzerland.

Word Bank Group, IFC Environmental Health and Safety Guidelines. Oil and Gas Development (Offshore), April 2007.

World Bank Group (WBG). 2006. http://www.worldbank.org/.

World Bank Group. 1998. General Environmental Guidelines. July 1998.

World Bank Group. 1998. Monitoring Guidelines. July 1998.

World Bank Group. 1998. Pollution Prevention and Abatement Handbook, 1998: Toward Cleaner Production. Washington, D.C.

World Commission on Dams. 2000. http://www.dams.org/. 2006.

www.ifc.org/ifc.org/ifcext/enviro.nsf/Content/EnvironmentalGuidelines

www.ifc.org/ifc.org/ifcext/enviro.nsf/Content/EnvironmentalGuidelines

Zdenko Mahmutović and all, Environmental Impact Study Summary for Multipurpose Projects, Novo Virje Hydroelectric Power Plant, not published.

Annexes

Annex 1: Summary of the phytoplankton taxa found in the pelagic waters of Lake Kivu, sorted by occurrence frequency (Sarmento et al. 2007)

Taxon	Fequency	Seasonality	Vertical distribution
Nitzschia bacata Hust.	Very common	All seasons	Epilimnion
Planktolyngbya limnetica (Lemm.)	Very common	All seasons	Epilimnion
Synechococcus sp.	Very common	All seasons	Epilimnion
Monoraphidium contortum (Thur.) Kom.-Legn.	Very common	All seasons	Epilimnion
Fragilaria danica (Kütz.) Lange-Bert.	Very common	All seasons	Epilimnion
Urosolenia sp.	Very common	All seasons	Surface
Cryptomonas sp.	Very common	All seasons	Epilimnion
Tetraedron sp.	Very common	All seasons	Epilimnion
Cylindrospermopsis cf. *curvispora* Wat.	Common	All seasons	Epilimnion
Microcystis sp.	Common	Rainy season	Surface
Pseudanabaena moniliformis Kom. and Kling	Common	All seasons	Epilimonion
cf. *Rhodomonas* sp.	Common	All seasons	Epilimonion
Peridinium sp.	Common	All seasons	Epilimonion
Peridinium umbonatum Stein	Common	All seasons	Epilimonion
Anabaena sp.	Rare	Rainy season	Epilimonion
Aphanocapsa sp.	Rare	All seasons	Epilimonion
Aphanothece sp.	Rare	All seasons	Epilimonion
Chroococcus sp.	Rare	All seasons	Epilimonion
Merismopedia trolleri Bach.	Rare	All seasons	Epilimonion
Pannus microcystiformis Hind.	Rare	Rainy season	Surface
Planktolyngbya undulata Komárek and Kling	Rare	All seasons	Epilimnion
Pseudanabaena mucicola	Rare	Rainy	Surface

		season		
Gymnodinium sp.	Rare	All seasons	Epilimnion	
Nitzschia fonticola Grun.	Rare	All seasons	Epilimnion	
Nitzschia tropica Hust.	Rare	All seasons	Epilimnion	
Thalassiosira rudolfi (Bach.) Hasle	Rare	All seasons	Epilimnion	
Paraphysomonas vestita Stokes	Rare	All seasons	Epilimnion	
Dictyosphaerium pulchellum Wood	Rare	All seasons	Epilimnion	
Tetraedron regulare Kütz.	Rare	All seasons	Epilimnion	
Oocystis lacustris Chod.	Rare	All seasons	Epilimnion	
Cosmarium cf. laeve Rabenh.	Rare	All seasons	Epilimnion	
Cosmarium cf. regnellii Wille	Rare	All seasons	Epilimnion	
Aphanocapsa holsatica	Very rare	-	-	
Cryptaulax sp.	Very rare	-	-	
Cyclotella meneghiniana Kütz.	Very rare	-	-	
Coelastrum reticulatum (Dang.) Senn.	Very rare	-	-	
Dictyosphaerium tetrachotomum Printz	Very rare	-	-	
cf. Sphaerocystis sp.	Very rare	-	-	
Oocystis cf. *submarina* Lagerh.	Very rare	-	-	
Siderocelis irregularis Hind.	Very rare	-	-	
Cosmarium sp.	Very rare	-	-	
Staurastrum sp.	Very rare	-	-	

Annex 2: Fish species composition of Lake Kivu (Descy et al, 2012)

Species	**Family**	**Endemism**
Limnothrissa miodon	*Clupeidae*	Introduced
Raiamas moorii	*Cyprinidae*	Native
‘ Barbus ’ kerstenii	*Cyprinidae*	Native
‘ Barbus ’ pellegrini	*Cyprinidae*	Native
‘ Barbus ’ apleurogramma	*Cyprinidae*	Native
Labeobarbus altianalis	*Cyprinidae*	Native
Amphilius cf. uranoscopus	*Amphilidae*	Native
Clarias liocephalus	*Claridae*	Native
Clarias gariepinus	*Claridae*	Native
Lamprichthys tanganicanus	*Poecilidae*	Introduced
Oreochromis niloticus	*Cichlidae*	Native
Oreochromis macrochir	*Cichlidae*	Introduced
Oreochromis leucostictus	*Cichlidae*	Introduced
Tilapia rendalli	*Cichlidae*	Introduced
Haplochromis spp.(15 species)	*Cichlidae*	Native

Annex 3: WHO Ambient Air Quality Standards

	Averaging Period	Guideline value in µg/m³
Sulfur dioxide (SO_2)	24-hour 10 minute	125 (Interim target-1) 50 (Interim target-2) 20 (guideline) 500 (guideline)
Nitrogen dioxide (NO_2)	1-year 1-hour	40 (guideline) 200 (guideline)
Particulate Matter PM_{10}	1-year 24-hour	70 (Interim target-1) 50 (Interim target-2) 30 (Interim target-3) 20 (guideline) 150 (Interim target-1) 100 (Interim target-2) 75 (Interim target-3) 50 (guideline)
Particulate Matter $PM_{2.5}$	1-year 24-hour	35 (Interim target-1) 25 (Interim target-2) 15 (Interim target-3) 10 (guideline) 75 (Interim target-1) 50 (Interim target-2) 37.5 (Interim target-3) 25 (guideline)
Ozone	8-hour daily maximum	160 (Interim target-1) 100 (guideline)

Annex 4: Environmental and Social Impact Assessment ("ESIA") Study for Symbion Power Lake Kivu Ltd Project, Rwanda
Proposed Terms of Reference

Introduction

Rwanda is a dynamic country, which is trying to speed up development after the events of 1994. Unfortunately, this attempt is made difficult by serious deficiencies in the availability of energy resources. Energy consumption in Rwanda is greatly inferior to that needed for industrialization. The required minimum is generally thought to be 0.6 tep (ton equivalent petroleum) per person per year, whereas at the moment available energy is of the order of 0.16 tep per person per year. Today 80% of electricity consumed is by the capital city, Kigali, where only 5% of the population lives.

The Government of Rwanda (GoR) has decided to increase the energy production with diversification of energy resources. One of these resources is the methane gas trapped in the deep waters of Lake Kivu. The Government of Rwanda (GoR) has called upon Independent Power Producers (IPPs) to use this resource to build Rwanda's power generation capacity, which promises to be one of the most cost-effective sources of electricity available to the country.

Symbion Power LLC (Symbion), one of the leading private sector partners of the U.S. Government's Power Africa Initiative, began targeting investment opportunities in Rwanda in 2013. In November 2014, following a competitive bidding process, GoR signed a Memorandum of Understanding (MoU) with Symbion to develop a 50 MW power plant supplied by methane extracted from Lake Kivu. Symbion subsequently undertook a four- month Feasibility Study to assess the viability of this Project.

The Project consists of extracting gas dissolved within a deep layer of water in Lake Kivu and processing it to remove water and other gases so as to concentrate the methane content until it is suitable for supplying gas- fired generators to produce electricity. The Gas Plant will have both an offshore and an onshore component, connected via submerged pipelines. The Power Plant will comprise the generators as well as step-up transformers to transfer electricity to the Rwandan 220 kV grid.
The total installed capacity of the power plant as measured at the generator terminals will be 68 MW (7 x 9.73 MW). The connection point to the grid shall be at the high voltage terminals of the step-up transformers. The total available capacity for export at the connection point will be approximately 55 MW after supplying the auxiliary loads, supplied with an average availability of 85%.

The viability of the project depends on whether the project is implemented in a sustainable development context. A development that ensures needs of future generations are not compromised.

Article 67 of the organic law № 04/2005 of 08/04/2005 determining the modalities of protection, conservation and promotion of the environment of Rwanda requires that every development project shall undergo an environmental impact assessment prior to its commencement.
It is in this regards that we, Symbion Power Lake Kivu Ltd have submitted our proposed terms of reference for the Environmental and Social Impact Assessment (ESIA) for the methane gas / production facility to be built on lake Kivu and the associated 100MW (nominal) gas engine, methane gas fueled power plant to be constructed at Rubavu, to Rwanda Development Board (RDB) for review and approval.

1.0 Executive summary

The executive summary will give a brief description of the project, the project site with its main environmental characteristics, the technologies and equipment to be used, the identified project impacts with the proposed mitigation measures to the negative impacts and a summary of the main findings and recommendations of the expert who conducted the study.

2.0 Legal and regulatory framework of the project

This Section will present the national legal framework and regulations for planning and environmental and social protection in Rwanda, as well as international standards of potential financier to the Project, initially understood to comprise the IFC

Identification of laws, policies, national and international guidelines (IFC), which will govern the conduct of the assessment, discussions on how relevant they are for this project and aspects related to compliance. This includes standards and norms related to energy production, works in lakes and near lakes, electricity generation and transmission, construction practices and technologies, operational regulations and standards, etc.
The study shall identify and describe the roles and responsibilities of all stakeholders in the project implementation, project monitoring and monitoring of Lake Kivu stability.
The study will assess the content of the Management Prescriptions (MPs) and how the project complies through the different project phases.
The Project is required to meet the international standards of the IFC, which is part of the World Bank Group.

The project should be categorized. IFC Standards categorizes projects and the assessment is conducted depending on the category where falls the project. IFC's Policy on Environmental and Social Sustainability, 2012 requires initial screening and categorization of each proposed Project to determine the appropriate extent and type of environmental assessment needed. The resulting category also specifies IFC's institutional requirements for disclosure in accordance with IFC's Access to Information Policy. Projects can be placed into one of four categories, depending on the type, location, sensitivity, and scale of the Project, as well as the nature and magnitude of its potential environmental impacts. The different categories are A, B, C or F1.

3.0 Project description

Detailed project description including the area of influence (spatial and temporal boundaries), location, layout, different activities related to the project, technologies and equipment to be used, phasing of activities, staffing during all phases of the project, etc. This will also include the gas balance in the lake and stability of the lake, the security and safety measures during all phases of the project.

Expected potential impact of the project on environment

Major impact that are expected to arise as a result if the implementation of the project include:

-Positive impacts

-Negative impacts (increased soil erosion, destruction of floral communities and loss of habitat, increased siltation of the lacustrine habitat, etc.)

4.0 Project Areas Description and Baseline information

The existing environmental features, characteristics and conditions, in and around the proposed development site as well as in all locations likely to be affected by the development or by ancillary interventions and operations.

