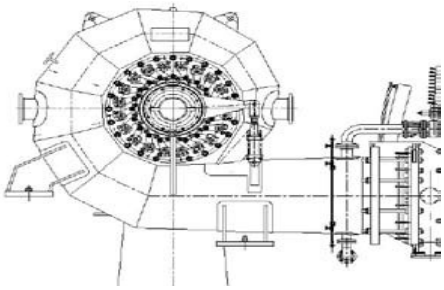
KENYA TEA DEVELOPMENT AGENCY LTD.



METUMI POWER COMPANY

KIRU – GATUNGURU – KANYENYAINI – GITHAMBO TEA FACTORIES

NORTH MATHIOYA SMALL HYDROELECTRIC POWER PROJECT

ON THE NORTH MATHIOYA RIVER IN GACHARAGEINI SUB – LOCATION.

MURANG'A NORTH DISTRICT, KENYA

VOLUME C: ENVIRONMENTAL PROJECT REPORT

FEBRUARY 2013

Prepared by:

Arundhati Inamdar Willetts

NEMA Lead Expert Registration No. 0051

On behalf of:

GRAEME WATSON ASSOCIATES

GWA

DECLARATION: EIA /EA LEAD EXPERT

I, ARUNDHATI INAMDAR WILLETTS, confirm that I have prepared this Environmental Project Report for the proposed Small Hydropower Station on the North Mathioya River, located in Mathioya Division in Muranga North District, in accordance with the Environmental Management and Coordination Act, 1999 and the Environmental (Impact Assessment and Audit) Regulations, 2003. The assessment is based on technical data (including flow data) and the proposed design of the scheme as described in this report.

Signed at NAIROBI on this day of 2009

Signature:

Designation: EIA/AUDIT LEAD EXPERT REGISTRATION NO. 0051

DECLARATION: CONSULTING ENGINEER

I, GRAEME M. WATSON, confirm that this Environmental Project Report for the proposed Small Hydropower Station on the North Mathioya River, located in Mathioya Division in Muranga North District, has been prepared on behalf of Graeme Watson Associates by the above named Lead Expert in accordance with the Environmental Management and Coordination Act, 1999 and the Environmental (Impact Assessment and Audit) Regulations, 2003.

Signed at NAIROBI on this day of 2009

Signature:

Designation:
GRAEME WATSON ASSOCIATES

DECLARATION: PROPONENT

I, , on behalf of the Kenya Tea Development Agency Ltd, hereby submit this Environmental Project Report for the proposed Small Hydropower Station on the North Mathioya River, located in Mathioya Division in Muranga North District, in accordance with the Environmental Management and Coordination Act, 1999 and the Environmental (Impact Assessment and Audit) Regulations, 2003.

Signed at NAIROBI on this day of 2009

Signature:

Designation:
KENYA TEA DEVELOPMENT AGENCY LTD

NORTH MATHIOYA SMALL HYDROPOWER PROJECT
MURANG'A NORTH DISTRICT, KENYA

VOLUME C: ENVIRONMENTAL PROJECT REPORT

CONTENTS

Annexes:

ACRONYMS AND ABBREVIATIONS

AfDB	African Development Bank
BHA	British Hydropower Association
CDM	Cleaner Development Mechanism
EATTA	East Africa Tea Trade Association
EHS	Environment, Health and Safety
EMCA	Environmental Management and Coordination Act, 1999
EMF	Electro-magnetic field
ERC	Electricity Regulatory Commission
ERP	Emergency Response Plan
ESHA	European Small Hydropower Association
GEF	Global Environment Fund
GHG	Green house gases
GTIEA	Greening the Tea Industry in East Africa Project
IARC	International Agency for Research on Cancer
ICNIRP	International Commission on Non-Ionizing Radiation Protection
KFFC	Kenya Fly Fishers' Club
KFS	Kenya Forest Service
KFWG	Kenya Forests Working Group
KPLC	Kenya Power and Lighting Company
KShs	Kenya Shillings
KTDA	Kenya Tea Development Authority
KWS	Kenya Wildlife Service
MWh	Mega Watt hours
NEMA	National Environment Management Authority
RGS	River Gauging Station
SHP	Small Hydro Power
UNEP	United Nations Environment Programme
WRMA	Water Resources Management Authority

PROJECT SUMMARY SHEET

Name of Proponent:	Kenya Tea Development Agency Ltd
Title of Project:	North Mathioya Small Hydropower Project
Location of Project:	Gacharageini Sub- location, Njumbi Location, of Mathioya Division in Muranga North District.
Objectives of Project:	To establish a small hydropower pilot project in Kenya as part of a strategy to reduce electrical energy cost, hence the cost of production, in the tea processing industry and to initiate a process of reducing green house gas emissions whilst enhancing power supply reliability.
Scope of Project:	To construct a diversion weir on the North Mathioya River, as well as a canal, penstock, power house and transmission lines of approximately 16.0 km in length, in order to generate and distribute 4.95 MW of electricity.
Design Flow:	5.30 m/s
Proposed Minimum Environmental Release Flow:	0.589 m^3/s
Current land Uses:	Agricultural – crops grown include tea, coffee, maize, beans
Consulting Engineer:	Graeme Watson Associates
Project Budget: Construction costs: Civil works Electro-Mechanical Equip. Transmission lines Land Overheads including design, supervision and administration **TOTAL:**	KShs ('000) 500,126 147,952 107,056 15,200 30,205 **800,539**

Executive Summary

Introduction

The East Africa Tea Trade Association (EATTA) has commissioned Graeme Watson Associates to carry out a Feasibility Study for Three Small Hydropower Sites in Kenya, being part of the Greening the Tea Industry in East Africa Project (GTIEA), funds for which are being provided by the Global Environmental Facility (GEF) with co-implementation by UNEP and the African Development Bank.

The overall objective of this project is to establish a small hydropower pilot plant, generating 2.925 MW of power, on the North Mathioya River, in Muranga District, as part of a strategy to reduce electrical energy cost, hence the cost of production in the tea processing industry and to initiate a process of reducing green house gas (GHG) emissions whilst enhancing power supply reliability.

The site is located on south-eastern slopes of the Aberdares Range, and is surrounded by numerous small holdings, the majority of which produce tea under the umbrella of Kenya Tea Development Agency (KTDA). The project intends to serve four tea factories of KTDA Region II Zone 3, namely Kiru, Gatunguru, Kanyenyaini and Githambo and will also be inter-connected with the KPLC rural distribution lines in the area.

This Environmental Project Report has been prepared in accordance with the Environmental Management and Coordination Act (1999) and the Environmental Management and Coordination (Impact Assessment and Audit) Regulations (2003). The Report highlights the potential adverse and beneficial environmental and social impacts that are likely to result from the proposed project, makes recommendations for mitigation of adverse impacts, and in addition, indicates whether further investigation or activities are required.

Project Setting

The project site is located in Gacharageini Sub - location, Njumbi Location, of Mathioya Division in Muranga North District. Mathioya Division falls in the western higher grounds with an average altitude of 2500m to 2900m asl. The topography of the project location is composed of undulating ground surfaces characterized by residual dissection, and its altitude ranges from 1,880m to 2100m asl. Climate is characterised by the altitude and topography, and the project area experiences an annual average rainfall of 2000 mm.

The soils of the project area correspond entirely with the typical Aberdares-Mount Kenya topo-sequence. The Gacharageini area is composed of red loam (nitisols) developed on tertiary basic igneous rocks.

The general drainage pattern of the project area is towards the east. This is true for the North Mathioya River as well. The total catchment area is 124.6 km^2 at gauging station RGS 4BD07 and 105.2 km^2 at the intake site. The yearly mean discharge for the North Mathioya River at RGS 4BD07 is 6.98 m^3/s, and whilst that at the proposed intake site is assessed to be 5.89 m^3/s.

The natural vegetation within the project area has been substantially disturbed by human activities. Most of the land has been settled, and small scale to medium scale farming is extensively practiced, the main crops being tea, bananas, potatoes and maize. The Aberdare Range Forests are located some 4 to 6 km to the northwest and west of the project site, but no pristine forests are found along the North Mathioya River within the project area.

Project Components

The North Mathioya scheme is expected to generate nearly 3 MW of power. The scheme will comprise a reinforced concrete diversion weir, some 26m in length and 2.9m in height, which will divert water into a 4.51 km long headrace canal contouring along the southern slopes of the river valley. Water from the canal will enter a forebay immediately north of Gacharageini school, from where it will be discharged via a steel penstock pipe to the power station located on the North Mathioya River bank 650m to the north-east. The water will be returned to the North Mathioya River via a tailrace channel 15m in length, discharging at a river bed level of 1833m.

The water diverted at the intake will be diverted from the river for a distance of approximately 4.5 km. It is intended that all the water diverted will be discharged back into the river at the tailrace outlet with no abstractions en route. Provision is made at the intake weir for a minimum of 0.589 m^3/s of compensation water to pass down the bypassed section of river at all times. This provision constitutes 10% of the mean flow.

In order to connect the power station to the tea factories, a small substation will be constructed adjacent to the powerhouse, step-up transformers will be installed, 1.5 km of 11kV and 14.5km of 33kV woodpole transmission lines will be constructed, and interconnections and switchgear at the four tea factories will be installed.

Construction traffic will for the most part use existing (classified) roads. However, access roads will be constructed to the diversion weir and powerhouse location. These will be all-weather gravel roads of approximately 550m and 500m in length, respectively.

Hydropower generation has no notable by-products or emissions. On the contrary because it is emission free, it is considered to be “green power”. “Effluent” from the power plant will be the discharge that will be directed back into the river some 4.5 km downstream of the intake after the water has flowed through the penstock and the turbine. This will be uncontaminated. Waste will be from solid waste, used lubricants, sanitary waste and wastewater from the Contractor’s Yard during construction and the operators’ houses during operation.

Environmental and Legislative Framework

It is intended that this project complies with all Kenyan legal requirements. Laws and regulations applicable to environmental and social management with respect to this particular project include:

- Environmental Management and Coordination Act of 1999 (EMCA)
- Environmental (Impact Assessment and Audit) Regulations, 2003
- Environmental (Impact Assessment and Audit) (Amendment) Regulations, 2009
- Environmental Management and Coordination (Water Quality Regulations), 2006
- Environmental Management and Coordination (Noise And Excessive Vibration Pollution Control)Regulations, 2009
- Energy Act, 2006
- Water Act, 2002
- Water Rules, 2008
- Wayleaves Act, Cap 292
- Forests Act, 2005
- Lakes and Rivers Act, rev. 1983
- Fisheries Act
- Occupational Health and Safety Act, 2007
- Factories and Other Places of Work (Health and Safety Committee) Rules, 2004
- Factories (First Aid) Rules, 1977
- Factories and Other Places of Work (Fire Risk Reduction) Rules, 2007
- Factories and Other Places of Work (Noise Prevention) Rules, 2005
- Factories (Building Operations and Works of Engineering Construction) Rules, 1984
- Workmen's Injury Benefits Act, 2007.

In addition, guidance has been sought from, amongst others, the World Bank's safeguard policies on Environmental Assessment (OP 4.01), Natural Habitats (OP 4.04), and Involuntary Resettlement (OP 4.12); the AfDB's Involuntary Resettlement Policy (2003) and Integrated Environmental and Social Impact Assessment Guidelines (2003).

International treaties and agreements of relevance to the project are:

- United Nations Framework Convention on Climate Change , the Kyoto Protocol and the Cleaner Development Mechanism
- Convention for Biological Diversity.

Stakeholder Consultations

A public consultation meeting was held on 14th November 2008 at the Chief's Office, Njumbi Location, and chaired by the Chief. Farmers, religious leaders and leaders from the surrounding communities were among those present. The stakeholders were of the general opinion that the scheme would be beneficial to the people within the project area, as it would create employment, support the local economy through the sourcing of construction materials locally, stimulate the informal sector (eg women would be able to supplement their incomes by providing the workforce with meals), and assist in making the production of tea more economic through reduced dependency on KPLC. They were aware that hydropower is cleaner, reliable and cheaper.

However the stakeholders felt that since the demand for power by the tea factories was so high, it was unlikely that they would benefit from any surplus power. They therefore said that the project designers and engineers should ensure that the existing Gacharageini community micro hydropower plant will not be interfered with or affected by the proposed project, and also stressed that they did not want the community hydropower plant to be absorbed by the new project. Another major concern was the acquisition of land for the

canal and transmission lines. The stakeholders requested that any land acquired for the project be compensated in a prompt and fair manner.

Beneficial Environmental and Social Impacts

As mentioned above, the overall aim of this GTIEA Project is to reduce electrical energy cost and use in the tea processing industry, and to initiate a process of reducing green house gas emissions whilst enhancing power supply reliability.

With regard to the North Mathioya Small Hydropower Scheme, it is anticipated that reliable and cost effective renewable electrical energy will be supplied to the four tea factories in the project area, namely Gatunguru, Kiru, Kanyenyaini and Githambo.

The project also intends to provide GHG-free energy to consumers; sell surplus environmentally energy to Kenya Power and Lighting Company; develop local energy resources to benefit the local community; and establish or expand rural electrification potential.

Benefits derived from the project as perceived by the stakeholders have been noted in the preceding section.

Adverse Environmental and Social Impacts and their Mitigation

While small hydropower schemes are generally regarded as being environmentally friendly, several activities that will take place during construction and operation would cause negative environmental and social impacts.