The consultants should also identify (and justify) wherever relevant:

-The geographic area (*e.g.* view shed or other area of influence) that needs to be covered by each study;

-The relevant sensitive receptors vis-à-vis the environmental parameter under consideration (*e.g.* residential communities, other users, natural ecosystems, specific populations of particular species, or individual physical features);

-The location of the reference points or stations (*e.g.* viewpoints, monitoring stations, or sampling points) to be used in the study; and

-Other methodological parameters of relevance, also noting that the assessment will normally require both desktop studies and on-site investigations (including visual observations and sampling, as relevant).

Note: *It is recommended that these details are discussed in advance with Rwanda Development Board prior to commencement of the relevant parts of the studies, in order to pre-empt (as much as possible) later-stage issues.*

The following physical characteristics on the project sites and environment are to be identified and described in sufficient detail, with particular attention to the aspects elaborated further in the next sections.

4.1 Land cover and land

A description of the land cover, land and sea uses within the area of influence of the project, including any roads, footpaths and public access routes. Details should include nature, magnitude, proximity to site, etc.

4.2 Landscape

The study should describe the landscape-related area of influence and landscape setting of the proposed site, identifying the component character areas and local landscape tracts, and the landscape elements.

4.3 Geology, Geomorphology, hydrology and soils

A comprehensive investigation of:

1. The geology and geomorphology of the site and its surroundings,
2. The geo-technical properties and considerations relevant to the site and its area of influence, including: land and lake stability; mechanical, erosional and structural properties of the terrain and land mass; any relevant fissures, faults, hollows, or weak points; the vulnerability of the sites to natural forces such as wave action, erosive elements, landslides and mass movements.
3. The quality of the material that will be excavated

Sampling and testing should comply with the relevant standards and should extend to a sufficient depth below the deepest level of the proposed development

4.4 Lake Kivu water body

The study should identify the hydrological, hydro morphological and physicochemical characteristics of the Lake Kivu from which the gas will be extracted for power generation, water resources and aquatic environments in the area under investigation, including (as relevant):

1. The hydrology of the site and its surroundings,
2. The type, size and physical characteristics of lake Kivu and water bodies within the area of influence
3. Natural dynamics including on-site and off-site drainage and run-off patterns; and,
4. Water quality, including microbiological load (with particular reference to any established bathing water quality parameters)

4.5 Terrestrial and Aquatic Ecosystem Assessment

The impact assessment for the ESIA will follow the revised IFC Performance Standard 6 (IFC PS6, Jan 2012) guidance on biodiversity conservation and sustainable management of living natural resources. IFC PS6 objectives are:

-To protect and conserve biodiversity

-To maintain the benefits from ecosystem services

- To promote the sustainable management of living natural resources through the adoption of practices that integrates conservation needs and development priorities. As part of the IFC PS6, it is a requirement that a conservation value is allocated to the ecological features (protected areas, habitats and species), which are likely to be directly, or indirectly impacted by the Project within an area of influence (AoI). Under the IFC guidance, the requirements of PS6 apply to projects in all habitats, whether or not those habitats have been previously disturbed and whether or not they are legally protected.

4.5.1 Terrestrial Ecology Assessment

The assessment should include:

1. An investigation of the ecology of the site and its surroundings
2. A reporting of the conservation status and ecological condition of the area and the surroundings
3. A reporting of all protected, endangered, rare, unique, endemic, and ecological conditions found in the area under study; and
4. An assessment of the potential impacts of the proposed project on the ecology of the site and its surroundings,

In particular, the study should identify all relevant species and assemblages (*e.g.* protected species or habitats, key species relevant to habitat characterization, and monitoring indicators), and assess their abundance and distribution patterns as well as the species' ecological niches.

4.5.2 Aquatic ecosystem assessment

Characterization of the aquatic ecosystems associated with the 50 MW Gas to power Symbion Power project should include:

-In situ water quality;
-General Habitat Assessment;
-Aquatic Macro invertebrates;
-Fish Species Diversity and Abundance;
-Identification of areas of particular sensitivity or existing impacts;
-Identification of the potential direct, residual and cumulative environmental impacts associated with the proposed project;
-Statement of the degree of potential irreversible damage to aquatic environment;
Recommendation of suitable mitigation measures where applicable.

4.6 Agriculture land

The study should identify any agricultural land within the area of influence of the development, and should provide physical quality and economic characteristics of the land.

4.7 Cultural heritage

The assessment should provide coherent information about the cultural assets present and their relation.

4.8 Air quality

The project may have a great impact on immediate surroundings, specifically in the immediate surroundings of the sites as provided by IFC standards. Possible impacts should be identified, analyzed and addressed.

4.9 Noise and vibrations

This study should provide sufficiently detailed information on representative background levels of noise, vibration and nocturnal lighting (as relevant), as a baseline for assessing the levels and effects expected to result from the development, including any short-term and long-term changes. The study should also take into account other relevant factors related to cumulative impact, additional effects, sensitive receptors and the potential attenuation by environmental factors.

4.10 Infrastructure Services

The assessment should investigate the currently available infrastructural services (access from both land and lake), including details about their carrying capacity, physical condition and other relevant practical considerations.

4.11 Public assess

The assessment should identify the current public access arrangements (particularly the accessibility of the sites and public open spaces), including existing footpaths and other public access routes, and should clearly indicate whether these would be affected and how.

4.11 Working conditions

4.12 Occupational health and safety

4.12 Other relevant environmental aspects and features

Other relevant environmental features or considerations not identified in the preceding sections should also be identified and described, as relevant.

5.0 Analysis of alternatives

An outline of the main alternatives studied and an indication of the main reasons for this choice, taking into account the relevant environmental effects and their prevention (or optimization) at source. The following alternatives need to be duly considered, as relevant to the development itself (or to one or more phases thereof) and its requirements and constraints:

1. Alternative sites.
2. Alternative technologies for construction of onshore and offshore facilities, gas extraction and power generation
4. Operating and maintenance procedures
5. Downscaling of the project, or elimination of project components.
6. Zero option (do-nothing scenario) - i.e. an assessment of the way the site would develop in the absence of the proposed project. [**Note:** The zero option should be considered in sufficient detail as a plausible scenario in the ESIA, wherever relevant, and not discarded upfront without proper discussion of its implications.]

6.0 Impacts predictions and Evaluation

All likely significant effects and risks posed by the proposed project on the environment during all relevant phases (including construction/excavation/demolition, operation and decommissioning) should be assessed in detail. Apart from considering the project on its own merits (i.e. if taken in isolation), the assessment should also take into account the wider surrounding context and should consider the limitations and effects that the surrounding environmental constraints, features and dynamics may exert on the proposed development, thereby identifying any incompatibilities, conflicts, interferences or other relevant implications that may arise if the project is implemented.

In this regard, the assessment should address the following aspects, as applicable for any category of effects or for the overall evaluation of environmental impact, addressing the worst-case scenario wherever relevant:

1. An exhaustive identification and description of the envisaged impacts;
2. The magnitude, severity and significance of the impacts;
3. The geographical extent/range and physical distribution of the impacts, in relation to: site coverage; the features located in the site surroundings; whether the impacts are short-, medium- or long-range; and any transboundary impacts (i.e. impacts affecting other countries);
4. The timing and duration of the impacts (whether the impact is temporary or permanent; short-, medium- or long-term; and reasonable quantification of timeframes);
5. Whether the impacts are reversible or irreversible (including the degree of reversibility in practice and a clear identification of any conditions, assumptions and pre-requisites for reversibility);
6. A comprehensive coverage of direct, indirect, secondary and cumulative impacts, including:

- Interactions (e.g. summative, synergistic, antagonistic, and vicious-cycle effects) between impacts;
- Interactions or interference with natural or anthropogenic processes and dynamics;
- Cumulation of the project and its effects with other past, present or reasonably foreseeable developments, activities and land uses and with other relevant baseline situations; and
- Wider impacts and environmental implications arising from consequent demands, implications and commitments associated with the project (including: displacement of existing uses; new or increased development pressures in the surroundings of the project; and impacts of any additional interventions likely to be triggered or necessitated by situations created, induced or exacerbated by the project);

7. Whether the impacts are adverse, neutral or beneficial;
8. The sensitivity and resilience of resources, environmental features and receptors vis-à-vis the impacts;
9. The probability of the impacts occurring; and

The impacts that need to be addressed are detailed further in the sub-sections below.

6.1 Effects on the environmental aspects

The assessment should thoroughly identify and evaluate the impacts and implications of the project on all the relevant environmental aspects identified in Section 3 above, also taking into account the various considerations outlined in the respective sections.

6.2 Impacts related to Climate Change and Climate Change Adaptation

The assessment should address the following aspects, as relevant:

1. The contribution of the project to greenhouse gas (GHG) emissions and climate change, including:

i.The direct, indirect and off-site GHG emissions and related impacts during all relevant phases of the project, including those arising as a result of the electrical power demand of the project;
ii.Any massive GHG emissions that may occur as a consequence of accidents or malfunctions;

iii.The impacts of the proposal on carbon sinks (*e.g.* wooded/afforested areas, agricultural soils, and marine environments);

iv.The components of the project that are expected to contribute to renewable energy generation on site or to a reduction in GHG emissions through substitution of current generation facilities, including a quantification and critique of their reliability and actual net contribution to climate change mitigation as well as an identification of the impacts of such components on other aspects of the environment (*e.g.* landscape, land take, avifauna); and

v.The implications of the project and its operations and ancillary demands on National GHG emission targets.

2. The implications of climate change on the proposal, including:

vi.The aspects/elements of the project that are likely to be affected by changes or variability in climate- related parameters (*e.g.* temperature, weather patterns, sea level, etc.); The potential impacts that such changes may have on the proposal, including any possible impacts resulting from changes to multiple parameters; and

vii.The adaptability of the project and its components and operations vis-à-vis the relevant climate change parameters and trends.

6.3 Environmental risk

This should be done in accordance with IFC PS1 on Assessment and Management of Environmental and Social Risks and Impacts.

The assessment should also address, in sufficient detail, any relevant environmental risk (including major- accident scenarios such as contamination, emissions, explosions, blast, flooding, major spillages, etc.) likely to result in environmental damage or deterioration. The range of accident scenarios considered should exhaustively cover, as relevant:

i.One-time risks (*e.g.* during construction or decommissioning works);

ii.Recurrent risks during project operation; and

iii.Risks associated with extreme events (*e.g.* effect of earthquakes or any other natural disasters on the project).

The assessment should include, as relevant: a quantification of the risk magnitude and probability; and risk analysis vis-à-vis any hazardous materials stored, handled, or generated on site or transported to/from the site.

6.4 Effects on Human Populations resulting from impacts on the environment

This assessment should also identify any impacts of the development on the workers on sites, surrounding and visiting population (*e.g.* effects on public health or on socio-economic considerations) that may result from impacts on the environment. In the case of health-related effects, reference should be made to published epidemiological and other studies, as relevant, and the views of the Environmental Health Directorate should be sought.

6.5 Acquisition of land and displacement

The loss of land and homes, and the consequent need for relocation and resettlement would be of concern due to the creation of buffer zone between the onshore facilities and the nearest settlement as provided by IFC/Word Bank guidelines. The developer will undertake a survey to determine how much and what type of land and other property will be lost, and what economic and other effects such loss will have on the users and occupiers of land, including loss of access to what is effectively common land. It should be understood that the government would undertake the land expropriation process, even though the impact needs consideration.

PS5 aims to avoid or at least minimize involuntary resettlement wherever feasible by exploring alternative project designs; mitigate adverse social and economic impacts from land acquisition by (i) providing compensation for loss of assets and (ii) ensuring that resettlement activities are implemented with appropriate consultation and disclosure; and improve or at least restore the livelihoods, standards of living and living conditions of displaced persons.

The project will check whether there are indigenous people to be affected by the project. IFC PS7 addresses indigenous peoples and may be excluded if no indigenous peoples will be affected by the Project.

6.6 Labour and working conditions

Impact on working conditions will be assessed in accordance with PS2. PS2 recognizes that economic development should be balanced with workers rights. PS2 aims to: establish, maintain and improve the worker-management relationship; promote the equal opportunity of workers, and compliance with national labour and employment laws; protect the workforce by addressing child labour and forced labour; and promote safe and healthy working conditions.

6.7 pollution prevention and Abatement in relation to waste management

Assessment on compliance with PSE on pollution prevention and Abatement in relation to waste management is required (PS3). It is achieved by implementing GIIP measures as described in the IFC EHS General Guidelines (2007) and The IFC EHS Guidelines for Construction Materials Extraction (2007).

6.8 Occupational health and safety

Impacts on health and safety will be done in consideration of PS2 and PS4.
PS2 and PS4 in relation to occupational and community health and safety respectively requires reference to be made to the relevant Environmental, Health and Safety (EHS) Guidelines. These are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP).

6.9 Cultural heritage

The project will also comply with PS8 on Cultural Heritage which aims to 'protect irreplaceable cultural heritage and to guide clients to avoid or mitigate adverse impacts on cultural heritage in the course of their business operations.
The project will be conducted in line with IFC Performance Standard 8 Cultural Heritage 2012, which aims to preserve and protect cultural heritage by avoiding, reducing, restoring, where possible, and in some cases compensating for the adverse impacts that projects might cause to cultural heritage' (IFC 2012).

6.10 Other Environmental Effects

Any other environmental effects deemed relevant to the project but not fitting within any of the above sections should also be identified and assessed.

7.0 Environmental Management and Monitoring Plan

7.1 Mitigation Measures

The expert should pay particular attention to identifying and recommending measures or practices for avoiding, mitigating or managing negative impacts of the project and for enhancing potential environmental and socio economic benefits. Any potential measures or practice identified by EIA experts should be brought to the attention of Symbion Power Lake Kivu Ltd for possible inclusion in project design and planning.

7.2 Environmental and Social Management Plan (ESMP)

In particular, there will be a preparation of an Environmental and Social Management Plan (ESMP) for construction, operation and decommissioning of the project. The EIA experts should estimate the costs of implementation of this plan including all capital operating and training costs.

The ESMP will describe the modalities provided in the project for the implementation of the proposed mitigation measures to its potential negative impacts. It will also identify and propose the monitoring indicators, the responsibility of each stakeholder, and the timeframe for the implementation of measures with the related costs.

An analysis of potential emergency situation at the gas production site will be taken into consideration focusing on environment and human consequences and mitigation measures that will curb the event.

Residual Impacts

Any residual impacts [*i.e.* impacts that cannot be effectively mitigated, or can only be partly mitigated, or which are expected to remain or recur again following exhaustive implementation of mitigation measures] should also be clearly identified.

Additional Measures

Compensatory measures (*i.e.* measures intended to offset, in whole or in part, the residual impacts) should also be identified, as reasonably relevant. Such measures should be not considered as an acceptable substitute to impact avoidance or mitigation.
If the assessment also identifies beneficial impacts on the environment, measures to maximize the environmental benefit should also be identified.
In both instances, the same practical considerations as indicated vis-à-vis mitigation measures should also apply.

Decommissioning Plan

A decommissioning plan (DP) should also be proposed to address the following circumstances, as relevant:

1. Removal of any temporary or defined-lifetime development (or of any structures, infrastructure or land use required temporarily in connection with it) upon the expiry of their permitted duration; and

2. Removal of the development (or of any secondary developments, infrastructure or land use ancillary to it) in the event of redundancy, cessation of operations, serious default from critical mitigation measures, or other overriding situations that may emerge in future.

The DP should also include, as relevant, a phasing-out plan, proposals for site remediation or decontamination, and methodological guidance on site reinstatement or appropriate after-use.

7.3 Environmental and Social Monitoring Plan

A realistic and enforceable programme for effective monitoring of those works envisaged to have an adverse or uncertain impact. The monitoring programme should include:
1.Details regarding type and frequency of monitoring and reporting, including spot checks;
2.The parameters that will be monitored, and the monitoring indicators to be used;
3.An effective indication of the required action to address any exceedances, risks, mitigation failures or non- compliances for each monitoring parameter;
4.An evaluation of forecasts, assessments and measures identified in the ESIA; and
5.An indication of the nature and extent of any additional investigations (including EIAs or ad hoc detailed investigations, if relevant) that may be required in the event of any contingencies, unanticipated impacts, or impacts of larger magnitude or extent than predicted.
The programme should address all relevant stages, as follows:
(a) Where relevant, monitoring of preliminary on-site investigations that may entail significant disturbance or damage to site features (*e.g.* archaeological excavations, geological sampling, or any works that require prior site clearance or any significant destructive sampling);
(b) Monitoring of the construction phase, including the situation before initiation of works (including site clearance), during appropriate stages of progress, and after completion of works;
(c) Monitoring of the operational phase, except where otherwise directed by RDB where monitoring would be more appropriately integrated into an operating permit); and
(d) Where relevant, monitoring of the decommissioning phase, including the situation before initiation of works, during appropriate stages of progress, and after completion of works.

To maximize the opportunity for good environmental planning and design of the project, the EIA experts should work closely with Symbion Power Lake Kivu Ltd to offer feasible options to enhance the project's environmental performance.

8.0 Public consultations

Symbion Power Lake Kivu Ltd will ensure that all concerned public and private stakeholders in the projects have adequate input during the ESIA study through a well-coordinated stakeholder engagement plan. The ESIA experts should therefore undertake comprehensive consultations with the following stakeholders:

- Symbion Power Lake Kivu Gas Ltd (SPLK), the developer
- Lake Kivu Monitoring (LKMP)
- Rwanda Energy Group (REG)
- Rwanda Environment Management Authority (REMA)
- Rwanda Development Board (RDB)
- Local government authorities (Rubavu District authorities)
- Local communities and NGOs

- Representative of international and regional development agencies and donors and other interested parties in addition to any relevant stakeholders identified when conducting the study.
- Consultations with LKMP will be an opportunity to measure compliance with the Management prescriptions (MPs) and confirm whether the project was designed in compliance with MPs for the Development of Lake Kivu Gas Resources.

9.0 Content of the ESIA report

At minimum, the ESIA report produced by EIA experts should contain information outlined in the appendix of Environmental impact assessment guidelines (2006).

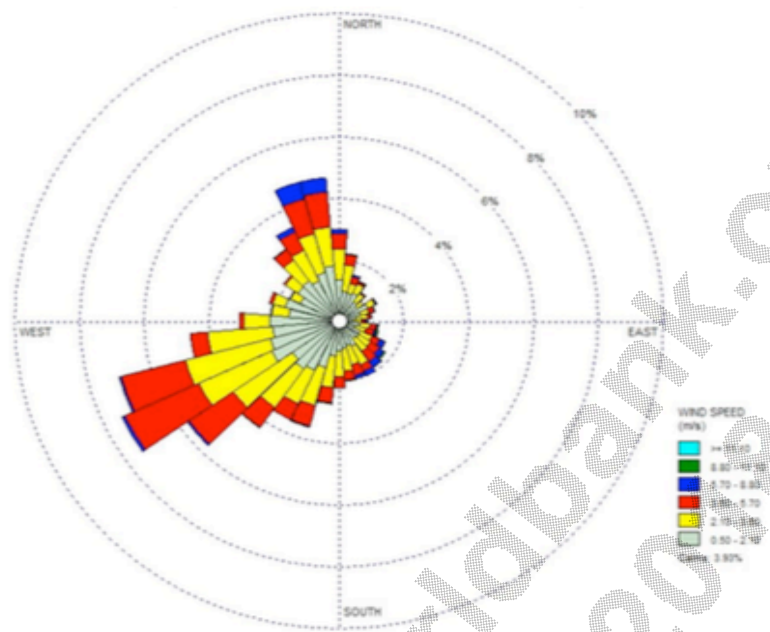
Reporting requirement

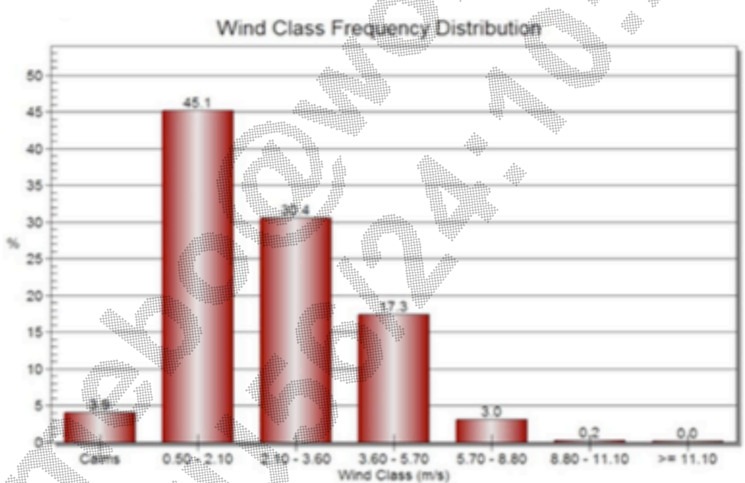
The experts should submit a final ESIA report including Environmental and Social Management Plan (ESMP) to Symbion Power Lake Kivu Ltd who after reviewing and appending an ESIA report addendum to it, if necessary will submit one hard copy and a soft copy (on a CD) of the final draft report to RDB.

The EIA experts and developer should be available for discussion with RDB on the ESIA Report and participate in any hearings organized by Rwanda Environment Management Authority (REMA) if need be.