The major environmental issue of concern is the need to allow an adequate compensation flow in the North Mathioya River at all times, in order to sustain aquatic habitats, and consequently aquatic fauna, as well as to provide for user demand downstream. Although virtually 100% of the water that is diverted for the hydropower plant will be returned to the river channel, there is a stretch of river some 4.5 km long that will have diminished flow, and this may affect aquatic flora and fauna (especially fish) downstream of the weir. According to the Water Act of 2002, the Water Resources Management Authority (WRMA) is required to establish compensation flows for all water resources in the country. However, compensation flow values for the North Mathioya River have not been established, nor have guidelines for determining compensation flow been gazetted or approved. In the absence of an accurate compensation value derived from an assessment of hydro-morphological and ecological needs, WRMA recommends using the 95% exceedence flow as the basis for developing a guideline. For the North Mathioya River, this is 2.0 m^3/s, and would jeopardise the economic feasibility of proposed small hydropower scheme. The Water Rules (2007) also stipulate that WRMA may impose special conditions on a licence if the amount of power generated by a hydro project is less than the full hydro power potential of a site. It was therefore proposed by WRMA that the Consultant should propose a compensation value which the Authority will assess for adequacy in terms of ecological and human demand. Thus a compensation flow of 0.589 m3/s has been proposed for the North Mathioya scheme, which is equivalent to 10% of the mean flow. WRMA must therefore make a decision on the

acceptability of this proposed compensation flow on the basis of optimisation of hydropower generation and maintenance of an ecologically acceptable compensation flow.

River flow may also be affected by factors external to the project, namely climate change and deforestation of the Aberdare Forests. Both have implications on hydrological flow in the Mathioya River and, consequently, on the amount of water that can be diverted for power generation.

Pollution due to air, dust, noise, oil and sediments will occur due to construction activities. Soil erosion may occur during construction on the site and along the transmission routes, particularly as a result of earthworks and excavation and, after construction, along the transmission lines. These impacts can be mitigated. Other impacts relate to construction waste and clean up after completion. These are minor, and easily managed.

The most significant social impact is the permanent acquisition of land and destruction of property due to the construction of the headrace canal, forebay, penstock and powerhouse, and some sections of the transmission lines. As these structures will be located in cultivated areas, some crops will also be destroyed. In addition, land will be required temporarily for the establishment of the Contractor's Yard. It is estimated that four households (4) at three (3) homesteads will need to be relocated to other parts of their existing plots (within the existing plot boundaries), but resettlement to a new location will be not be necessary. All land that is acquired and crops that are destroyed will have to be compensated for in accordance with national procedures and requirements.

Occupational health and safety is important during both construction and operation. A full prevention programme must be implemented, appropriate PPE must be worn by all persons working on the installation, and regular maintenance must be carried out on the turbines and power plant machinery as well as on the transmission lines.

Other public health issues are associated with pollution, particularly during construction, the propagation of STD/HIV/AIDS (encouraged by the interaction of the workforce with the local communities) and the disposal of solid and sanitary waste. Proposals have been made to address these impacts. Disturbance to the public will also occur during construction, but not afterwards.

Visual intrusion, in this case, is considered to be a minor impact, as the project infrastructure will not be visually obtrusive once the surrounding vegetation has re-established, and the power transmission lines are mounted on wooden poles, which are less of an eyesore compared with pylons.

Environmental and Social Monitoring and Management

Environmental and social monitoring enables the detection of unforeseen impacts, for which mitigation can then be proposed.

The environmental and social monitoring plan provides parameters that can be monitored, and suggests how monitoring should be done, how frequently, and who should be responsible for monitoring and action.

Monitoring activities that need to be undertaken for the purposes of this project include:

Environmental (Bio-physical) Monitoring

- Culverts and bridges to allow unimpeded flow beneath structures
- Daily measurements of volume of water diverted into headrace canal
- Daily measurements of flow remaining in the river channel
- Efficiency of soil erosion measures
- Noise levels at site boundary
- Noise levels inside powerhouse
- Rehabilitation of gravel borrow pits(s)
- Rehabilitation of cleared areas
- Baseline survey of aquatic flora and fauna, and follow up study 5 years later.
- Provision of support to Kenya Forest Service (KFS), Kenya Wildlife Service (KWS), and the local communities in the management of the Aberdare Forests to maintain current status
- Efficiency of fishway/bypass.

Social/Socio-Economic Monitoring

- STD/HIV/AIDS rates of infection
- Success of compensation plan
- Recruitment of people from local communities
- Recruitment of women
- Security and safety level of site infrastructure
- Use of PPE.

An environmental and social management plan has been prepared to cover all the phases of the project life: planning, design, construction, operation and maintenance. The plan describes each of the main mitigation measures to be implemented, their frequency and timing, and who should be responsible during and after construction.

Other means to enhance environmental management during the project life include training of site personnel, preparation of an environment, health and safety manual and an emergency preparedness and response plan.

During construction, the Supervising Engineer and the Contractor will be responsible for implementing all the proposed mitigation measures, but the overall task of ensuring that mitigation is in fact implemented lies with KTDA for the power station and the transmission lines. When the plant is functional, the responsibility for the operation and maintenance of the project and transmission lines will lie with KTDA.

The cost of environmental and social mitigation and monitoring during construction is estimated at approximately KShs 16,300,000 (US$ 217,340), including costs for compensation for loss of land and crops. In the first year of operation, mitigation and monitoring costs will be in the range of KShs 1,630,000 (US$ 21,740).

Conclusions

The proposed small hydropower project is likely to achieve its intended objectives, as well as realise a number of benefits for the local communities provided that:

- The compensation flow approved by WRMA is maintained in the bypassed section of the North Mathioya River between the intake and the tailrace re-entry point;
- All land acquired for the purposes of the project is promptly and fairly compensated for, and any relocation of affected persons or property is carried out in accordance with national legislation and international guidelines;
- The mitigation measures proposed in this report for addressing adverse environmental and social impacts are implemented; and
- Recommendations made for monitoring and management are adhered to.

1 Introduction

1.1 BACKGROUND

The East Africa Tea Trade Association (EATTA) has commissioned Graeme Watson Associates to carry out a Feasibility Study for Three Small Hydropower Sites in Kenya, being part of the Greening the Tea Industry in East Africa Project (GTIEA), funds for which are being provided by the Global Environmental Facility (GEF) with co-implementation by UNEP and the African Development Bank. The executing agency is EATTA. The Feasibility Study includes an Environmental and Social Impact Assessment Study.

The aim of the GTIEA Project is to:

- Increase investment in small hydropower to reduce energy costs to the tea industry in countries covered by EATTA;
- Improve reliability of power supply;
- Increase power supply for rural electrification; and
- Reduce greenhouse gas emissions (GHGs) through the removal of barriers.

This pilot initiative is programmed over a four year period and has been endorsed by all eight EATTA member countries.

The proposed small hydro scheme located on North Mathioya River on the eastern slopes of the Aberdares has been investigated to pre-feasibility level by IED and reported on in their *Prefeasibility Study: Small Hydro Development in Tea Catchment Areas of Kenya* (January 2005).

The North Mathioya River site was selected on the basis of it having the lowest development cost, in terms of yearly Euro/MWh (210 Euro/MWh), of the sites studied. Depending on the scenario assumed, the internal Rate of Return (IRR) determined by the study varied from 11% to 15.5% which will have to be enhanced to 16% if the project is to benefit from selling certified emission reduction units and also qualify as Cleaner Development Mechanism (CDM).

The site is located on south-eastern slopes of the Aberdares Range, North West of Muranga town. The surrounding area is occupied by numerous small holdings, the majority of which produce tea under the umbrella of Kenya Tea Development Agency (KTDA). The project intends to serve four tea factories, the nearest being located at Gatunguru, about 1km away from the powerhouse location.

1.2 OBJECTIVES OF THE ESIA STUDY

The objective of this study is to provide KTDA with an indication of the environmental viability of the various technical options proposed, as well as to identify the key environmental issues and risks associated with the proposed project. In addition, an environmental impact assessment (EIA) is required to be carried out in accordance with the Environmental Management and Coordination Act of 1999, in order to obtain

the necessary statutory licenses and permits to establish the small hydro power plant, and to meet the requirements of banks and financing institutions.

1.3 STUDY APPROACH AND METHODOLOGY

This study has been conducted in accordance with the Environmental Management and Coordination Act of 1999 (EMCA), and the Environmental (Impact Assessment and Audit) Regulations, 2003, which provide the basis for procedures for carrying out EIAs.

Since neither screening nor scoping was carried out for this project, the Consultant has prepared this Environmental Project Report in accordance with the Environmental (Impact Assessment and Audit) Regulations, which stipulate that a project report be submitted to NEMA as the first step in the EIA process. This Project Report therefore highlights the possible environmental and social impacts resulting from the project, proposes means for mitigation of adverse impacts, and indicates where further investigation is required.

As stipulated in the Consultant's Technical Proposal for the assignment, where further investigation is required, this has been indicated in the Project Report. However, the Project Report does not contain an extensive baseline, nor were detailed investigative studies carried out.

The Consultant has also indicated whether a resettlement action plan (RAP) is necessary or not, but a RAP has not been prepared under this assignment, as this is beyond the scope of the Project Report. Moreover, a RAP should not be undertaken unless it is confirmed that the project will proceed, and the final design and transmission routes agreed upon.

The Environmental (Impact Assessment and Audit) (Amendment) Regulations, 2009, stipulate the prescribed fee for an EIA licence as being 0.05% of the total project cost to the maximum of KShs 1,000,000, of which 50% is payable upon submission of the project report, and the remaining 50% is payable on collection of the EIA licence.

Field work for this EIA study was conducted between September 2008 and October 2009. During the study, discussions were held with various district officials, stakeholders and the local communities.

2 Description of the Project Area

This chapter describes the current setting around the project area and its area of influence. Data and information presented here have been sourced from various documents which were used for reference, including the *Draft Muranga North District Development Plan 2008-2012*, *the Farm Management Handbook Central Province 2nd Edition, Farm Management Guidelines 2005 Muranga District*, and 1:50,000 scale topographical maps. A list of references is provided in Annex 1.

Baseline surveys on surface and ground water quality, noise, flora and fauna, and socio-economic aspects were not undertaken as part of this study. Where deemed necessary, recommendations have been made for further investigations for these aspects.

2.1 LOCATION

2.1.1 Site Location

The project site is located in Gacharageini Sub location, Njumbi Location, of Mathioya Division in Muranga North District.

This site is located on the south-eastern slopes of the Aberdare range, north-west of Muranga town. The surrounding area is occupied by numerous smallholdings, the majority of which produce tea under the umbrella of the Kenya Tea Development Agency (KTDA). The nearest tea factory to the site is that at Gatunguru, some 1km distant.

The site is located between two ridges, running west to east. Two natural permanent rivers, the Githugi/Hembe and Mathioya Rivers, converge just east of the Fly Fishers Camp to form the North Mathioya River downstream of the bridge crossing.

The proposed intake is located about 600m downstream of the North Mathioya Fly Fishers Camp, and 210m downstream of the existing discharge structure for the Gacharageini Rural Electrification Project (which is currently under construction).

Site location maps are presented in Annex 4, and photographs of the proposed site and project area are presented in Annex 5.

2.1.2 Area of Influence

The proposed project will directly influence the section of river between its intake and the powerhouse, a section of about 5km in length downstream of the intake, as well as the area between the existing road (which runs along the southern slopes of the river valley) and the river itself which forms the corridor for the canal route.

In addition, the area straddling the new transmission line from the powerhouse to its terminus at Gatunguru Tea Factory and the areas underlying the distribution lines

from Gatunguru to the other three tea factories at Kiru, Kanyenyaini and Githambo should also be considered as influenced areas, though in a more indirect manner.

2.2 ADMINISTRATIVE SET UP

Muranga North District is one of the eleven districts in Central Province. It is bordered to the north by Nyeri South District, to the south by Muranga South District, to the west by Nyandarua North District and to the east by Kirinyaga District. It lies between latitudes 0 34' south and longitude 36 East and 37 27' East.

The district occupies a total area of 756 km^2 (excluding a section of the Aberdare Forest which covers 174 km^2).

The district has four administrative divisions, 18 locations and 73 sub locations. There are also three parliamentary constituencies, viz. Mathioya, Kangema and Kiharu, and 32 electoral wards. The district has three local authorities, namely Muranga Municipal Council, Muranga County Council and Kangema Urban Council.

Mathioya Division, within which the project site is located, is one of the five administrative divisions of Muranga District in Central Province. It was hived off the Kangema Division and is located in the northern part of the district, bordering Nyandarua District to the west and Nyeri District to the North. Mathioya Division covers an area of about 221 km^2.

2.3 ENVIRONMENTAL SETTING

2.3.1 Topography, Climate and Rainfall

The topography of Muranga District in general rises from an altitude of 914m asl in the east to 3,353m asl along the crest of the Aberdare Range to the west. The highest areas in the west have deeply dissected topography and are drained by several rivers which include the North Mathioya, South Mathioya and Maragua, all of which flow eastwards eventually joining the Tana River. The land area generally slopes downwards from the crestline of Aberdares to the eastern lowlands of the district.

Mathioya Division falls in the western higher grounds with an average altitude of between 2500 to 2900m asl. The topography of the Gacharageini Sub-location is composed of undulating ground surfaces characterized by residual dissection. The steep river valleys require the construction of bridges to connect one ridgeline to the next; this makes construction and road maintenance difficult and expensive.

The climate in Muranga North District exhibits a higher level of rainfall and an increase in the agro-humid period, which is characteristic of increasing altitudes, due to the effect of south eastern trade winds.

The rainfall pattern is bimodal in nature with the "long rains" falling between the months of March and May and the "short rains" between October and December. The annual average rainfall reaches a maximum of 2700mm at 2500m asl. However

Mathioya Division is generally wet and humid due to the influence of the nearby Aberdare Range and Mt Kenya massif. Long term data for the rainfall around the project area was not readily available from the local authorities, but for the purposes of the hydrological study carried out for the engineering study, information for a number of years has been obtained from the tea factories involved, ie Kiru, Kanyenyaini, Gatunguru and Githambo Tea factories. These records indicate that the area received substantial rainfall (ranging between 1400 - 3500 mm annually) between 2005 and 2007, and that the average annual rainfall is in the region of 2000 mm, which is distributed throughout most of the year, due to the topographical influences described earlier.

The maximum daily temperature ranges between 26 º C and 30º C, while the daily minimum temperature ranges between 14º C and 18º C.