Annex 5: Wind roses

Annual average 24-hour wind movement statistics



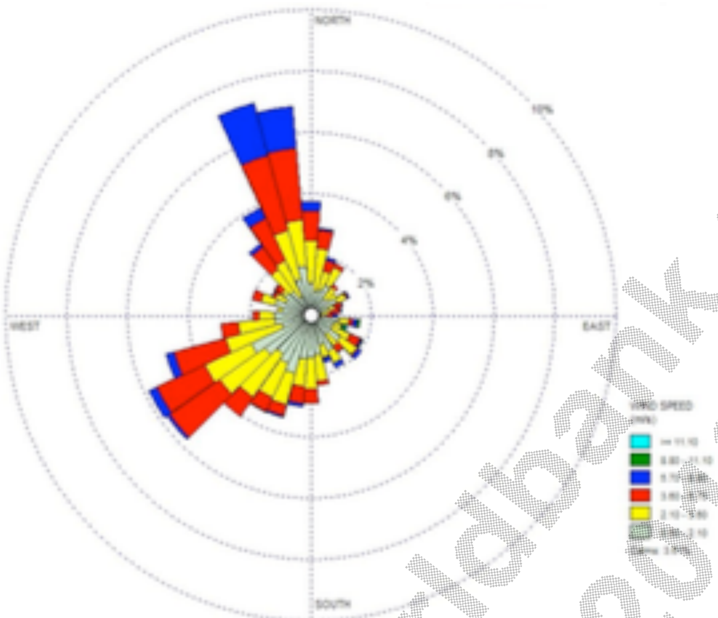


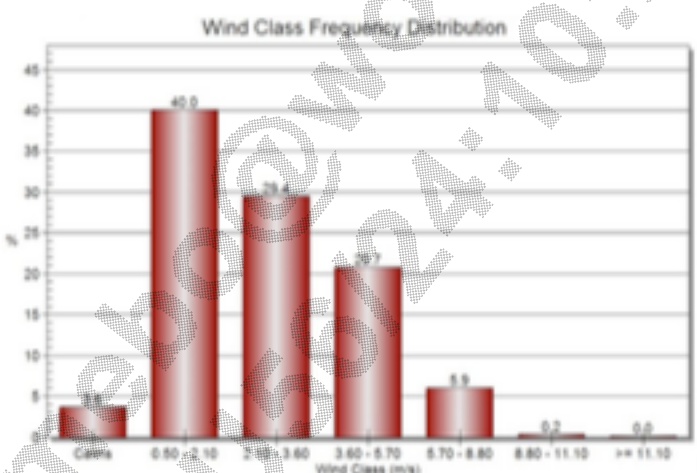
The average annual wind rose was generated from one year meteorology data (2015). This wind rose is generated from the full daily 24 hour Met Data over the one year period.

The wind rose revealed the following wind motion trends:

- The prevailing wind flew from the South West- West direction
- The prevailing wind speeds range from 5.70 – 8.80 m/s
- The bar chart shows the relative frequency of wind speed categories over the one year period

January - March average 24-hour wind movement statistics



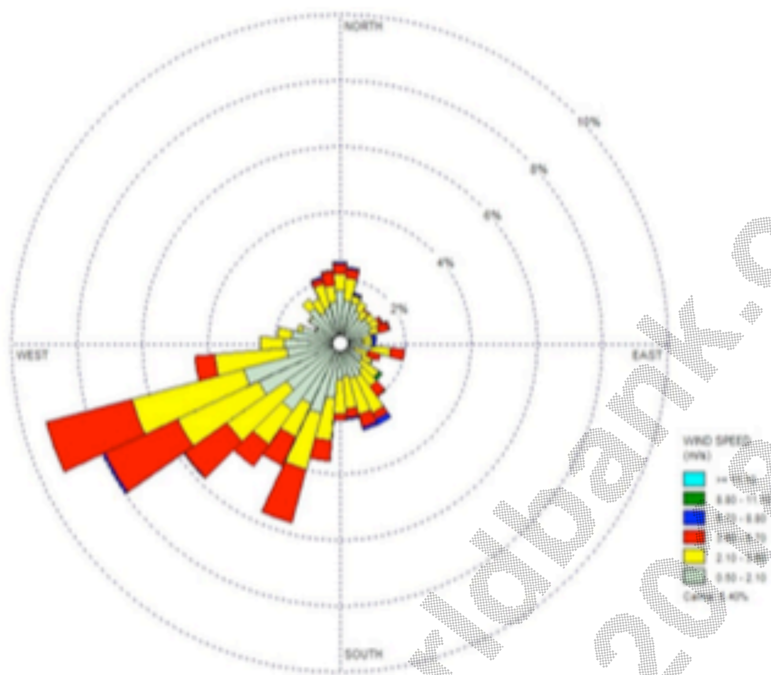


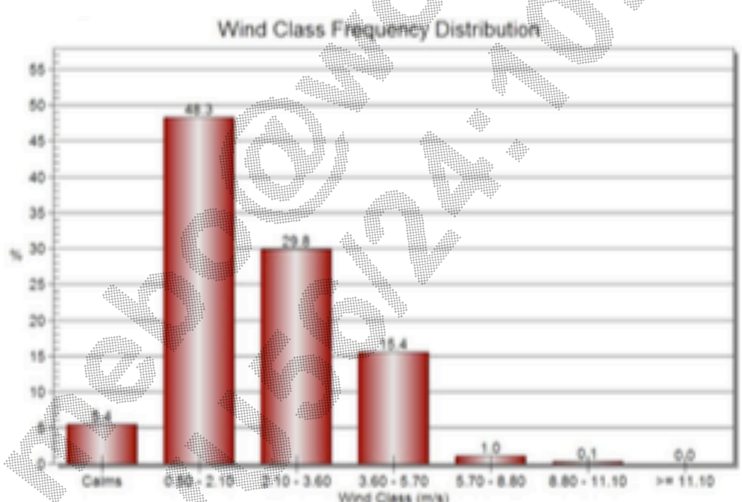
The average wind rose for the annual quarter (January - March) was generated for the one year period using the full 24 hour met data for that period.

The wind rose revealed the following wind motion trends:

- The prevailing winds flew from the North –North West direction
- The predominant wind speed ranged from 5.7 - 8.8 m/s
- The bar chart shows the relative frequency of wind speed categories for the first annual quarter (January - March)

April - June average 24-hour wind movement statistics

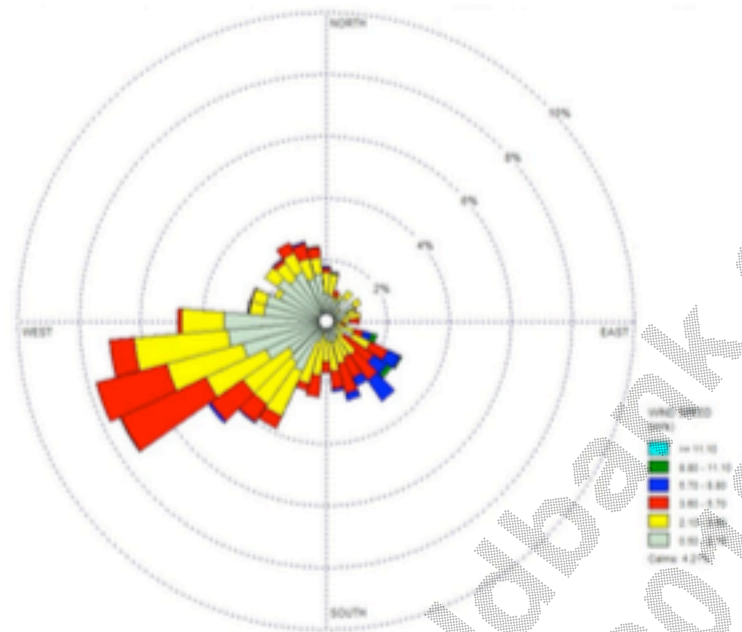


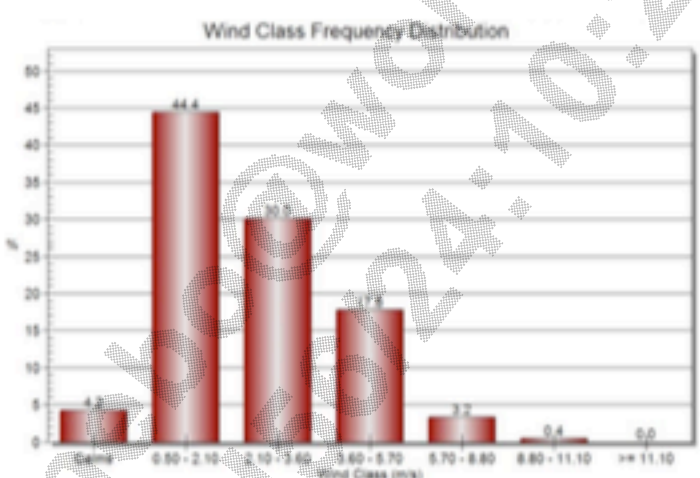


The average wind rose for the annual quarter (April - June) was generated for the one year period using the full 24 hour met data for that period. The wind rose revealed the following wind motion trends:

- The winds predominantly flew from the South West-West direction
- The prevailing wind speeds range from 3.60- 5.70 m/s
- The bar chart shows the relative frequency of wind speed categories for the second annual quarter (April - June)

July - September average 24-hour wind movement statistics

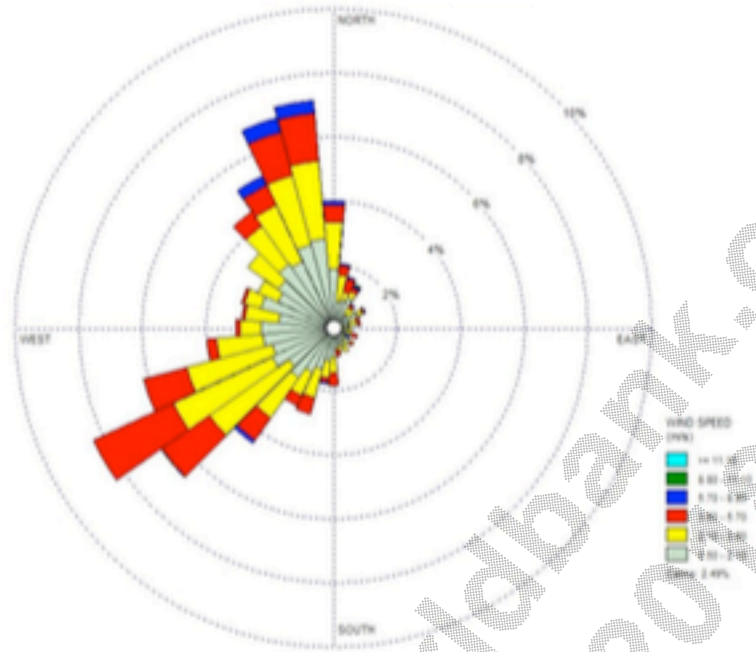
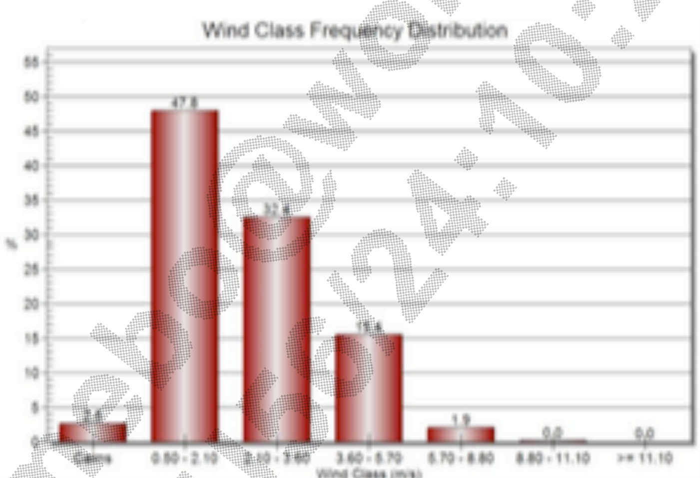




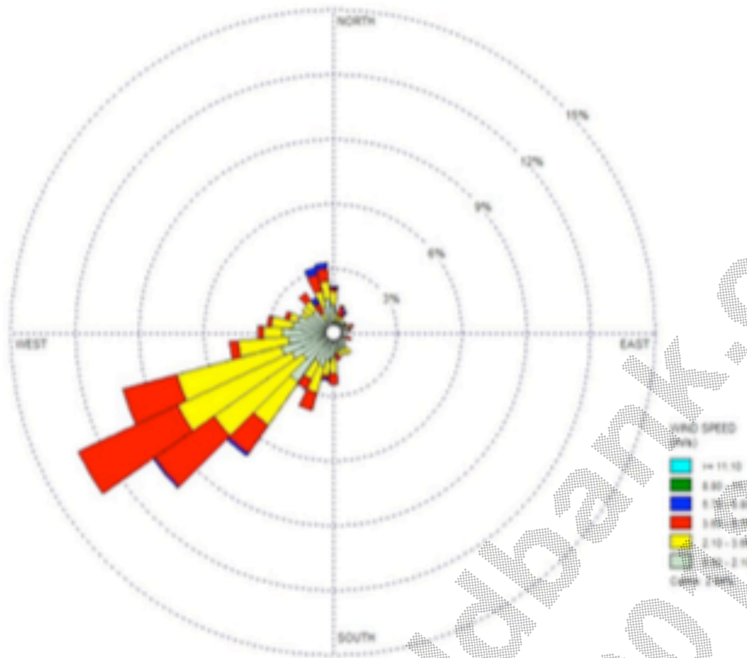
The average wind rose for the annual quarter (July - September) was generated for the one year period using the full 24 hour met data for that period.

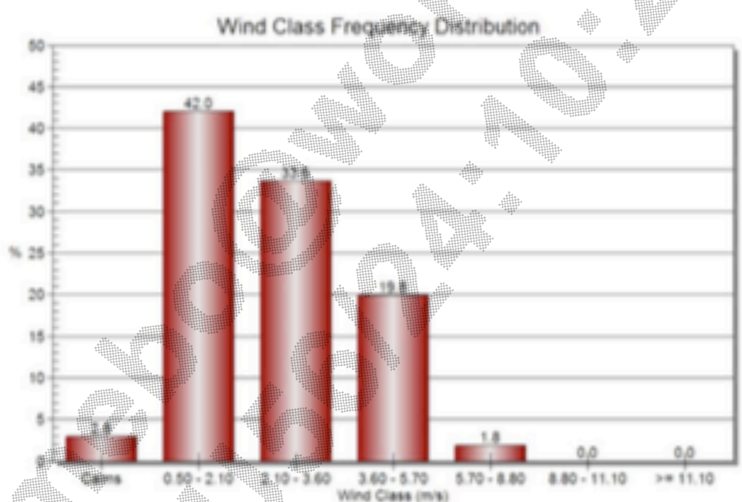
The wind rose revealed the following wind motion trends:

- The winds predominantly flew from South West-West direction
- The predominant wind speeds range from 3.60- 5.7 m/s
- The bar chart shows the frequency of wind speed categories for the third annual quarter (July - September)

October - December average 24-hour wind movement statistics  	The average wind rose for the annual quarter (October - December) was generated for the one year period using the full 24 hour met data for that period. The wind rose revealed the following wind motion trends: • The winds predominantly flew from the South Wes-West direction • The predominant wind speeds range from 3.60- 5.70m/s • The bar chart shows the relative frequency of wind speed categories for the fourth annual quarter (October - December)

October – December average daytime wind movement statistics



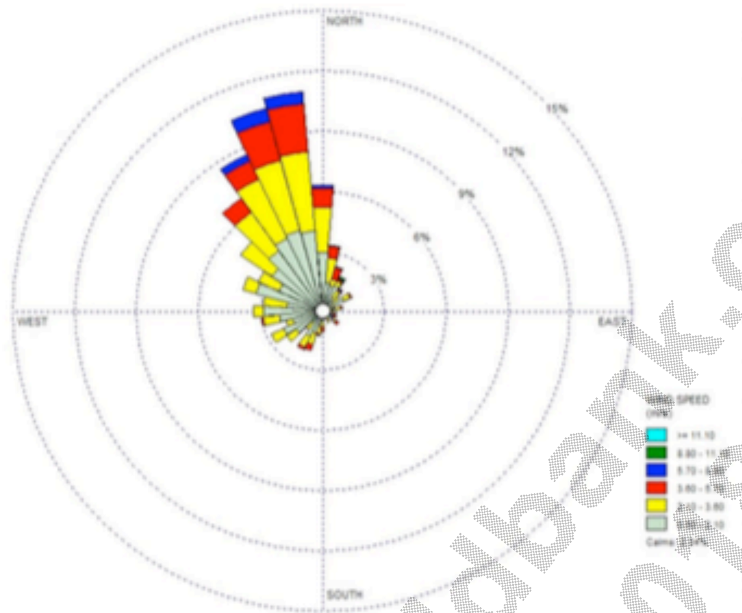


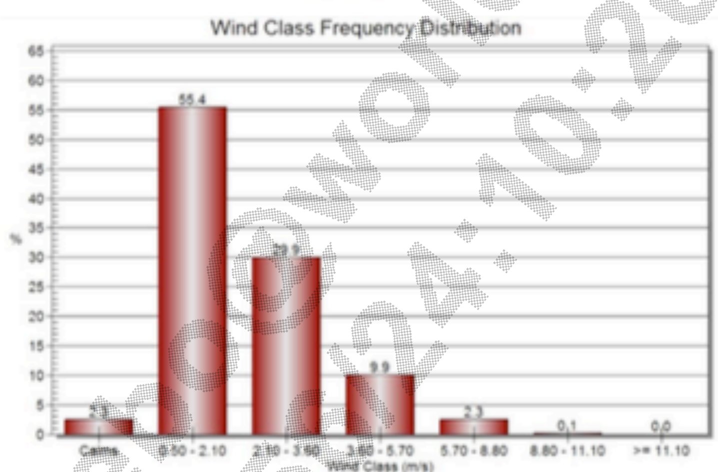
The average daytime wind rose for the annual quarter (October - December) was generated by filtering the source met data from 6:00 hrs in the morning to 18:00 hrs in the evening for that quarter

The wind rose revealed the following wind motion trends:

- The winds predominantly flew from South West-West direction
- The predominant wind speeds range from 0.5 m/s to 8.8 m/s
- The bar chart shows the frequency of daytime wind speed categories for the fourth annual quarter (October - December)

October – December average nighttime wind movement statistics





The average nighttime wind rose for the annual quarter Oct - December) was generated by filtering the source met data from 18:00 hrs in the evening to 6:00 hrs in the morning

The wind rose revealed the following wind motion trends:

- The winds predominantly flew from the North –North West direction
- The wind speeds range from 5.70- 8.80m/s.
- The bar chart shows the frequency of nighttime wind speed categories for the third annual quarter (October - December).

Annex 6: Predicted Ground Level CO and NOx results (24-hour concentraction)

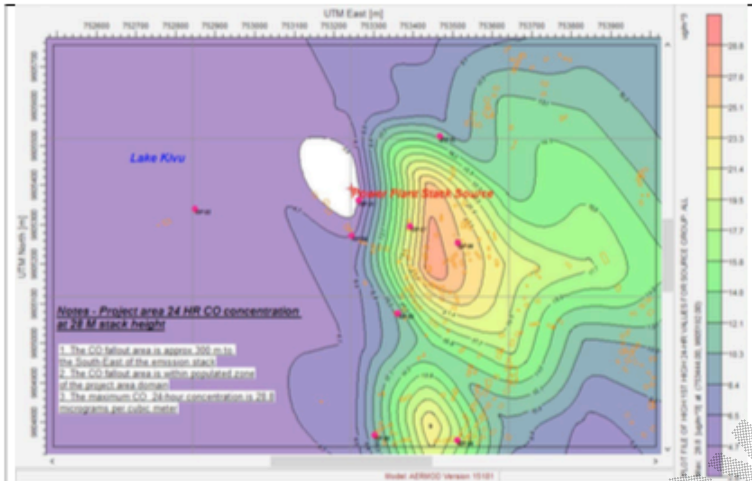


Figure 9: Predicted project area CO 24-hour concentration levels at 28m stack height

Discussion/Results

1. The CO fallout area is approximately 300 meters to the South-East of the power plant emission stack position.
2. The CO fallout area is within the populated zone of the project area domain.
3. The maximum CO 24-hour concentration at 28-meter stack height is 28.8μg/m^3. The ground level concentration is below the East African Standard of 2,000μg/m^3

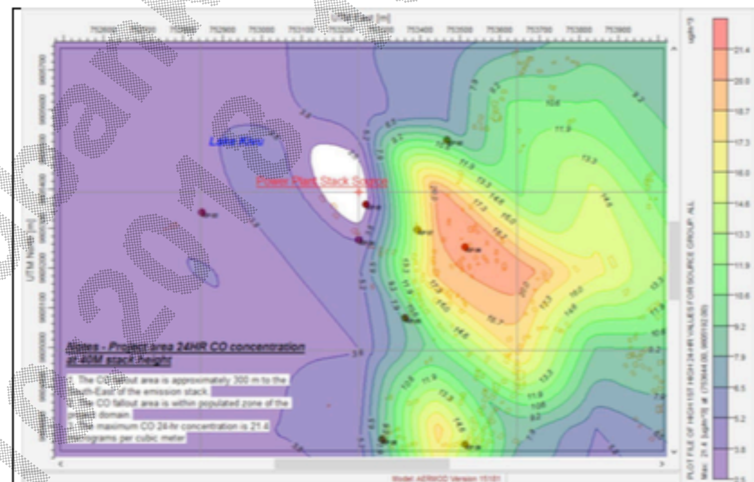


Figure 10: Predicted project area CO 24-hour concentration levels at 40m stack height

Discussion/Results

1. The CO fallout area is approximately 300 meters to the South-East of the power plant emission stack position.
2. The CO fallout area is within the populated zone of the project area domain.
3. The maximum CO 24-hour concentration at 40-meter stack height is 21.4μg/m^3.
4. The predicted ground level concentration is below the East African Standard of 2,000μg/m^3

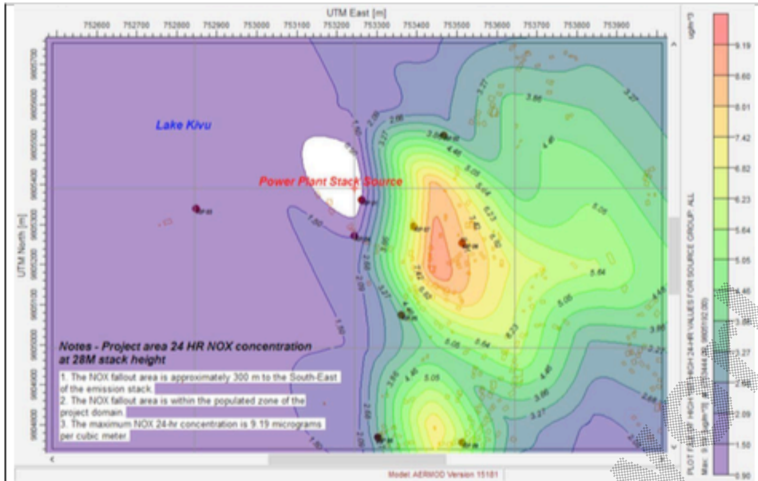


Figure 15: Predicted project area NOX 24-hr concentration levels at 28m stack height