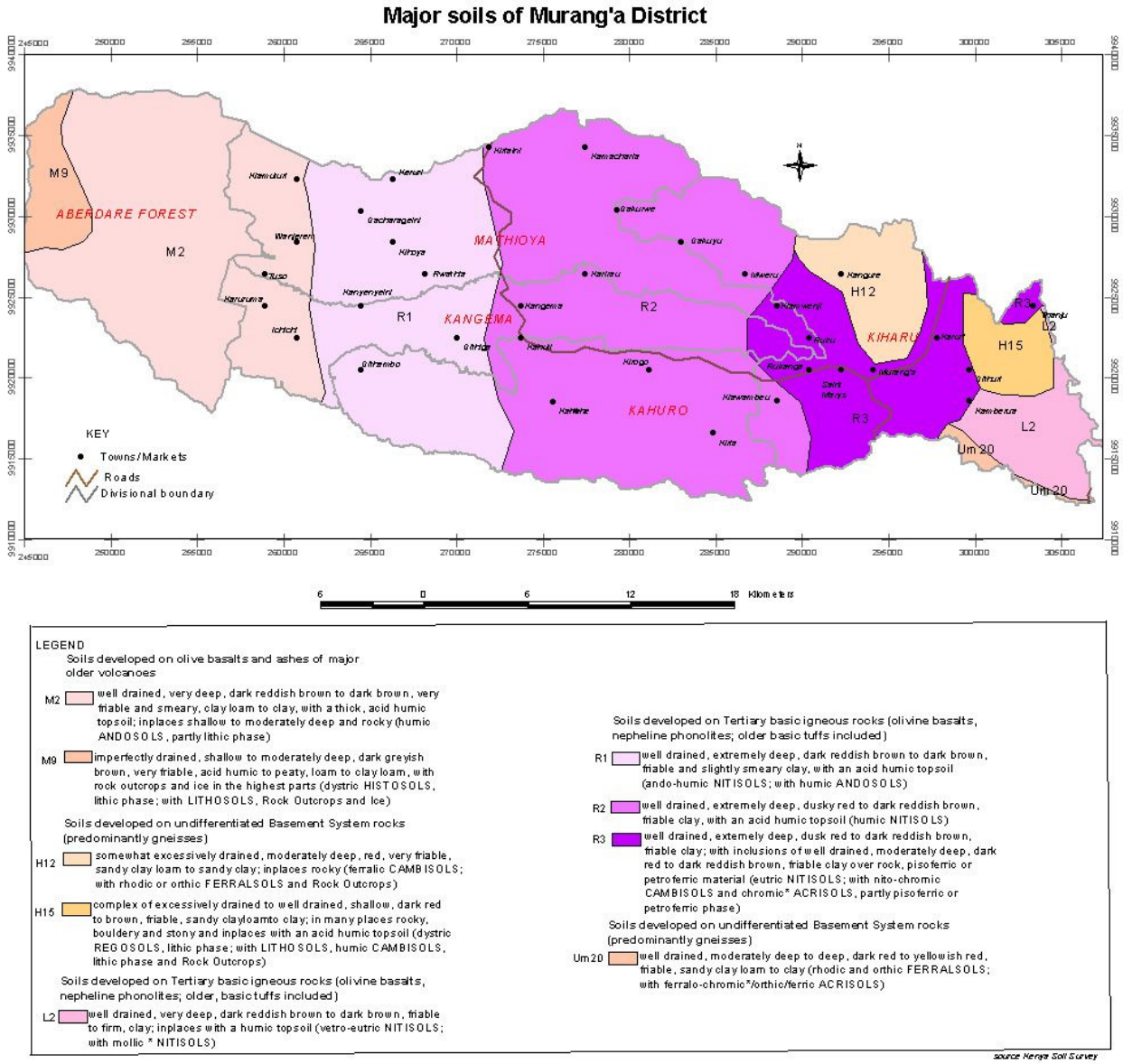
2.3.2 Geology and Soils

The geology of the district consists of volcanic rocks of the Pleistocene age and basement system rock of Achean type. Volcanic rocks occupy the western part of the district bordering the Aberdares, whilst Basement rocks are found in the eastern parts of the district. Porous beds and disconformities within the volcanic rock system form important aquifers, collecting and allowing movement of ground water, thus regulating water supply from wells and boreholes.

The soils of the project area correspond entirely with the typical Aberdares-Mount Kenya topo-sequence. The Gacharageini area is composed of red loam (nitisols) developed on tertiary basic igneous rocks. The soil description of the area is categorised as R1 which is well drained, extremely deep, dark reddish brown to dark brown, friable and slightly smeary clay, with an acid humic top soil (ando-humic NITISOLS; with humic ANDOSOLS. *(Kenya Soil Survey / Min of Agr. and GTZ, R. Jaetzold, GIS-Cartor. J. Wieczoreck).*

Figure 2.1 overleaf shows the soil types present in Muranga District.

Figure 2.1: Soil Map of Muranga District



Source: Kenya Soil Survey

2.3.3 Hydrology and Drainage

North Mathioya River flows in an easterly direction. Its catchment area is 124.6 km^2 at gauging station and 105.2 km^2 at intake site. Its mean elevation is about 2000 m.

There used to be several active gauging stations in the upper reaches of the Tana basin including one on the North Mathioya river. The latter, RGS 4BD07, is the nearest to the proposed intake site, being located some 12.5 km downstream. Many of the gauging stations, including RGS 4BD07), have not been maintained and have fallen into disuse. However, RGS 4BD07 has been rehabilitated as part of this project to provide up to date flow records, and daily readings have been reinstated since 26 January 2009.

The hydrological analysis for the scheme is based on historical data from RGS 4BD07 available between 1972 and 1996 (which were also the data used for the pre-feasibility study prepared by IED in January 2005), supplemented by the daily readings taken from January to October 2009.

The yearly mean discharge for the North Mathioya River at RGS 4BD07 is 6.98 m³/s, whilst that at the proposed intake site is assessed to be 5.89 m^3/s. The mean monthly, maximum and minimum flows are shown in the Table 2.1 below.

Table 2.1: Mean Monthly Flows at Mathioya RGS 4BD07

Monthly Flows (m^3/s)	Jan	Feb	Mar	April	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Mean	4.7	4.0	5.2	12.0	15.5	7.1	4.1	3.7	3.5	6.8	10.4	6.6
Maximum	30.7	18.8	37.6	54.1	64.3	91.3	7.8	6.5	11.7	30.7	64.5	23.5
Minimum	2.2	1.9	1.7	1.9	2.9	2.1	2.4	2.2	2.1	2.1	2.5	2.6

Source: Development Of a Small Hydro Power Station on the North Mathioya River, Kenya; Hydrological Analysis, June 2009; prepared by GWA based on historical data from Ministry of Water, Nairobi.

Mean monthly flows at the intake were calculated based on historic data supplemented with field and other data. These are presented in the table below.

Table 2.2: Mean Monthly Flows at Intake (Historic plus Supplementary Data) m^3/s

Monthly Flows (m^3/s)	Jan	Feb	Mar	April	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Mean	3.95	3.32	4.28	9.69	12.7	6.00	3.47	3.12	3.00	5.77	8.77	5.61
Maximum	25.9	15.8	31.8	45.7	54.3	77.1	6.59	5.48	9.90	25.9	54.4	19.8
Minimum	1.84	1.41	1.08	1.08	1.41	1.76	2.00	1.84	1.76	1.76	2.09	2.17

Source: Feasibility Study for North Mathioya Small Hydropower Project, Murang'a North District, Kenya; Draft Final Feasibility Study Report; Volume 1; February 2010; prepared by GWA based on historical data from Ministry of Water, Nairobi.

Table 2.3 below shows the percentage duration flow exceeded at the intake. From the table, the flow exceeded 95% of the time is 2.0 m^3/s.

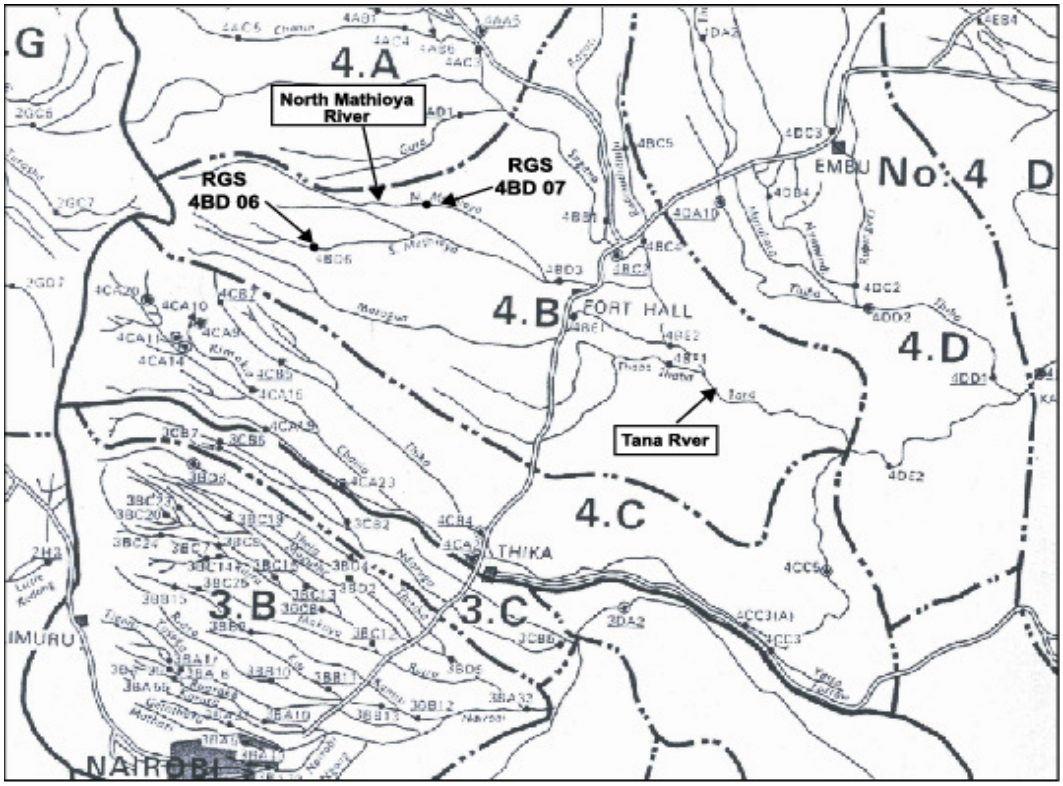
Table 2.3: Percentage Duration Flows at Intake Site (Historic plus Supplementary Data)

% Flow Exceeded	1	5	10	20	30	40	50	60	70	80	85	90	95	98
Flow (m^3/s)	24.9	16.5	11.6	8.14	5.91	4.47	3.80	3.23	2.87	2.62	2.45	2.26	2.00	1.84

Source: Feasibility Study for North Mathioya Small Hydropower Project, Murang'a North District, Kenya; Draft Final Feasibility Study Report; Volume 1; February 2010 ; prepared by GWA based on historical data from Ministry of Water, Nairobi

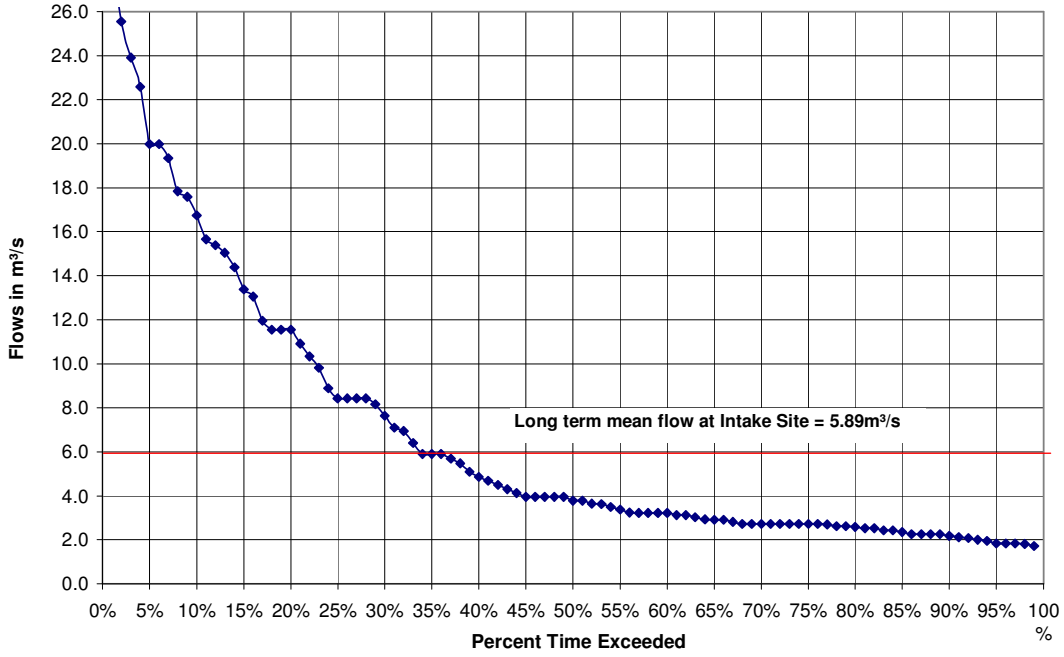
The flow duration curve of the North Mathioya River at the intake site has been generated from 20 years' daily data from RGS 4BD07 transferred on the basis of the catchment area ratio.

Figure 2.2: Location of North Mathioya RGS 4BD07



The correction linked with the difference of watershed areas has been taken into account. This is presented in Figure 2.3 below.

Figure 2.3: Flow Duration Curve at the Intake Site based on RGS 4BD07



Source: : Feasibility Study for North Mathioya Small Hydropower Project, Murang'a North District, Kenya; Draft Final Feasibility Study Report; Volume 1; February 2010; prepared by GWA based on historical data from Ministry of Water, Nairobi

The full hydrological report, together with flow data, is presented in Annex 6 of this report.

2.3.4 Land Use

The project area is located within agro-ecological zone LH1, that is the "Tea-Dairy zone with permanent cropping possibilities dividable into a long to very long cropping season followed by a medium one" (*Ref: Min of Agr. and GTZ, R. Jaetzold, GIS-Cartor. J. Wieczoreck).* Agriculture is the predominant land use within the project area as well as in most parts of the District (see Section 2.4.5 below).

There are also a number of trading centres and social amenities.