Discussion/Results

1. The NOx fallout area is approximately 300 meters to the South-East of the power plant emission stack position.
2. The NOx fallout area is within the populated zone of the project area domain.
3. The maximum NOx 24-hour concentration at 28-meter stack height is 9.19μg/m³. The predicated value is below the East African Air Quality Standard of 80 μg/m³

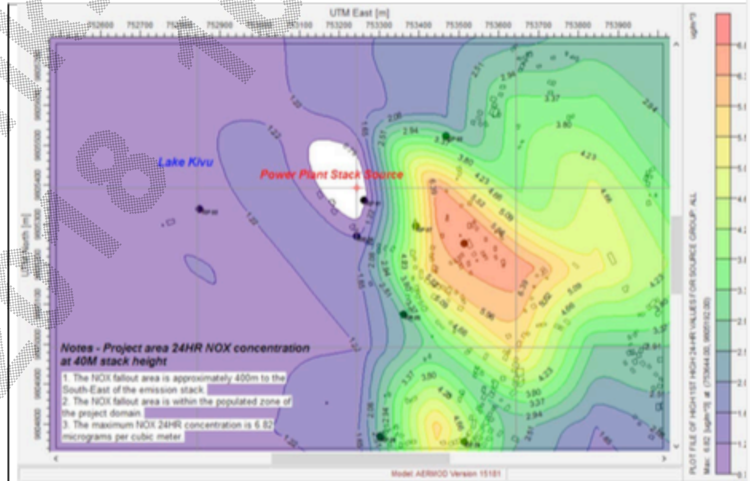


Figure 16: Predicted project area NOX 24-hr concentration levels at 40m stack height

Discussion/Results

1. The NOx fallout area is approximately 400 meters to the South-East of the power plant emission stack position.
2. The NOx fallout area is within the populated zone of the project area domain. The predicated value is below the East African Air Quality Standard of 80 μg/m³
3. The maximum NOx 24-hour concentration at 40-meter stack height is 6.82μg/m³. The predicated value is below the East African Air Quality Standard of 80 μg/m³

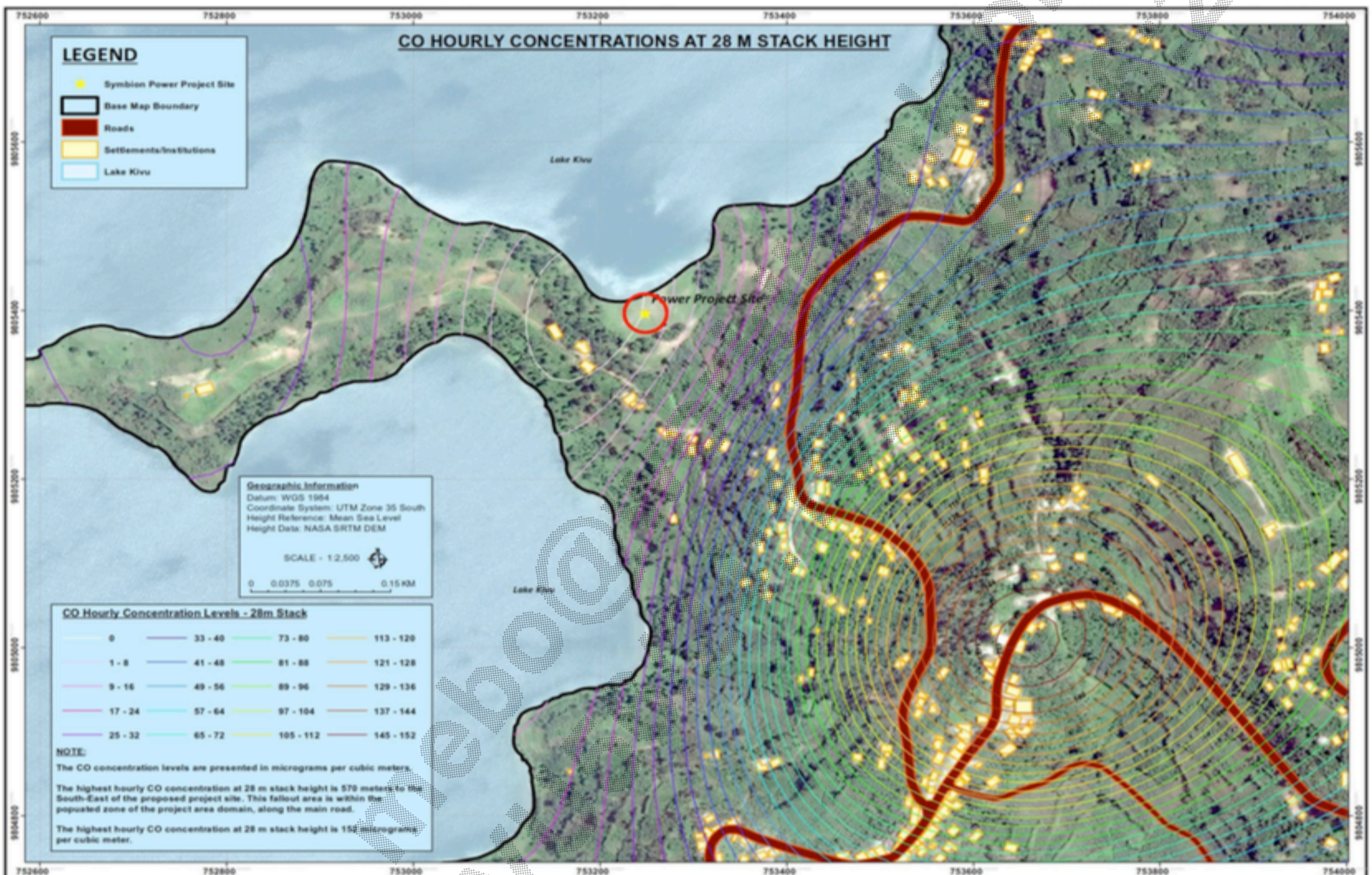
Annex 7: List of people to be affected by the project

Updated list of affected properties (Symbion Project)

	Code	Name	Area(m^2)	ID
1	3/03/09/02/190	MOHAMED Amid	400	1196170025407096
2	3/03/09/02/189	NSHIMIYIMANA CALLIXTE	151	1197480047450064
3	3/03/09/02/188	BAZIMAZIKI CYPRIEN	204	1197680048424028
4	3/03/09/02/187	GUMIRA GILBERT	923	1196880002989026
5	3/03/09/02/186	NYIRABAJYAMBERE FRANCOISE	547	1196170025407096
6	3/03/09/02/185	MOHAMED Amid	300	1196170025407096
7	3/03/09/02/184	GASENGE MARCELINE	427	1193170003703065
8	3/03/09/02/183	GUMIRA GILBERT	1770	1196880002989026
9	3/03/09/02/182	NSHIMIYIMANA CALLIXTE	333	1197480047450064
10	3/03/09/02/181	NYIRABAJYAMBERE FRANCOISE	523	1196170025407096
11	3/03/09/02/180	NSHIMIYIMANA CALLIXTE	149	1197480047450064
12	3/03/09/02/179	HAGUMA PASCAL	7210	1196580030096060
13	3/03/09/02/178	HITIMANA ASSOUMANA	226	1196080073959110
14	3/03/09/02/177	MUHAWENIMANA HASHIMU	466	1195780024795059
15	3/03/09/02/176	HITIMANA ASSOUMAN	816	1196080073959115
16	3/03/09/02/175	MWAVITA AFWA	63.6	1196070033551010
17	3/03/09/02/174	MUHAWENIMANA HASHIMU	149	1195780024795059
18	3/03/09/02/173	NSHIMIYIMANA CALLIXTE	543	1197480047450064
19	3/03/09/02/172	MUHAWENIMANA HASHIMU	164	1195780024795059
20	3/03/09/02/171	NYIRABAJYAMBERE FRANCOISE	524	1196170025407096
21	3/03/09/02/21	GASHAYIJA BAPTISTE	719	1195880027878090

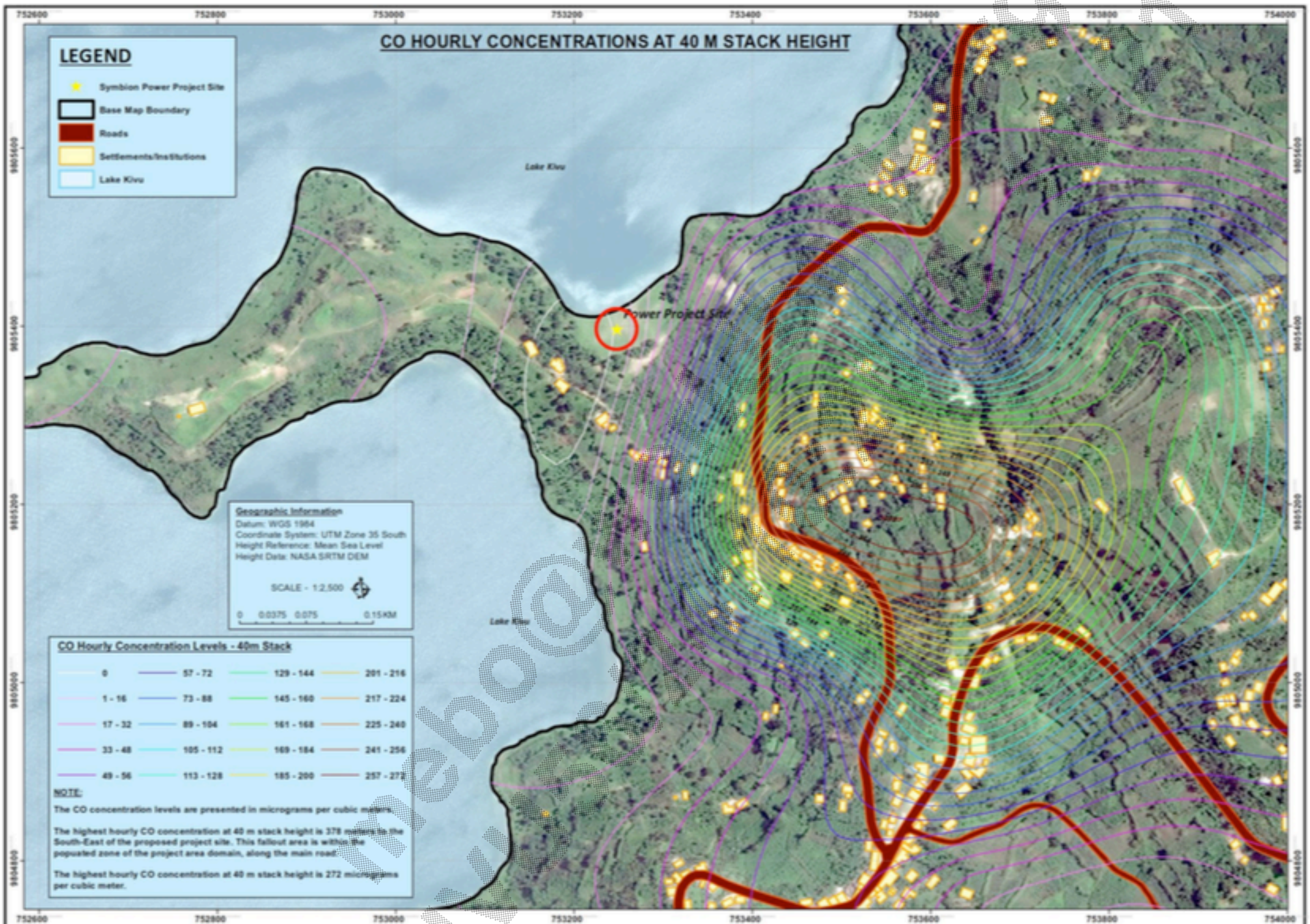
22	3/03/09/02/20	SAUDUBRAY FRANCIS	3210	07CR564124(2011/2017)
23	3/03/09/02/19	HAGUMA PASCAL	597	1196580030096060
24	3/03/09/02/18	NTAWUMENYIZAZA FABIEN	640	1195380019241000
25	3/03/09/02/17	NZABAKURIKIZA CHRISOLOGUE	1070	1194880013318070
26	3/03/09/02/16	MUHAWENIMANA HASHIMU	920	1195780024795050
27	3/03/09/02/13	HAGUMA PASCAL	1270	1196580030096060
28	3/03/09/02/12	NTAWUMENYIZAZA FABIEN	276	1195380019241000
29	3/03/09/02/10	SINANZE OLIVIER	2410	1198580087212060
30	3/03/09/02/9	KAYIHURA LEOPORD	2750	1196980069867050
31	3/03/09/02/8	MUNYANEZA LAURENT	2190	1196180025400160
32	3/03/09/02/7	UKIZEBARAZA GASPARD	1140	'1195680025028070
33	3/03/09/02/6	UYISENGA PHILBERT	6010	1198190075667040
34	3/03/09/02/7775	MARC SADIK	864	5806305073087
1	3/03/09/02/189	ANNE MARIE	151	
2	3/03/09/02/188	ANNE MARIE	204	
3	03/03/09/02/186	MOHAMED Amid	547	1196470075336020
			40856	