2.3.5 Water Resources

The availability and supply of water in Muranga District are dependent on the rainfall regime. The upper agro-ecological zones bordering the Aberdares, where the project site is located, experience plentiful rainfall which feeds the rivers that originate from the mountain range. The Lower Ecological Zone IV in the eastern part of the district receives less than 900mm of rain and is therefore more prone to drought. It has only two permanent rivers hence the need to preserve the seasonal rainfall through catchment and harvesting programmes. Currently 50% of the population depends on streams for water, while 44.5% has access to piped water. The District has proposals

for roof catchments, dams, shallow wells and bore holes to supplement water supplies.

In the Upper Ecological Zones I, II, III existing water schemes, such as those at Kahuti, Mathioya and Gatangu, were designed for a smaller number of people than the present population. The supply of water is therefore inadequate.

The most serious constraint to water supply in the district is the high cost of construction of large scale water schemes and the cost of maintenance. Most of the water has to be treated and the cost of this strains the capacity of the local community, as does the maintenance of the self-help water projects completed with the assistance of the constituency development fund (*Source: Muranga Water Department*). Table 2.4 below gives current permitted abstraction along the North Mathioya River.

Table 2.4: Water Abstraction from North Mathioya River (m^3/day)

NAME	DOMESTIC	IRRIGATION / INDUSTRY	POWER	TOTAL	USE
DIRECTOR OF WATER (GATAMATHI WATER & SANITATION)	2640.0	0.0	0.0	2640.0	PUBLIC USE
SIMON WAIYA	0.0	0.0	2454.5	2454.5	POWER GENERATING
DIRECTOR OF WATER (MURANGA WATER & SANITATION CO.) MUWASCO (MATHIOYA SOUTH INTAKE)	1600.0	0.0	0.0	1600.0	PUBLIC USE
DIRECTOR WATER DEVELOPMENT (MURANG'A WATER SUPPLY)	591.0	0.0	0.0	591.0	PUBLIC
MWANGI AYUB KARIUKI	1.4	163.7	0.0	165.0	DOMESTIC & GENERAL IRRIGATION
SISTERS OF MARY IMMACULATE	91.1	18.2	0.0	109.3	DOMESTIC & IRRIGATION
KIGONDU GICHEHA JOHN	4.5	104.5	0.0	109.1	DOMESTIC & GENERAL IRRIGATION
BEN MBUCHI S. MBATIA	3.6	79.5	0.0	83.1	DOMESTIC & GENERAL IRRIGATION
GABRIEL WAMBURU KURIA	0.5	59.1	0.0	59.5	DOMESTIC & GENERAL IRRIGATION
GIKUNGU GATHARA	1.1	45.5	0.0	46.6	DOMESTIC & GENERAL IRRIGATION
BENSON MWANGI WANDERI	2.3	36.4	0.0	38.6	DOMESTIC & GENERAL IRRIGATION
PETER KARIMI	0.5	36.3	0.0	36.8	DOMESTIC & GENERAL IRRIGATION
KAMAU MUTHUITA	0.0	27.3	0.0	27.3	GENERAL IRRIGATION
WILLIE JOHN KANYEKI	0.0	27.2	0.0	27.2	GENERAL IRRIGATION
MAINA KANINI	0.0	27.0	0.0	27.0	GENERAL IRRIGATION
JAMES MAINA MWATHA	0.5	23.6	0.0	24.1	DOMESTIC & GENERAL IRRIGATION

KEN GEN	22.6	0.0	537,926.4	537,949.0	DOMESTIC USE & POWER GENERATING
SAMUEL MUCHOKI ELIJAH	0.0	18.2	0.0	18.2	MINOR IRRIGATION
GITUGI GIRLS SECONDARY SCHOOL	9.1	9.1	0.0	18.2	DOMESTIC & MINOR IRRIGATION
PETER MAINA MACHARIA	2.3	13.6	0.0	15.9	DOMESTIC & MINOR IRRIGATION
JULIUS KANYINGI MWANGI	2.9	9.1	0.0	12.0	DOMESTIC & MINOR IRRIGATION
NANCY WANGARI ROBERT	0.3	9.1	0.0	9.4	DOMESTIC & IRRIGATION
GACHARAGEINI SUB-LOCATION ELECTRICITY PROJECT	0.0	0.0	35,000.0	35,000.0	POWER GENERATING
NATHANIEL HUNJA (KAMUYU WATER PROJECT)	0.0	0.0	132.4	132.4	POWER TO OPERATE POSHO MILL
WAWERU MACHARIA & COMPANY	0.0	0.0	2454.0	2454.0	POWER
PAULO MUNA KIRATU & COMPANY	0.0	0.0	4908.0	4908.0	POWER
KARUGA ELECTRICITY SELF HELP GROUP	0.0	0.0	15,000.0	15,000.0	POWER
DIRECTOR OF WATER (KAHUTI WATER & SANITATION CO.) (MATHIOYA NORTH INTAKE)				0.0	PUBLIC USE
NICODEMUS KAMAU MANYEKI	9.0	0.9	0.0	9.9	DOMESTIC & IRRIGATION
FRANCIS KIENJI NDIRANGU	1.8	154.5	0.0	156.3	DOMESTIC & GENERAL IRRIGATION
TOTAL	**4984.4**	**862.7**	**597,875.3**	**603,722.3**	

Source: Water Resource Management Authority (Upper Tana Sub Region), November 2008

The table above shows that 99% of the water abstracted is used for power generation and is returned to the river(s), whilst less than 1% is used for domestic purposes.

Discussions with the Water Resources Management Authority's Muranga Sub Region Office revealed that, there is only one licensed water abstractor between the proposed intake and the proposed discharge point. This permit has been in force since the early 1980s and does not affect the river's low flows. Apart from the Gacharageini scheme and the Gatango Water Project (which is not listed in the above list provided by the WRMA's Muranga Sub Region Office), the rest of the licenced abstractors are located downstream of the discharge point of the proposed scheme. WRMA does not plan to issue other licences for now as the agricultural production is based purely on rainfed tea cultivation, and no irrigated agriculture is practised.

2.3.6 Flora

The natural vegetation within the project area has been substantially disturbed by human activities. As mentioned above, most of the land has been settled, and small scale to medium scale farming is extensively practiced. What natural vegetation has remained is basically a mosaic of various vegetation types interspersed amidst

human settlement and farm lands. The area is mainly covered by exotic tree species including A*cacia mearnsii (muthanduku), Grevellia robusta (mukima)*, Cypress and Eucalyptus species. Indigenous vegetation includes *Cordia abyssinica (muringa), Albizia gummifera (mukurwe),* and *Prunus africanum (muiri)* among others. Along the river bank are reeds adapted to the fast flowing river system, and planted tree species mainly comprising *Eucalyptus* spp.

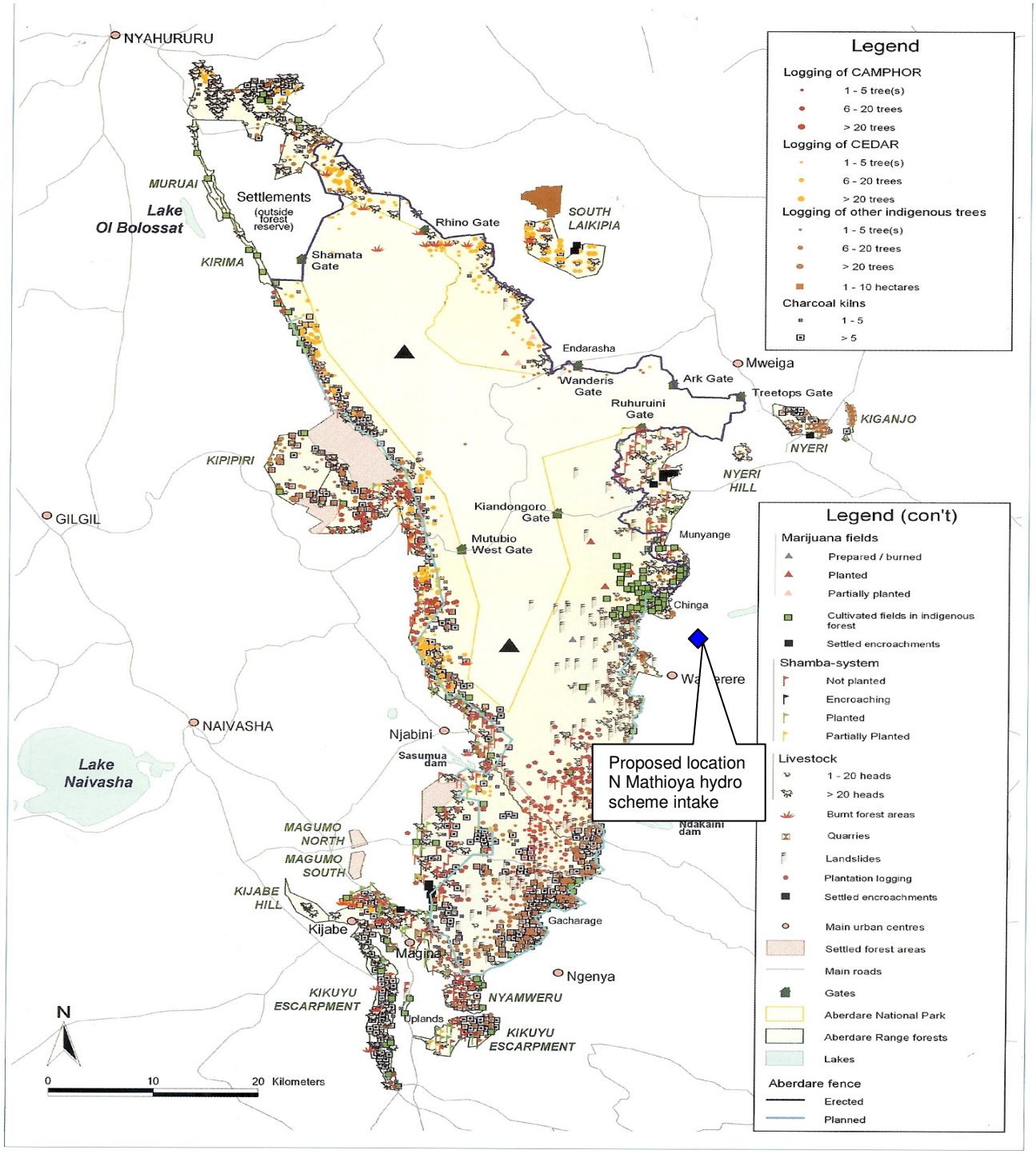
2.3.7 Forests

The Aberdare Range Forests are located some 4 to 6 km to the northwest and west of the project site, but no pristine forests are found along the North Mathioya River within the project area.

An aerial survey of the Aberdare Range Forests conducted by the UNEP, KWS, Rhino Ark and the Kenya Forest Working Group found that the main threats to the forest are logging of indigenous trees (especially camphor and cedar), and clearing of the forest for charcoal production, cultivation of marijuana, agriculture (food crops and cash crops such as tobacco), quarrying and settlement (*Source: UNEP, KWS, Rhino Ark, KFWG; April 2003*). Livestock grazing is also considered a threat, as is abuse of the shamba-system which was originally introduced in order to establish forest plantations. Along the eastern slopes the logging of indigenous trees and illegal cultivation and encroachment are the main issues. These are illustrated in Figure 2.4 below. The survey concluded that the forests of the Aberdare Range *"are being devastated by large scale uncontrolled, irregular and illegal human activities… the ongoing assault poses a grave threat to Kenya's security, biodiversity conservation and economic development*". The chief potential impact of deforestation in the Aberdare Range Forests will be the reduction of water stored in the catchment, and a consequent reduction in flow in the rivers that originate in the Aberdare Range. This is discussed further in Chapter 6.

The concept of agro forestry in Muranga North has been well received. The steep terrain of the district makes agro-forestry a necessity. Trees, Napier grass and bananas are typically grown on the steeper hillsides, while tree shrubs and other food crops are planted on the less steep slopes. Inter-cropping is done to achieve the purpose of soil conservation and intensive use of scarce land resources. Mathioya Division has 38 tree nurseries. *(Source: District Forest Office).*

Figure 2.4: Threats to the Aberdare Forests



Source: UNEP, KWS, Rhino Ark, KFWG; April 2003

2.3.8 Fauna

There is little documentation on wildlife and their numbers in the project area and its environs. Wildlife species and numbers decreased as human settlement and associated activities increased. Thus, within the project area, it is not likely that terrestrial and avian fauna of significant conservation value will be impacted upon.

Fish species found in North Mathioya River include Rainbow Trout *Onchorhynchus mykiss* and Brown Trout *Salmo trutta* (both are introduced species), Eel, Tilapia, Clarias, Common Carp, Labeo, Barbus and Mormyrus. Along the lower reaches of the river (some 42 km downstream), Tilapia and Carp are dominant, while the upper parts are rich in Trout, which favour the cold waters emanating from the Aberdares.

2.4 SOCIAL SETTING

2.4.1 Land Tenure

Land parcels in the area measure approximately one (1) acre and are predominantly agricultural. The land has been subdivided and is individually owned. Parcels of land neighbouring the project site have been settled for quite some time: members of the local community recalled that their forefathers had been living there since colonial times.

All the said parcels of land have titles. There are beacons in place showing the plot boundaries.

Mapping of the area around the project site is satisfactory. The existing cadastral maps are considered valid for legal purposes.

2.4.2 Population and Demographic Characteristics

The 1999 Housing and Population Census recorded a population of 384,304 people for Muranga North District with a growth rate of 0.2% per annum. The population is projected to rise to 356,952 persons by 2010 and 259,630 persons by 2012. The female/male sex ratio in 2007 is estimated at 100:90. The higher female population in relation to the male is attributed to high male out-migration to other districts and towns in search of employment and business opportunities.

Table 2.5: District Population Projections 2010 and 2012

Age Groups	1999			2008			2010			2012		
	M	F	TOTAL	M	F	TOTAL	M	F	TOTAL	M	F	TOTAL
<1yr	4,573	4,747	9,500	4,839	4,833	9,672	4,859	4,853	9,712	4,908	4,901	9,809
1-4yrs	17,747	17,422	35,169	18,069	17,738	35,807	18,142	17,810	35,952	18,324	17,989	36,313
5-14yrs	50,230	49,556	99,786	51,142	50,456	101,598	51,347	50,658	102,005	51,863	51,168	103,013
15-55yrs	76,560	90,920	167,480	77,951	92,920	170,871	78,263	92,942	171,205	79,050	93,876	172,296
55-65yrs	6,801	8,944	35,745	6,925	9,106	16,031	6,952	9,143	16,095	7,022	9,235	16,257
<65 yrs	8,522	11,993	20,515	8,677	12,211	20,888	8,712	12,260	15,972	8,799	12,383	21,182
Total Popn	**164,670**	**18,3634**	**34,8304**	**167,603**	**187,264**	**354,867**	**168,333**	**187,719**	**356,952**	**170,025**	**189,605**	**359,630**

Source: District Statistics Office, Muranga North

Mathioya Division, in which the project is located, has the second largest share of the district's population at 26.4%.

Table 2.6: Population Distribution and Density by Division

Division	Area (sq km)	1999		2008		2010		2012	
		Popn	Density (sq km)	Popn	Density (sq km)	Popn	Density (sq km)	Popn	Density (sq km)
Kahuro	167.9	92,104	552	93,777	558	94,153	560	95,099	566
Kangema	172.7	79,482	482	80,926	468	81,250	470	82,067	474
Kiharu	239.6	84,868	356	86,409	360	86,756	361	87,628	365
Mathioya	175.8	91,839	502	93,507	531	93,882	533	94,825	539
Aberdare Forest	174.0	11	0.06	11	0.06	11	0.06	11	0.06
Total Popn	**930**	**348,304**	**377**	**354,630**	**381**	**356,052**	**383**	**358,630**	**387**

Source: District Statistics Office, Muranga North

2.4.3 Settlement Trends

Muranga North District has diverse settlement patterns which are essentially dictated by the different agro ecological zones that the district possesses, namely the lowland areas, the transitional zone (middle zone) and the upper tea growing areas of the district.

Mathioya Division, in which the project is located, falls in the upper tea growing area and has a density of 531 persons per km^2. The topography of the division generally consists of steep valleys, and human settlements are found along steep slopes and generally limited flat areas.

Kiharu Division, (in the lowland zone) has the lowest population density of 360 persons per km^2.

As mentioned above, most people in the area still live on small family holdings, but many have seen opportunities in business and have moved to the cities.

2.4.4 Ethnicity, Language and Religion

The majority of the residents in Muranga North District are from the Kikuyu community. The WaKikuyu are traditionally agricultural people and have a reputation for being hard working.

The main languages spoken in the district are Kikuyu, Kiswahili and English. The traditional Kikuyu religion is monotheistic. The religion states that Ngai (God) created the land and gave it to the people, thus creating an inseparable bond between man and land.

Colonization eroded many traditional practices and values, although the language has survived and continues to evolve. In the present day, most Kikuyus are Christians and there has been a general decline in traditional beliefs.

2.4.5 Economic Activities

Agriculture

Over 80% of the households in the district depend on agriculture. Average farm holdings are very small with some households occupying less than one acre of land. Crop diversification in Mathioya Division is, however, limited because of the predominantly wet weather and the most predominant crop grown is tea, although dairy farming is also very popular. Coffee is also grown as a cash crop. Other crops grown for subsistence, as well as for sale, include maize, beans, Irish potatoes and cabbages.

Agricultural land is limited and the supply of farm inputs is irregular, particularly to non cash crop growers who are not members of cooperative societies. Prices of the inputs are high and their distribution is not well coordinated. Shortages of inputs lead to low productivity.

Sale of cattle feeds is important in the district; however land for growing fodder is scarce and manufactured feed for cattle and poultry are too expensive for farmers.

While coffee and tea have well defined marketing arrangements in the district, other horticultural crops, such as maize, beans, Irish potatoes and bananas, depend on local weekly markets where prices vary according to demand and supply.

As a consequence of the diminishing area of land available per household or family, households have to purchase their food, and this both bears heavily on household incomes and impacts negatively on other forms of livelihood.

Fisheries

Fishing is an important sector in the district, and the North Mathioya River is one of the most important rivers for this activity. The table below shows the number of fish farmers in the district and the total area under ponds per division.

Table 2.7: Fish Farming in the Muranga District

Division	Fish Farmers No.	Total area Under Ponds m^2
Kiharu	17	2,953
Kahuro	74	4,397
Kangema	44	3,558
Mathioya	***26***	***2,673***
Total	**161**	**13,581**

Source: District Fisheries Office

Off Farm Activities

Off farm employment opportunities such as cottage manufacturing industries, commerce and trade, and "jua kali" activities are the emerging sectors in the economy of the district.

Mathioya Division has a number of upcoming market centres which have flourishing commercial and business activities, and direct commercial links to Nairobi. They have attracted private investment.

2.4.6 Poverty

The district has high poverty levels, and according to the1997 Welfare Monitoring Survey about 39% of the population live below the poverty line. The poor are not able to access the basic necessities of life. The food poor constitute 36% of the district's population. The vulnerable groups hardest hit by poverty include; women, the unemployed youth, widows and orphans, neglected retired old people, the street children and those living in the marginal areas of the district. The table below shows the incidence of poverty by division in the district. Kiharu Division has the largest number of poor, followed by Kahuro Division. Mathioya Division has the least number of people living below the poverty line.

Table 2.8: Percentage of Poor by Division

Division	Population size	% poor persons	No. of poor persons
Kahuro	92,104	35	32,236
Kangema	61,182	30	18,355
Kiharu	84,868	50	42,434
Mathioya	110,139	25	27,535
Total	**348,293**	**140**	**120,560**

*Source***:** *Muranga District Poverty Assessment Report*

Poverty manifests itself in many ways including: inaccessibility to health services, food insecurity, inadequate potable water, lack of good and proper clothing, inaccessibility to proper education and landlessness. However the main causes of poverty in the district include its poor physical infrastructure, which increases the cost of accessing and marketing of agricultural produce, and low returns from coffee, tea and milk, which make it difficult for the entire agricultural community to meet the

costs of their basic needs such as education for children, a balanced diet, shelter, clothing and health care.

2.4.7 Health Profile

Muranga North District has two hospitals, one run by the government and one by a mission. There are four health centres. The district has 44 dispensaries distributed according to concentration of population and 90 private clinics evenly distributed in all the four divisions. The table below shows the distribution of health facilities by administrative division.

Table 2.9: Health Facilities by Division and Establishing Agency

Division	Hospitals	Health Centres	Dispensaries	Private Clinics
Kiharu	1 District (GOK)	–	6 GOK 5 Mission	23
Kahuro	1 Sub- Hospital (GOK)	1 GOK	8 GOK 4 Mission	24
Kangema	–	1GOK	2 Mission 7 GOK	16
Mathioya	1 Mission Hospital	2 Mission	12	27
Total	**3**	**4**	**44**	**90**

Source: *MOH Muranga*

The Muranga District Hospital has the highest share of doctors, clinical officers, nurses and public health officers. The District Hospital is a referral hospital for the health centres and dispensaries in the district. The major constraint in these facilities is inadequate staff.

2.4.8 Education Profile

The table below shows the distribution of education facilities and their enrolment.

Table 2.10: Education Facilities in Muranga North District

	Pre - Primary		Primary		Secondary	
Division	**No**	**Students**	**No**	**Students**	**No**	**Students**
Kiharu	91	2,958	65	22,731	26	5,146
Kahuro	77	2,355	79	22,225	33	7,740
Kangema	85	2,251	55	28,939	25	5,415
Mathioya	***97***	***2,872***	***67***	***22,789***	***28***	***5,689***
Total	**350**	**10,436**	**266**	**86,680**	**112**	**23,990**

Source: *District Education Office, Muranga.*

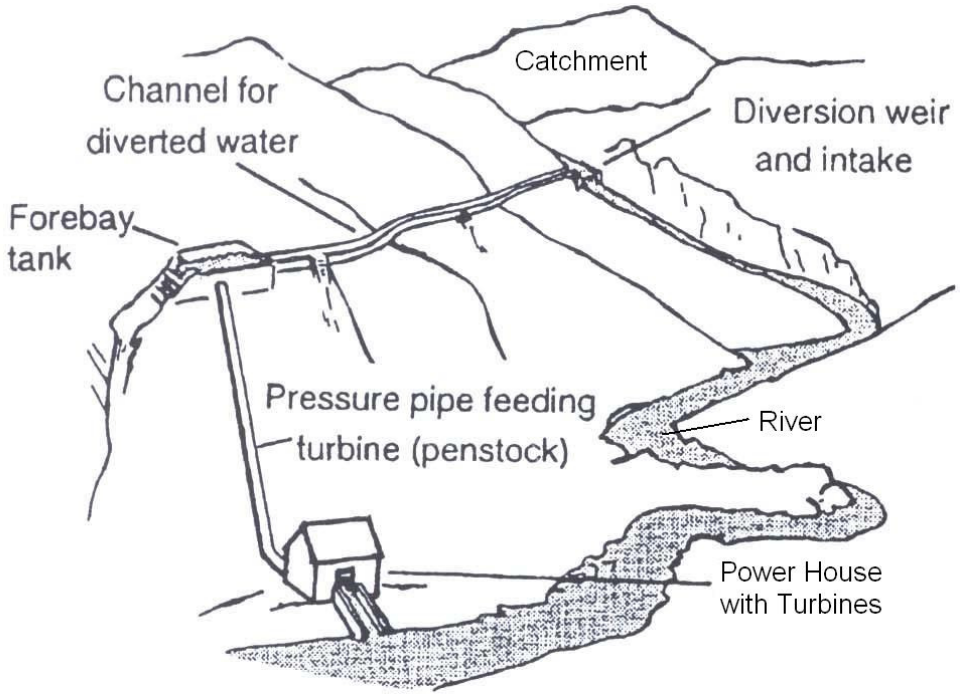
Currently there are 350 pre-primary schools with an enrolment of 10,436 pupils, 266 primary schools with an enrolment of 86,680 and 112 secondary schools with an enrolment of 23,990 students. The teacher pupil ratio at pre-primary level is 1:24, primary level 1:32 and secondary level 1:18.

3 Description of the Project and its Components

3.1 OVERVIEW

There are various definitions of small hydropower (SHP) schemes. The European Small Hydropower Association (ESHA) describes SHP schemes as being those generating up to 10 MW of power, while UNEP and GEF categorise SHP schemes as those generating between 0.2MW and 5 MW of power. The type of scheme that is planned for North Mathioya is presented diagrammatically in Figures 3.1 and 3.2 below.

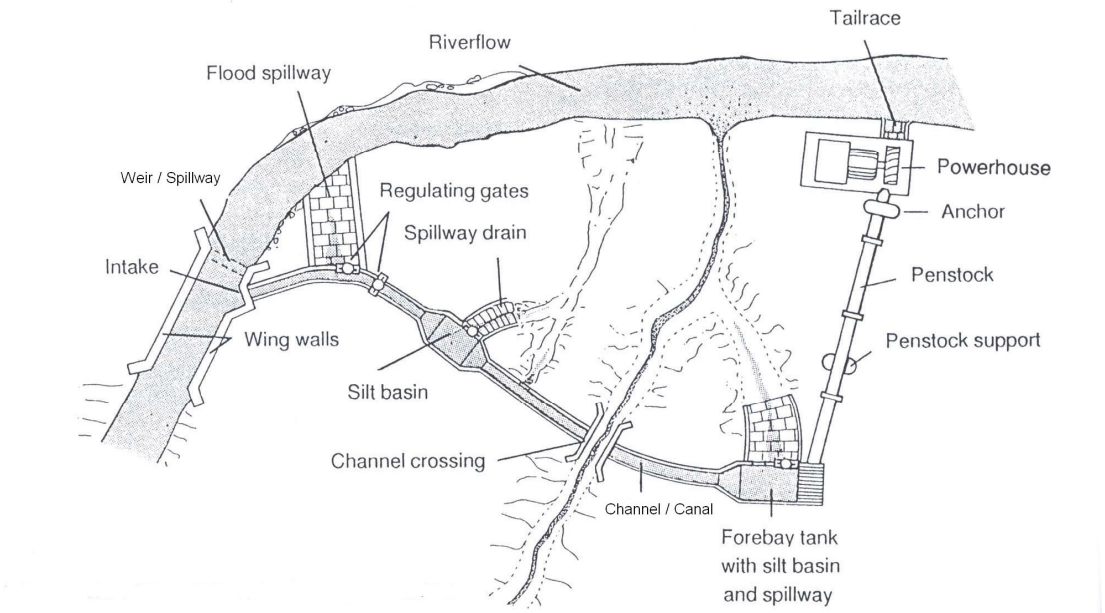
Figure 3.1: General Layout of Small Hydropower Scheme



The North Mathioya scheme is expected to generate 3 MW of power. The scheme will comprise a reinforced concrete diversion weir, some 26m in length and 2.5m in height, which will divert water into a 4.51 km long headrace canal contouring along the southern slopes of the river valley. Water from the canal will enter a forebay immediately north of Gacharageini school, from where it will be discharged via steel penstock pipes to the power station located on the North Mathioya River bank 650m to the north-east. The water will be returned to the North Mathioya River via a tailrace channel 15m in length, discharging at a river bed level of 1833m.

The location of the scheme is shown on Drawing NM / T / 001 in Annex 7 of this document.

Figure 3.2: Principal Components of the Small Hydropower Scheme



The diversion weir itself is located 500m downstream of the confluence of the North Mathioya and Githugi/Hembe Rivers, directly east of the Fishing Camp and 210m downstream of the tailrace outlet of the partially built Gacharageini Rural Electrification Project. The location of the weir has been governed, amongst other factors, by the requirement to ensure that water impounded upstream of it does not affect the discharge of the Gacharageini project. The weir is designed to pass the 1 in 100 year frequency flood, calculated for the chosen site to be 180 m^3/s. The weir will be provided with a low level discharge gate, a compensation water outlet, a fish ladder and an adjustable sluice gate to control flow into the headrace canal.