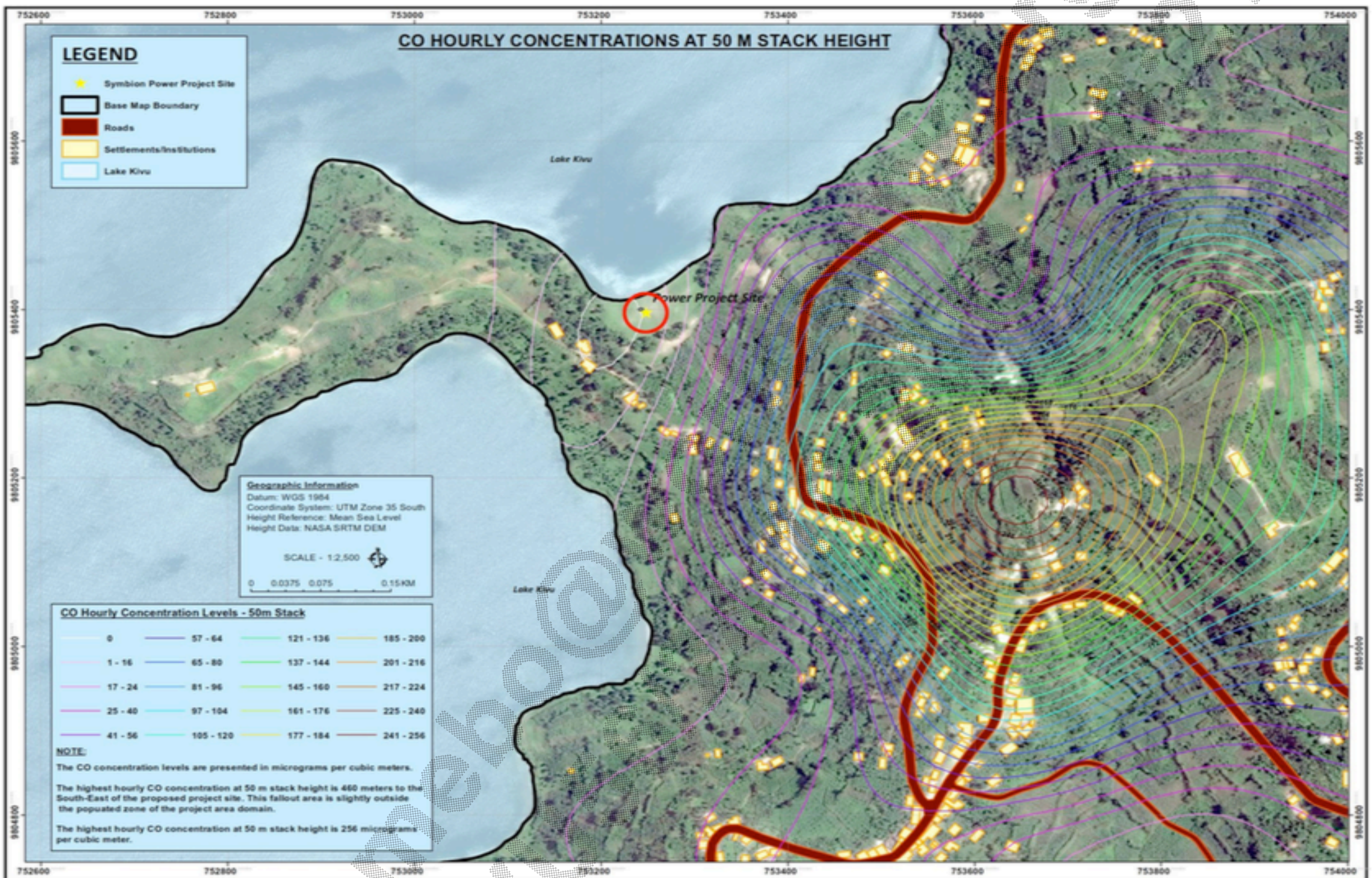
Annex 8: CO and NOx concentrations at 28m, 40m and 50m stack height



Eco design & Protection LTD

SYMBION
SYMBION POWER LAKE KIVU LTD

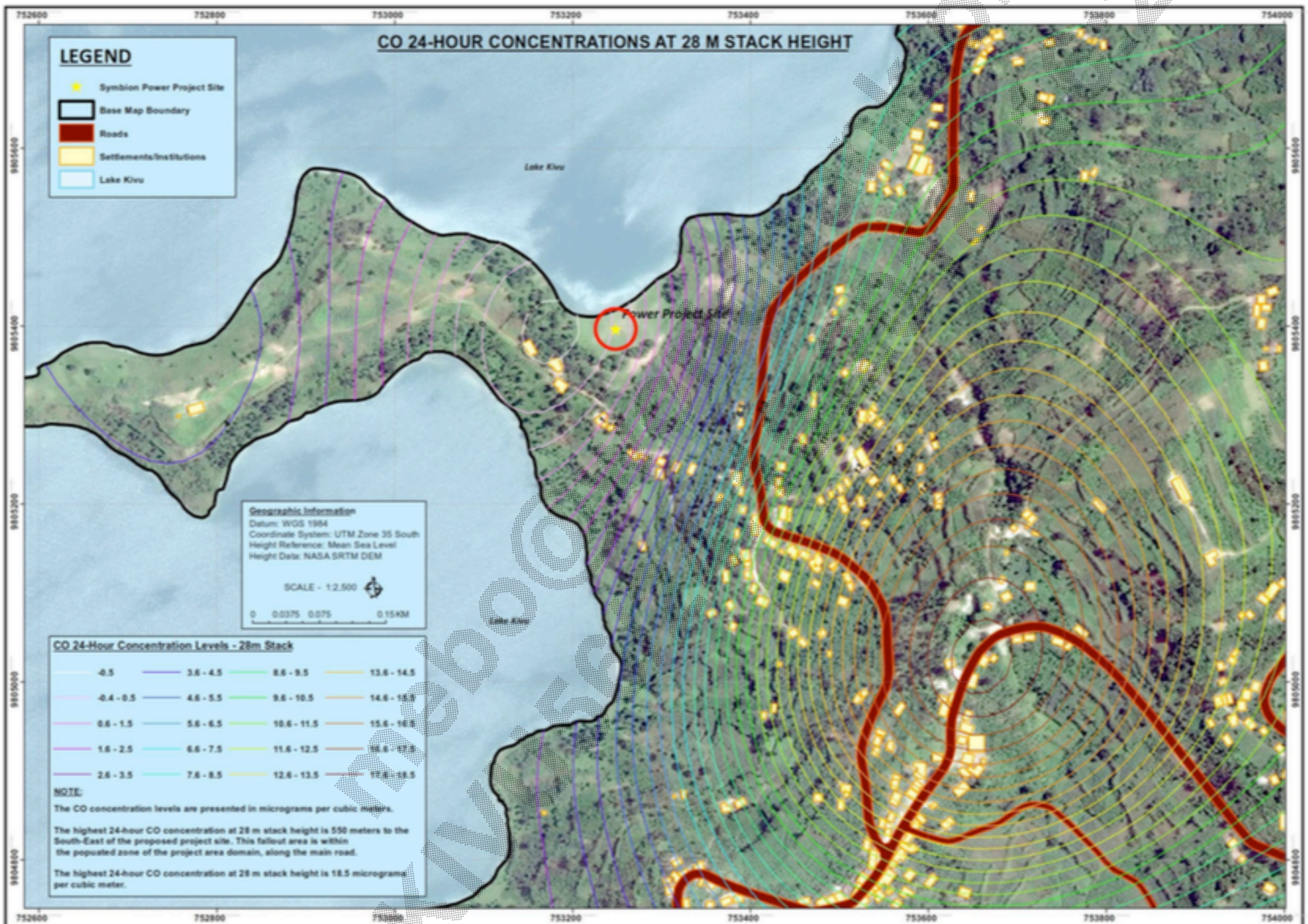

CO HOURLY CONCENTRATIONS AT 40 M STACK HEIGHT
LEGEND
Symbion Power Project Site
Base Map Boundary
Roads
Settlements/Institutions
Lake Kivu
Lake Kivu
Power Project Site
Lake Kivu
Geographic Information
Datum: WGS 1984
Coordinate System: UTM Zone 35 South
Height Reference: Mean Sea Level
Height Data: NASA SRTM DEM
SCALE - 1:2,500
0 0.0375 0.075 0.15KM
CO Hourly Concentration Levels - 40m Stack
0
1 - 16
17 - 32
33 - 48
49 - 56
57 - 72
73 - 88
89 - 104
105 - 112
113 - 128
129 - 144
145 - 160
161 - 168
169 - 184
185 - 200
201 - 216
217 - 224
225 - 240
241 - 256
257 - 272
NOTE:
The CO concentration levels are presented in micrograms per cubic meters.
The highest hourly CO concentration at 40 m stack height is 378 meters to the South-East of the proposed project site. This fallout area is within the popuated zone of the project area domain, along the main road.
The highest hourly CO concentration at 40 m stack height is 272 micrograms per cubic meter.
752600
752800
753000
753200
753400
753600
753800
754000