The catchment area of the river at the site of the weir is 105.2 km^2. The hydrology of the river catchment at this site has been determined from natural river flows recorded at River Gauging Station 4BD07 located where the Kangema – Nyeri road crosses the North Mathioya, some 12.5 km downstream of the proposed weir site. The catchment area of RGS 4BD07 is 124.6 km^2. Daily readings are available from 1976 to 1996 indicating a mean flow of 6.9 m^3/s. A flow duration curve has been generated for the gauge site and transferred to the power scheme intake site on the basis of the catchment area ratio. The flow exceedence values have been determined from the latter as follows:

30% exceedence	5.91 m^3/s
45% exceedence	3.96 m^3/s
60% exceedence	3.23 m^3/s
75% exceedence	2.72 m^3/s
90% exceedence	2.26 m^3/s

The mean flow at the intake site is assessed to be 5.89 m^3/s.

The gross head available for development at the site is 126.9m. The anticipated power capacity of the power station is 2.925 MW which will be developed on the basis of the 42% exceedence flow.

The water diverted at the intake will be diverted from the river for a distance of approximately 4.5 km before it is returned to the river. It is intended that all the water diverted will be discharged back into the river at the tailrace outlet with no abstractions en route. The canal is to be lined to prevent losses of water through seepage. Provision is made at the intake weir for a minimum of 0.589 m^3/s of compensation water to pass down the bypassed section of river at all times. This provision constitutes 10% of the mean flow.

3.2 PROJECT COMPONENTS

The project consists of three components: the power plant, the access roads and the transmission lines.

3.2.1 Small Hydro Power Plant

The power plant components essentially comprise an intake weir, diversion canal, head pond or forebay structure, penstock and the power house. These are described here briefly, while details of the proposed scheme are presented in Annex 7.

The site is located on the North Mathioya river between grid references E262300, N9931755 (intake) and E266400, N9930480 (proposed power house tailrace discharge site).

Intake Weir

The location of the intake weir is based on various parameters, including optimizing the catchment of streamflow, suitability of foundation material and suitability for passing design floods safely. Other considerations influencing the design are hydrostatic pressure and silt load effect, hydrostatic uplift, lateral earth pressure, dead weight of the structure, forces from gates and screens and seismic loads.

The intake weir structure will have an overall length of 34 m, and the width of the spillway will be 26 m. The height of the spillway crest is expected to be 2.9 m above existing river bed level. It will be constructed of concrete, and will have a 2m wide low level scour outlet with control gates. There will be a canal inlet controlled by two sluice gates and a compensation flow[1] outlet pipe.

Flood considerations are also accounted for. In this case the design flood is based on a 1 in 100 year flood, and the spillway for a flood of 180 m^3/sec. Side abutments will be keyed into firm ground on each side of the river valley, whilst the operational

[1] In the Water Act (2002), compensation (or environmental) flow is defined as the flow released from a dam or weir which is required for downstream uses and the Reserve.

fittings of all gates will be located above the top flood flow level. There will be a controlled escape outlet incorporated off the canal in the event of flood flow into the canal.

The inlet gates will have protection screens to prevent the ingress of cobbles, deadwood and debris to the canal which might give rise to blockages and overflows.

A scour outlet will be located on the rock surface on the side of the weir to facilitate operation and discharge sediment. It will be controlled using lockable gates. The levels will be inverted to match the natural river bed. Screens may be provided for protection during flood flows, and the outlet can also be used as a secondary spillway during flood flows.

Headrace or Diversion Canal

River water will be diverted to pass through an open rectangular or trapezoidal lined channel or canal from the intake to the headpond or forebay. The canal length will be 4.51 km, with a bed slope of accommodating a flow rate of 3.0 m^3/sec. The speed of flow in the canal will be less than 1.5 m/s with the canal being lined on its sides and base (to prevent scouring and loss of water through permeation into the ground). The canal will have an escape outlet to facilitate water draw down and desilting (which is also useful as an emergency overflow during flood flows). A silt / sedimentation basin will be located immediately after the intake inlet chamber, and overflow outlets will be provided at convenient locations.

The average general cross slope of the ground varies from 1 in 2 to 1 in 3 (steeper in some few isolated areas), and in some cases valleys with small streams or dry valleys (so-called re-entrants) will be intercepted. Retaining walls and culverts will be constructed at the stream re-entrants.

Most of the canal traverses land under agricultural use, mainly cash crops (tea) or subsistence farming (maize, beans etc). The entire canal route traverses private farmland and therefore land will have to be acquired for construction of the canal. It is estimated that a landstrip of 20m width will be required, affecting some 90 separate landholdings and three household compounds comprising four houses and structures. Together with the headpond, penstock and power house, it is estimated that a total area of 15.5 ha will be have to be acquired. Four families may have to be relocated and resettled, but this can be done within the boundaries of their existing plots.

Head Pond / Forebay Structure

This is located at the canal terminus and its location is determined by the intersection of the canal alignment and penstock route. The forebay ensures the water flow in the canal is terminated and the flow stilled. Here further sedimentation of large suspended particles can take place and provisions are made for this to be flushed out.

The forebay will have two gated inlets for the penstock pipes (both for current use and provision for potential future extension), coarse and fine screens on the frontage

of the inlets gates, a scour outlet gate, a spillway weir, and an overflow channel to clear spillway outflow. The overflow channel will follow a route downhill to a natural watercourse and from thence to re-join the river.

Penstock Pipe

The penstock pipe will run from the forebay / headpond to the power house. This will comprise a welded steel pipe with VJ couplings at the joints. The penstock pipe length will be 660 m, and it will have a diameter of 1250 mm. It will be internally lined with epoxy paint. The gross head will be 130 m. The water flow in the penstock will have a design flow of 3.0 m^3/sec and a flow speed of 2.45 m/sec.

Power House

The location of the power house is dictated by suitable topography and foundation materials, the topography of the river channel with respect to flood flow requirement, and the optimal drop (head) from the forebay/headpond. Vehicle accessibility to the site is also a consideration.

Power house facilities comprise a concrete foundation for the turbines and generators and underlying draft tubes to drain the water from the turbines. The superstructure will be provided with an overhead gantry crane for maintenance and servicing equipment. The installed equipment will consist of three turbines and adjoined draft tubes, three generators, switch and control panels, governors and hydraulic control valves.

A tailrace channel will be constructed to carry water from the draft tubes back to the river. The river banks will be provided with revetments to control scour and prevent erosion.

Miscellaneous Works

Fencing will be required to ensure safety and enhance security at the intake, along the canal, at the headpond/forebay and the power house area.

For inspection and maintenance purposes, an access road will be provided alongside the canal and headpond, as well as to the powerhouse. A minimum access width of 3.5m is required for tracking. The access road will be constructed from compacted earth fill excavated from the canal.

Operators' offices and residential facilities will also be provided.

3.2.2 Transmission Lines and Routes

The hydropower station will be supplying power to the four tea factories of KTDA Region II Zone 3, namely Kiru, Gatunguru, Kanyenyaini and Githambo and will also be inter-connected with the KPLC rural distribution lines in the area. A total of 1.5 km of 11kV and 14.5 km of 33kV woodpole supported transmission lines will require to be constructed.

The transmission lines will be constructed in accordance with KPLC standards. The alignment will be chosen on the basis of seeking an optimal balance between minimising the length of transmission line required, minimising crossings of the KPLC network, facilitating access for maintenance purposes and reducing the acquisition of wayleaves to be obtained and impacts on agricultural activities. It had initially been anticipated that the transmission lines would generally follow existing road reservations. However, due to the high density of existing KPLC lines, the narrowness of many of the tea road reservations, and the windiness of the roads in the hilly terrain, a substantial proportion of the transmission lines will, of necessity, be across country. Wayleave rights will acquired for all 16 km.

The prospective layout of the powerlines is shown on Drawing NM / T / 001 in Annex 7.

3.3 CONSTRUCTION METHODOLOGY

The components which will be constructed will include the following:

i. General Items

The general items include the preliminary works required for the Contractor to mobilize and proceed with construction on site, including establishment of a secure site office, storage and working yard, camp type accommodation for non-local skilled artisans and clearing of the land to be occupied by the individual elements of the project of vegetation and obstructions. Basic building works required by the project, such as operator's housing, may also be constructed at this stage to be used temporarily as stores or housing during the construction period.

ii. Road Works

Permanent access roads are required to the principal operational centres of the scheme including the diversion weir and intake, and the powerhouse. These roads will be constructed to a permanent graveled standard and provided with all necessary drainage. Temporary access arrangements are required to other sectors of the works, including the headpond and its associated overflow channel, which will not require vehicular access in the future. These access arrangements will be reinstated upon completion of the works. The construction of the canal will require coincident construction of motorable access along its 4.412 km length and it is intended that a permanent access road will be provided alongside the canal as part of its overall cross-section to facilitate long term maintenance. This road will be designed for occasional vehicle access only and will be to compacted earth standard with its surface reverting to grass.

iii. Weir Works and Intake

The weir to be constructed is designed to divert water into the canal and allow passage of flood and compensation water downstream. The North Mathioya scheme is designed to operate on a "run-of-river" basis and the weir is not therefore designed

to act as a water storage structure. The weir and intake will incorporate the following elements:

- A simplified concrete ogee profiled spillway, 26m in length and maximum 2.9m in height, keyed into both riverbanks and provided with end wingwalls enabling it to pass the design flood of 180 m^3/s;
- A low level scour outlet controlled by sluice gates, designed to flush out sediment from upstream of the weir and to serve as an additional spillway. This outlet also serves to satisfy the requirements of Article 63 of the Water Resources Management Rules, 2007, set out in accordance with Article 63 of the Water Act, 2002, in respect of compensation flow to ensure that "*the normal flow……can be passed through or around……the weir at all stages*";
- A compensation water outlet pipe, located through the weir at existing riverbed level, designed to pass the amount of compensation water earlier described at all times with the water level upstream of the weir at weir level;
- A reinforced concrete water intake chamber, located on the right bank of the river and controlled by two sluice gates, designed to still the water and direct the design flow into the upstream end of the headrace canal.

The weir will be constructed in two halves with the aid of a temporary cofferdam. The right section, incorporating the low level scour outlet, will be constructed first. The cofferdam will then be modified to divert water through the scour outlet and enable the left side of the weir to be constructed. This activity will, of necessity, be undertaken in the dry season.

iv. Headrace Canal

The headrace canal will commence at the water intake chamber and contour along the southern slopes of the North Mathioya river valley to terminate some 5 km downstream at the headpond. For reasons of cost effectiveness, water conservation, stability, limitation of erosion and durability the canal will be lined with a concrete base and dressed masonry sides. It will be trapezoidal or rectangular in cross-section. For operational and safety purposes it will be provided with adequate freeboard and safety spillways. The latter will be located at existing watercourses along the valley side. The canal crossings of these watercourses will be provided with underlying culverts to enable unimpeded passage of local rainfall runoff. For access and maintenance purposes the canal will be provided with an access road located on its left (downhill) shoulder. For safety purposes, the canal will be provided with fencing along each shoulder as well as pedestrian and livestock crossings where necessary.

v. Settling Basin

During normal flows the amount of sediment in the North Mathioya within the tea zone is low (measurements from water samples retrieved during January 2009 indicated a sediment loading of 0.007% by weight). During periods of high flow and floods, however, the sediment loading could be more significant (as evidenced by the high level of sedimentation experienced lower down the same river at Wanjii power station, for example).

A settling basin will therefore be constructed of reinforced concrete some 150m downstream of the canal intake to allow solids suspended in the river flow to settle and be flushed out as the need arises. The settling basin will be located on the natural terrace which exists some 8m above the right bank of the river and within 20m of the riverbank. Flushing water will be discharged through a low level sluice to clean out deposited material via a stepped lined spillway channel to the river. A lateral spillway will be provided to regulate the water level in the canal and to assist in passing the 1: 100 year design flood. Inflow to the canal is controlled by a further sluice gate.

vi. Forebay

The forebay structure is located at the termination of the canal and at the upper end of the penstock pipe(s) which will transport the water flow to the powerhouse. It comprises a reinforced concrete water retaining structure and serves several functions. These include transfer and control of the water from the open channel to pressurized flow in the penstock pipe; regulation of the water and protection from potential surges in the channel by means of a spillway and diversion channel/pipe discharging into a natural watercourse; removal of trash from the water by means of screens and secondary sediment which may have entered the canal flow. The forebay is also provided with sluice valves at the entry to each penstock to allow the penstock to be isolated and dewatered and for maintenance works to be carried out safely downhill. It will also be provided with a low level sluice gate discharging into a 500m long spillway channel for the purposes of emptying the canal and forebay and flushing out accumulated silt.

vii. Penstock Pipes

The water for power generation is conveyed from the forebay to the turbines in the powerhouse at steadily increasing pressure by means of mild steel penstock pipes. For safety purposes these are designed with a high safety margin to accommodate surges which may result from sudden machine shutdowns. The penstock pipes at North Mathioya will be located above ground, or in open excavation (in order to facilitate inspection and maintenance, following the general ground profile of a subsidiary ridgeline running down the right side of the river valley to the powerhouse on the river bank. The weight of the pipes will be supported on saddled support piers constructed of reinforced concrete and founded on sound material, whilst forces at bends will be taken by specifically designed reinforced concrete thrust blocks. The pipes will be provided with watertight expansion joints to accommodate expansion and contraction due to thermal changes.

viii. Powerhouse and Tailrace

The powerhouse is the building which accommodates the equipment for generating power which, in the case of North Mathioya, will comprise three 965 kW capacity Francis turbines, each driving a similar sized generator. The building will be constructed with a steel framework to support both the roof and the manually operated overhead gantry crane for installing and lifting heavy items of plant. The walls will comprise masonry and blockwork and be provided with windows and

ventilation openings for comfortable working conditions. The roofing will be IT4 corrugated sheeting. The substructure will comprise reinforced concrete foundations and floor slab and will incorporate the draft tubes which convey the water from the turbines to the tailrace channel. The floor level of the powerhouse will be located 1.0m above the assessed 1:100 year flood level of the river. The powerhouse is sized to accommodate the electro-mechanical equipment described above and including the turbine governors, the electrical control cabinets and working space for maintaining the machines. Its plan dimensions are 30.0m by 7.5m. A separate room will be provided for the sensitive electrical control (SCADA) equipment.

The powerhouse is to be located some 15m from the south bank of the North Mathioya River. In order to return the generation water to the river a masonry lined channel will be constructed to convey the flow from the draft tubes to the river channel. The geometry and construction of the channel will be designed so as not to cause or incur erosion. The south bank of the river upstream of the channel is on a bend and will be safeguarded with the installation of gabions.

ix. Substation and Transmission Lines

The energy generated at the powerhouse has to be transmitted to the four tea factories at Kiru, Gatunguru, Kanyenyaini and Githambo as well as be connected to KPLC's extensive rural power distribution in the area. This will require: an 11 kV substation plus 1.5 km of 11kV transmission line to Kiru tea factory, and a 33kV substation plus 14.5 km of 33kV transmission lines to Gatunguru, Kanyenyaini and Githambo tea factories; the installation of step up transformers and interconnections and switchgear at the four tea factories; as well as inter-connection with KPLC and facility for connection to rural electrification.

3.4 RAW MATERIALS, CONSTRUCTION MATERIALS AND PROCESS CHEMICALS

In the case of hydropower, the only raw material is river water.

Construction materials for the civil works will comprise cement and reinforcing steel, as well as coarse and fine aggregates for making concrete for the various structures and walls. These will be sourced from established off site suppliers or sources. Gravel will be obtained locally from existing commercial sources; however, if the quality or quantity of gravel is inadequate or inappropriate the project may need to identify and excavate gravel from further afield. The lining of the canal will require chisel dressed stone (tuff or similar) which will be sourced as close to the site as practicable. Formwork for the concrete works will require softwood timber and plywood which are expected to be brought from bona fide sources in Nairobi. The structural steel element of the powerhouse is expected to be fabricated in Nairobi or locally from imported steel. Fill for the maintenance road alongside the canal will be acquired from the canal excavation.

The transmission lines will require provision of suitable long and cured eucalyptus poles from established suppliers to the electrical industry, as well as imported transmission cables and insulators.

The use of chemicals is anticipated to be very limited, with the exception of concrete additives where these are found to be necessary to ensure the standard of works. A grout curtain formed by pumping cement and bentonite slurry into vertically drilled holes in the rock underlying the diversion weir may be found to be necessary to reduce seepage under the weir.

3.5 BY-PRODUCTS, EMISSIONS AND EFFLUENTS

Hydropower generation has no notable by-products or emissions. On the contrary because it is emission free, it is considered to be "green power".

"Effluent" from the power plant will be the uncontaminated discharge that will be directed back into the river some 5 km downstream of the intake after the water has flowed through the penstock and the turbine.

Other effluents will be from solid waste, used lubricants, and sanitary waste and wastewater from the Contractor's Yard during construction and the operators' houses during operation.

3.6 CONTRACTOR'S YARD AND WORKFORCE

3.6.1 General

A Contractor's Yard will be set up during the construction phase, for which land will have to be rented or acquired.

Implementation of the above works, including the fabrication, supply, installation and commissioning of the electro-mechanical equipment is expected to take 24 months. The works will be divided into three contracts, namely the civil works, the electro-mechanical supply and installation works and the miscellaneous electrical and transmission line works.

3.6.2 Construction Labour

It is expected that 150 people will be employed during construction of the project. The majority will be semi-skilled labourers sourced from the local communities, while skilled personnel may have to be employed from outside the project area. This will reduce the need for the provision of housing on site, and whilst local labour will be transported to and from the site from assigned pick up and drop off points, skilled labourers who are not resident in the locality will be given allowances to find accommodation in the nearby settlements. Thus it is not envisaged that a workmen's camp will be set up.

The anticipated numbers of labour and artisans who will be engaged on the project are as follows:

Civil Works:	100
Electro-mechanical Installation:	15
Transmission Line Construction:	35

The principal elements of the civil works comprising the diversion weir/intake, the headrace canal/forebay and the powerhouse/penstocks will be undertaken in parallel with the critical element of work being the canal, construction of which is estimated to take 18 months. Given the steep hillsides and the difficulties of access to areas such as the forebay, the civil works are expected to be undertaken by a mixture of mechanized and labour based techniques. Whilst excavation of the canal will most efficiently be done by forming a terrace and then excavating the channel with a suitable mechanical digger, work such as site clearance, trimming of excavated slopes, concrete and masonry works as well as slope protection works and fencing will be carried out by artisans with considerable labour assistance. Construction of the weir and intake works will require the use of a crane and concrete batching and placing equipment, but fixing of formwork and steel reinforcement as well as establishment of the necessary cofferdams and fitting of sluice gates and other metal works. The penstock pipes are expected to be manufactured and supplied by Kenya based companies and their installation will require both labour and equipment such as winches and standard concreting plant. Construction of the powerhouse will require building workers such as steel erectors, masons, steel fixers, concrete placers and labourers.

The electro-mechanical equipment will be tendered out at an early stage as high worldwide demand in the sector has led to a relatively lengthy delivery period for such equipment. The principal elements of this equipment, including the turbines, generators, governors, valves, control gear and transformers will be manufactured and installed by overseas suppliers, though they will require assistance and support from locally engaged mechanical and electrical technicians. The equipment is expected to require 12 months for fabrication and delivery and six months for installation and commissioning.

Construction of the 11kV and 33 kV transmission lines and associated inter-connection and control equipment is expected to be undertaken by a Kenya based firm. As well as the electrical technicians who will be engaged on these works there will be need for labour for clearing vegetation, erecting poles, pulling lines and digging and backfilling trenches.

Blasting will be necessary only where hard in situ material which is obstructing water passages has to be removed, but this activity will be kept to a minimum, primarily due to the costs incurred and the issue of safety during blasting. The services of a licenced blaster will be used, who will have to demonstrate that he will put into effect all the necessary safety precautions.

3.7 ACCESS TO THE SITE

The main road passing through the project area is a single carriageway bituminised road (the Muranga-Kangema-Othaya-Nyeri Road), which is in good condition. The rest of the road network accessing the proposed sites are gravel roads in varying condition. Many of the rural access roads are impassable during a large part of peak production seasons.

Construction traffic will use the existing E546 gravel road leading off the D440 Kangema-Othaya road westwards along the ridge past Gatunguru Tea Factory to Gacharageini and the North Mathioya Fishing Camp. For access to the powerhouse, penstock, headpond and downstream canal areas, it will fork northwards at Gatunguru onto a tea road which runs east-west midway down the southern slopes of the North Mathioya valley. For access to the diversion weir and upstream half of the canal, traffic will continue a further 5km west of Gatunguru and access the sites from the western end of the same tea road.

One of the first activities to be undertaken by the civil contractor will be to construct access roads from the tea road to the diversion weir and powerhouse locations respectively. Alignments for these access roads have already been identified. The access road to the diversion weir will follow a recently demarcated reservation across Plot 289, intended to provide access to the river for local residents, to within 150m of the weir site, from where it will divert north-west to the weir and canal intake site.

Access to the powerhouse will be from the tea road 0.5 km east of its crossing the proposed penstock. This road will be some 400m long and will cross 10 individual plots. The two access roads described will be constructed to all-weather gravel standard and be provided with adequate side drains, cross drains and culverts as necessary, together with scour checks.

Access along the canal will be along the compacted fill berm on the downhill side of the canal constructed as part of the canal cross-section. Vehicular use of this is expected to be occasional only and the surface will be earthfill protected from erosion by grass.

The access routes can be inspected on the Plot Boundaries and Land Acquisition Drawings available in the Design Consultant's offices.

3.8 ACTIVITIES DURING OPERATION

Once constructed, the hydropower station will be operated and maintained by the KTDA. Permanent operations and maintenance staff comprising electrical and mechanical technicians will be engaged for the general daily operations of the station, whilst other technical staff and labour may be drafted in for routine maintenance activities or unscheduled problems and breakdowns as necessary.

The permanent staff will be engaged on a 24 hour shift basis to operate the station including starting, stopping and adjusting the turbines, operating the control sluice gates, monitoring and controlling the electrical production and distribution by means

of the switchboard, carrying out routine inspections of the power plant and civil installations to ensure their sound performance and to detect any problems at an early stage, implementing routine maintenance of the equipment and installations to a pre-determined schedule, carrying out simple repairs and contributing to any more complex repair works which may be found necessary. The operators' housing will be located close to the power station so that there is a presence on the site at all times.

A structured system for overall operations and maintenance is essential. Routine O & M activities will be set out in an Operations Manual and will include activities such as the following:

i. Civil installations

- Monitoring river flows and water levels
- Checking for damage such as cracking, leakage, undercutting and erosion
- Cleaning screens, removing debris and obstructions to water flow
- Checking operation of regulating sluices, lubricating and adjusting as required
- Draining, flushing out and cleaning the intake chamber, settlement tank and forebay
- Draining and cleaning the canal, safety spillways and underpassing culverts
- Sealing and repairing leaks
- Checking for leakage and corrosion of the penstock and painting periodically
- Cutting grass and keeping the power station, waterways and installations free of obstructive vegetation.

ii. Electro-mechanical installations

- Routine maintenance checks and activities in accordance with the suppliers' operations manuals
- Checking control meters, bearing temperatures, valve seals etc
- Checking turbine seals, runner damage from silt, tailwater level (and that draft tube is submerged)
- Checking of mechanical or electronic governors
- Inspection of alternator windings and cleaning out dust
- Checking and lubricating alternator bearings
- Checking electrical connections
- Checking and replacing switchboard switches and fuses as well as functionality of safety trips and protection devices.

iii. Transmission Lines

- Seasonal trimming back of tree branches within 2m of the lines
- Ensuring functionality of lightning arrestors
- Confirming temperature and performance of transformers and coolant oil levels
- Operating and confirming performance of inter-connections with tea factories, KPLC distribution system and localised rural electrification system including switching, metering and recording power consumption and distribution levels.

iv. General

- Maintaining an adequate stock of spares and lubricants for general operation
- Maintaining a full set of maintenance tools and implements
- Upkeeping a full set of operations manuals, including component and installation manuals
- Maintaining a daily log of station activities, performance and observations.

3.9 ANALYSIS OF ALTERNATIVE TECHNOLOGIES AND SITING

3.9.1 Analysis of Technologies for Power Generation

As stated in Section1.1, the objective of this project is to generate green power. Small-scale hydropower is considered to be one of the most cost-effective and reliable energy technologies to be considered for providing clean electricity generation. According to the British Hydropower Association (BHA) (ref: www.british-hydro.org), key advantages that small hydro has over wind, wave and solar power are:

- A high efficiency (70 - 90%), by far the best of all energy technologies
- A high capacity factor (typically >50%), compared with 10% for solar and 30% for wind
- A high level of predictability, varying with annual rainfall patterns
- Slow rate of change - the output power varies only gradually from day to day (not from minute to minute)
- A good correlation with demand – in the Kenyan context output is maximum during the tea harvesting/processing season
- It is a long-lasting and robust technology, and power plants can readily be engineered to last for 50 years or more
- Run-of-river schemes, as proposed in this case, are more environmentally benign in that any dam or barrage is quite small, usually just a weir, and little or no water is stored. As a result these schemes do not have the same kinds of adverse effects on the local environment as do large-scale hydropower schemes.

The tea growing areas of Kenya are located in the highland areas, which provide ideal conditions for small hydro schemes, given that running water is available perennially in the rivers and streams, and that sufficient heads can be found over horizontal short distances.

3.9.2 Siting Options

During the pre-feasibility study (IED, 2005), sites along the South Mathioya and North Mathioya Rivers were investigated. Three potential sites along the North Mathioya were considered with the intention that they be developed sequentially to operate in cascade. The selected site (NM1) was found to be the cheapest in economic terms, giving an output of 2.01 MW at a design flow of 3 m^3/s, with a power utilisation factor of 64%. The selection was based purely on economic feasibility, and environmental considerations were not taken into account. At feasibility stage it was found to be more cost effective to develop this section of the river in two steps rather than three and the NM1 scheme was adjusted to take in the upper half of Scheme NM2.

During the initial site visit to the area, it was determined that a partially constructed mini-hydro scheme is being developed by the Gacharageini community for household power immediately upstream of the proposed NM1 intake. Consideration was therefore given to any modifications in approach which might benefit both the community and NM1 schemes. Various options were considered:

i. Incorporating the existing scheme (and effectively extending it) by constructing the NM1 intake at the intake of the community scheme and utilising its 300m intake canal as the first section of the NM1 canal.
ii. Constructing the NM1 intake about 200 m below the powerhouse tailrace of the existing structure, so as to keep the two schemes completely separate, but resulting in a minor loss of head to the NM1 scheme.

At a meeting called to discuss the options, the local community advised that it was not in favour of the first option, as they had already contributed KShs 10,000 per household for its development and wanted to remain in control of its operation and power distribution. The design of the NM1 scheme has therefore adopted the intake 200 m below the discharge point of the existing scheme, the location of which has been selected to ensure that the production of the community scheme is not affected.

The location of the powerhouse has been dictated by the topography of the site, in order to maximise the exploitable head for the generation of power; the topography at the river bank, since a fairly flat area is required for the powerhouse; the feasibility of constructing a motorable access road; the underlying ground conditions, to support the powerhouse and heavy machines; and the geometry of the riverbed to minimise erosion.

4 Policy, Legal and Institutional Framework

4.1 INSTITUTIONAL FRAMEWORK FOR ENVIRONMENTAL MANAGEMENT

Kenya has approximately seventy seven statutes which relate to environmental concerns. Most of these statutes are sector specific, covering issues such as public health; soil erosion; protected areas; endangered species; water rights and water quality; air quality, noise and vibration; cultural, historical, scientific and archaeological sites; land use; resettlement; etc.