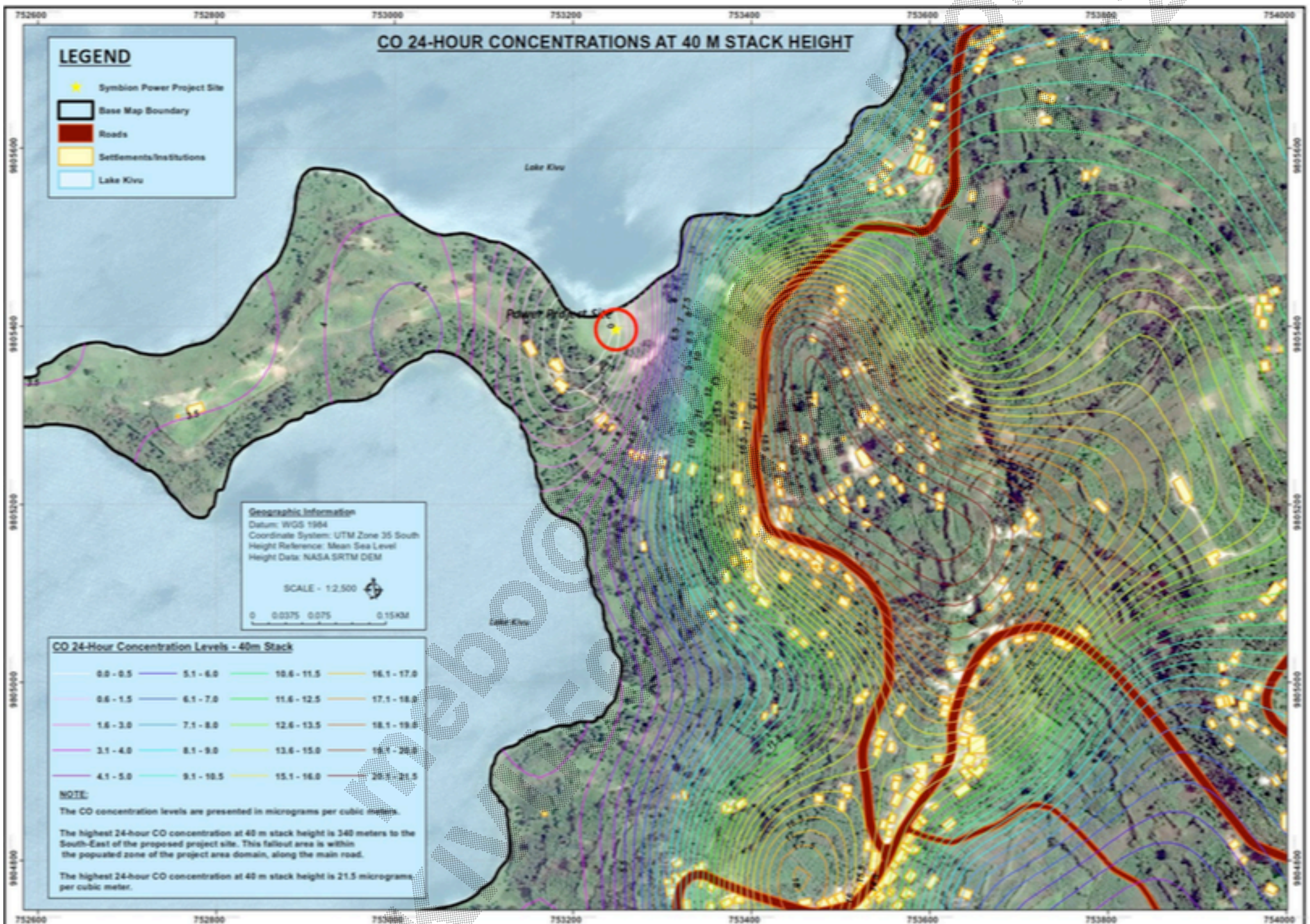
Eco design & Protection LTD

SYMBION
SYMBION POWER LAKE KIVU LTD

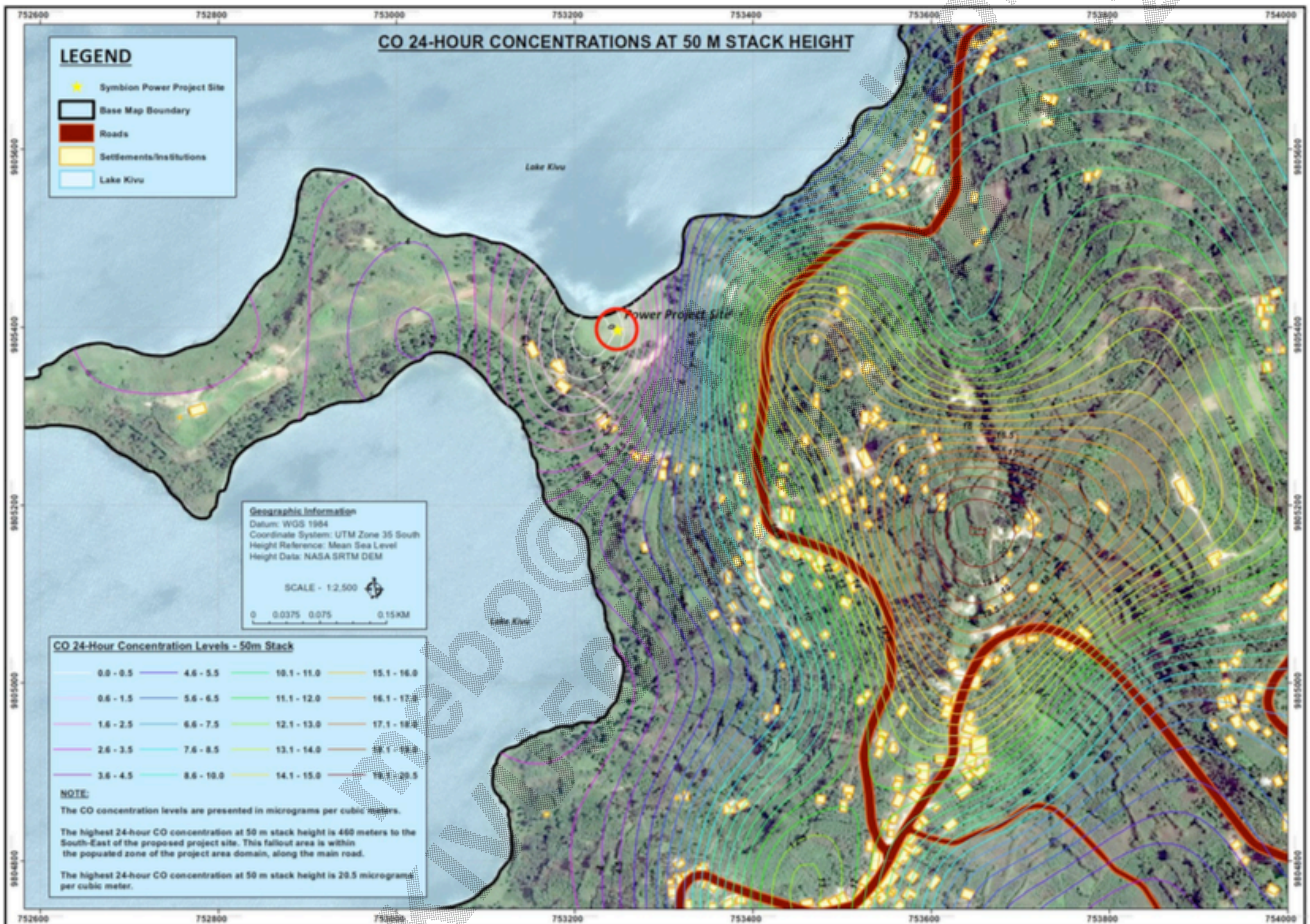
NOx


CO 24-HOUR CONCENTRATIONS AT 28 M STACK HEIGHT
LEGEND
Symbion Power Project Site
Base Map Boundary
Roads
Settlements/Institutions
Lake Kivu
Lake Kivu
Power Project Site
Geographic Information
Datum: WGS 1984
Coordinate System: UTM Zone 35 South
Height Reference: Mean Sea Level
Height Data: NASA SRTM DEM
SCALE - 1:2,500
0 0.0375 0.075 0.15 KM
Lake Kivu
CO 24-Hour Concentration Levels - 28m Stack
-0.5
-0.4 - 0.5
0.6 - 1.5
1.6 - 2.5
2.6 - 3.5
3.6 - 4.5
4.6 - 5.5
5.6 - 6.5
6.6 - 7.5
7.6 - 8.5
8.6 - 9.5
9.6 - 10.5
10.6 - 11.5
11.6 - 12.5
12.6 - 13.5
13.6 - 14.5
14.6 - 15.5
15.6 - 16.5
NOTE:
The CO concentration levels are presented in micrograms per cubic meters.
The highest 24-hour CO concentration at 28 m stack height is 550 meters to the South-East of the proposed project site. This fallout area is within the popuated zone of the project area domain, along the main road.
The highest 24-hour CO concentration at 28 m stack height is 18.5 micrograms per cubic meter.
752600
752800
753000
753200
753400
753600
753800
754000

NOx


CO 24-HOUR CONCENTRATIONS AT 40 M STACK HEIGHT
LEGEND
Symbion Power Project Site
Base Map Boundary
Roads
Settlements/Institutions
Lake Kivu
Lake Kivu
Geographic Information
Datum: WGS 1984
Coordinate System: UTM Zone 35 South
Height Reference: Mean Sea Level
Height Data: NASA SRTM DEM
SCALE - 1:2,500
0 0.0375 0.075 0.15KM
CO 24-Hour Concentration Levels - 40m Stack
0.0 - 0.5
0.6 - 1.5
1.6 - 3.0
3.1 - 4.0
4.1 - 5.0
5.1 - 6.0
6.1 - 7.0
7.1 - 8.0
8.1 - 9.0
9.1 - 10.5
10.6 - 11.5
11.6 - 12.5
12.6 - 13.5
13.6 - 15.0
15.1 - 16.0
16.1 - 17.0
NOTE:
The highest 24-hour CO concentration at 40 m stack height is 340 meters to the South-East of the proposed project site. This fallout area is within the popuated zone of the project area domain, along the main road.
The highest 24-hour CO concentration at 40 m stack height is 21.5 micrograms per cubic meter.
752600
752800
753000
753200
753400
753600
753800
754000

NOx


CO 24-HOUR CONCENTRATIONS AT 50 M STACK HEIGHT
LEGEND
Symbion Power Project Site
Base Map Boundary
Roads
Settlements/Institutions
Lake Kivu
Lake Kivu
Power Project Site
Geographic Information
Datum: WGS 1984
Coordinate System: UTM Zone 35 South
Height Reference: Mean Sea Level
Height Data: NASA SRTM DEM
SCALE - 1:2,500
0 0.0375 0.075 0.15KM
CO 24-Hour Concentration Levels - 50m Stack
0.0 - 0.5
0.6 - 1.5
1.6 - 2.5
2.6 - 3.5
3.6 - 4.5
4.6 - 5.5
5.6 - 6.5
6.6 - 7.5
7.6 - 8.5
8.6 - 10.0
10.1 - 11.0
11.1 - 12.0
12.1 - 13.0
13.1 - 14.0
14.1 - 15.0
15.1 - 16.0
NOTE:
The CO concentration levels are presented in micrograms per cubic
The highest 24-hour CO concentration at 50 m stack height is 460 meters to the South-East of the proposed project site. This fallout area is within the popuated zone of the project area domain, along the main road.
The highest 24-hour CO concentration at 50 m stack height is 20.5 micrograms per cubic meter.
752600
752800
753000
753200
753400
753600
753800
754000