Previously environmental management activities were implemented through a variety of instruments such as policy statements and sectoral laws, and also through permits and licences. But with the enactment of the Environmental Management and Coordination Bill in December 1999, the institutional framework for environmental management has been strengthened. The Environmental Management and Coordination Act of 1999 (EMCA) provides for the establishment of a National Environment Management Authority (NEMA), which became operational in July 2002. NEMA has the statutory mandate to coordinate all environmental activities.

4.1.1 Electricity Regulatory Commission Environmental, Health and Safety Policy Framework

The Electricity Regulatory Commission's (ERC) Environmental, Health and Safety Policy Framework was finalised in October 2005. The document harmonises the rights and obligations as well as the boundaries and rules of conduct for role players in the electric power sub-sector in respect of environmental, health and safety performance. It draws on the Industry Safety Code and the attendant subsidiary legislations under the Factories and Other Places of Work Act (Cap 514).

The document lists Instruments that may be used to enforce environmental policy, including:

a. Command and Control regulations
b. Internalisation of social costs
c. Voluntary Agreements
d. Public participation
e. Environmental Management Systems
f. Special tariffs for renewable energy

With regard to the generation of electricity from renewable sources, the document stipulates that:

- It is the responsibility of power generating entities to generate electric power efficiently while conserving resources and with the least possible adverse environmental impact;
- Renewable energy electricity generation plant shall be operated in such a manner as to conserve resources; facilitate the abatement and prevention of environmental pollution; and minimise environmental degradation;

- Renewable energy electricity generation plant shall comply with prescribed EHS quality and performance standards as well as the statutory annual reporting requirements;
- All renewable energy electricity generating plants shall establish and adopt an EHS policy and ensure that all employees working in the generation plant are familiar with it and are guided by it;
- All the employees working in the generation plant shall receive training and education on matters relating to EHS to ensure effective EHS performance and continuous improvement in the same;
- For all generating plants the licensees are expected to audit and review their individual EHS performance with a view to continually improving the EHS performance;
- At the end of each Fiscal Year the Board will compile and make public league tables comprising the EHS performance of all utilities in Kenya's electricity supply industry utilising renewable energy sources.

Similarly for transmission and distribution, the document states that:

- It is the responsibility of the transmission and distribution entities to operate the network efficiently while conserving resources and with the least possible adverse environmental impact;
- The network should be operated in such a manner as to conserve resources eg. by minimising system losses; facilitating the abatement and prevention of environmental pollution; and minimising environmental degradation in general;
- The network operators shall comply with prescribed EHS quality and performance standards as well as the statutory annual reporting requirements, including minimising system losses;
- The network operators shall establish and adopt an EHS policy and ensure that all employees working with the network are familiar with it and are guided by it;
- All the employees working with the network should receive training and education on matters relating to EHS to ensure effective EHS performance and continuous improvement in the same. In addition the network utilities should ensure that staff have appropriate levels of authorisation as appropriate;
- For the whole network the licensee is expected to audit and review the EHS performance with a view to continually improving the same.

The Framework document notes that the Government has articulated relevant strategies in the Sessional Paper No. 4 of 2004 on Energy with a view to levelling the playing field and keeping the costs of renewable energy as low as possible. The Commission draws its guidance from the Energy Policy and is committed to implement it as appropriate.

The Policy Framework puts emphasis on the need for performance monitoring and compliance protocols. It has developed monitoring protocols for various types of power plants, specifying descriptions and technical details of monitoring measures as well as the monitoring and reporting procedures.

4.2 KENYAN LAWS RELEVANT TO THE SITE

The ***Environmental Management and Coordination Act of 1999*** (EMCA) establishes an appropriate legal and institutional framework for the management of the environment, and supersedes all other environmental legislation. EMCA, in Part VI Section 58(1) states that *"Notwithstanding any approval, permit of licence granted under this Act or any other law in force in Kenya, any person, being a proponent of the project, shall, before financing, commencing, proceeding with, carrying out, executing or conducting or causing to be financed, commenced, proceeded with, carried out, executed or conducted by another person any undertaking specified in the Second Schedule to this Act, submit a project report to the Authority in the prescribed form, giving the prescribed information and which shall be accompanied by the prescribed fee*".

The ***Environmental (Impact Assessment and Audit) Regulations, 2003***, provide the basis for procedures for carrying out Environmental Impact Assessments (EIAs) and Environmental Audits. Part I Section 4 of the Regulations states that "*no proponent shall implement a project that is (a) likely to have a negative environmental impact; or (b) for which an environmental impact assessment is required under the Act or these Regulations*".

The ***Environmental (Impact Assessment and Audit) (Amendment) Regulations, 2009***, stipulate the prescribed fee as being 0.05% of the total project cost to the maximum of KShs 1,000,000, of which 50% is payable upon submission of the project report, and the remaining 50% is payable on collection of the EIA licence.

In addition, there are numerous other laws and regulations which influence the various environmental and social aspects and activities of the proposed power plant. The main ones are:

Environmental Management & Coordination (Water Quality) Regulations, 2006

- Prohibits activities that cause direct or indirect pollution of water sources
- Activities that are likely to impact water quality and quantity require an EIA
- Requires protection of lakes, rivers, streams, springs wells and other water sources
- Use of water for trade and industry must comply with standards
- Prohibits pollution of water for fisheries, wildlife, recreational purposes
- Discharge into aquatic environment must comply with standards.

Environmental Management and Coordination (Noise and Excessive vibration Pollution Control) Regulations, 2009

- Requires the operation or repair any machinery, motor vehicle, construction equipment or other equipment, pump, fan, air-conditioning apparatus or similar mechanical device to comply with levels prescribed in the Regulations
- Requires that motor vehicles do not produce any loud and unusual sound; or exceed noise levels of 84 dB(A) when accelerating
- Construction equipment (including but not limited to any pile driver, steam shovel, pneumatic hammer, derrick or steam or electric hoist) and construction or repair work must conform to permissible levels set out in the Regulations.

Energy Act, 2006

- Amends and consolidates laws relating to energy
- Provides for the establishment, powers and functions of the Electricity Regulatory Commission (ERC) and Rural Electrification Authority
- Promotes the development and use of renewable energy technologies, including biomass, biodiesel, bioethanol, charcoal, fuelwood, solar, wind, tidal waves, hydropower, biogas and municipal waste
- The Energy Regulatory Commission may require buildings to provide factual information on energy conservation.

The Physical Planning Act, 1996

- The local authority can prohibit/control development of buildings, approve development applications and grant development permission
- Empowers local authorities to request existing facilities to conduct environmental assessments.

The Registered Land Act, Cap 300

- Makes provision for the registration of title of land, and for the regulation of dealings in land so registered.

Trade Licensing Act, Cap 497

- Requires a licence for carrying out of business related activities.

The Water Act, 2002

- Makes provision for the conservation, control, apportionment, use of water resources of Kenya
- Requires the reserve for each water source to be determined
- Regulates the management of water supply and sewerage services
- Requires permits to be obtained for use of water from a water resource
- Makes it an offence to pollute any water resource, and
- Requires a permit to be obtained for the discharge of a pollutant into any water resource.

The Water Rules, 2008

- Requires a permit for the abstraction, diversion, instream works and storage of surface water
- Controlling devices must be installed to measure water abstracted/diverted
- Sets charges for water abstracted, diverted, stored or used for hydropower generation (no charge for installed capacities of less than 1MW, but for installed capacities greater than 1 MW a rate of 5 cents per KWh is charged)
- Permits to develop an amount of power less than the full hydro power potential of the site may be subject to special conditions if the Authority considers that the full power development of the site at a later date may be required
- Requires a reserve flow to be maintained in all rivers.

Building Code, 1997

- Prior to erection of buildings an application, submission of plans and payment of fees are to be made to the municipal/county council contains requirements relating to certificates for occupation of premises.

Local Government Act, rev. 1998

- Empowers local authorities to grant licences to carry out business, trade or occupation.

The Wayleaves Act, Cap 292

- Gives the Government the power to carry sewers, drains, or pipelines into, through, over or under any lands, but may not interfere with any existing building
- Compensation must be paid for any tree or crops that are damaged or destroyed.

Public Health Act (rev. 1986)

- Can confer powers to local authorities to inspect buildings, workshops and trade premises
- The local authority is responsible for the passing and rejection of building plans including the supervision of drainage structures.

Forests Act, 2005

- Requires indigenous forests and woodlands to be managed on a sustainable basis for purposes of conservation of water, soil and biodiversity; riverine and shoreline protection; cultural use and heritage; recreation and tourism; sustainable production of wood and non-wood products; carbon sequestration and other environmental services; education and research purposes; habitat for wildlife in terrestrial forests and fisheries in mangrove forests
- Any activity carried out in the forest, shall, where the activity concerned is likely to result in the depletion of forest cover in any forest, be required to undertake compulsory re-vegetation immediately upon the completion of the activity, in consultation with the KFS.

Lakes and Rivers Act, rev. 1983

- Provides for the protection of bird and animal life on or in a lake or river.

Fisheries Act

- Provides for the development, management, exploitation, utilisation and conservation of fisheries
- States that no person shall fish for trout in Kenya fishery waters unless he is a holder of a valid trout fishing licence issued to him under this regulation and is fishing in accordance with the terms and conditions of the licence.

Occupational Health and Safety Act, 2007

- Secures the safety, health and welfare of all workers and all persons lawfully present at workplaces
- Protects persons, other than persons at work, arising out of or in connection with activities conducted by person at work
- Provides for a National Council for Occupational Safety and Health
- Requires all workplaces to be registered by the Director of Occupational Health and Safety Services
- Gives guidance on the safe use of machines and chemicals
- Employers must ensure safety, health and welfare of all employees, through, inter alia, maintenance of plant and equipment, safe procedures, provision of information

- Employers must undertake risk assessments and send report to Area Safety and Health Officer
- Employer must prepare a safety and health policy statement
- Safety and health committees must be established as prescribed in the Act
- Employees are required to ensure their own health and safety, to comply with safety and health procedures (eg wearing PPE), cooperate with employer, report hazardous situations, accidents and incidents.

Factories and Other Places of Work (Health and Safety Committee) Rules, 2004

- Requires health and safety committees to be formed
- Describes the functions and duties of the health and safety committees, meetings and minutes, and roles in the committee.

The Factories (First Aid) Rules, 1977

- Requires the provision of First Aid boxes
- Prescribes the contents of First Aid boxes, the required number of trained personnel, and qualifications of First Aid personnel
- Requires qualified First Aiders, with valid certificates, to be in charge of First Aid Box.

The Factories and Other Places of Work (Fire Risk Reduction) Rules, 2007

- Outlines requirements for fire safety, location, marking, training in use of, and maintenance of fire fighting equipment on site.

Factories and Other Places of Work (Noise Prevention) Rules, 2005

- Gives maximum permissible noise levels
- Requires a noise prevention programme to be implemented where noise in a workplace exceeds the continuous equivalent of 85 dB(A), through for example hearing protection, engineering noise control, noise measurement, hearing tests, education and training, annual reviews.

Factories (Building Operations and Works of Engineering Construction) Rules, 1984

- Describes health and safety requirements for engineering construction.

Workmen's Injury Benefits Act, 2007

- Provides for compensation to employees for work related injuries and diseases
- Employers must have an insurance policy and be registered with the Director of Occupational Safety and Health Services.

4.3 LICENCES AND PERMITS

Several of the pieces of legislation listed above require licences or permits to be issued for activities undertaken by the plant. These are tabulated below:

Table 4.1: Licences and Permit Requirements

Legislation	Permits / Licences Required
Energy Act, 2006	▪ Electricity Generating Licence
The Petroleum Rules (applicable under the Energy Act, 2006)	▪ Petroleum licence for bulk storage of fuel oil (>2000 litres)
Building Code, 1997	▪ Notice of Inspection card required for plant
Public Health Act, rev. 1986	▪ Council approval of plans for plant
Occupational Safety and Health Act, 2007	▪ Registration of work place certificate
Local Government Act, rev. 1998	▪ Trade / Business Licence
Trade Licensing Act	▪ Trade Licence
Physical Planning Act, 1996	▪ Development permission
Environmental Management & Coordination Act, 1999	▪ EIA Licence ▪ Water discharge licence
The Water Act, 2002	▪ Abstraction permit for use of river water
Water Rules, 2008	▪ Consent required from the licensed water service provider for the area for carrying out works ▪ Permit required from WRMA for diversion of surface water and instream works for hydropower generation

The site must therefore ensure that all the required permits and licences are obtained and valid.

4.4 ENVIRONMENTAL AND SOCIAL GUIDELINES AND SAFEGUARD POLICIES

The conduct of this assignment has been guided by the Environmental Management and Coordination Act of 1999, the Environmental (Impact Assessment and Audit) Regulations of 2003, and NEMA's Draft Environmental Impact Assessment Guidelines and Administrative Procedures (2002).

This study has also taken into consideration requirements of the following safeguard policies:

- World Bank's OP 4.01 Environmental Assessment
- World Bank's OP 4.04 Natural Habitats
- World Bank's OP 4.12 Involuntary Resettlement
- World Bank's Environmental Assessment Sourcebook 1999 (Chapter 10, Energy and Industry)
- IFC Environmental Health and Safety Guidelines for Electric Power Transmission and Distribution
- African Development Bank's Involuntary Resettlement Policy (2003)
- African Development Bank's Environmental and Social Impact Assessment Guidelines (2003).

4.5 INTERNATIONAL TREATIES AND CONVENTIONS

Kenya is has ratified or acceded to numerous International Treaties and Conventions. Those that have implications on this scheme are described here.

The ***1992 United Nations Framework Convention on Climate Change*** sets an ultimate objective of stabilising greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic (human-induced) interference with the climate system. Pursuant to the objectives of this Convention, the ***Kyoto Protocol*** was drawn up in 1997, in which the developed nations agreed to limit their greenhouse gas emissions, relative to the levels emitted in 1990.

The objectives of the ***Convention for Biological Diversity of 1994*** are the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources.

5 Public Consultation

5.1 OVERVIEW

Potential beneficiaries of the project and members of the public living near the proposed project site were consulted to seek their views and opinions regarding the project. Public consultations for the proposed Mathioya North Small Scale Hydropower Project were carried out in two phases designed to capture the key concerns of the communities in the area as well as other stakeholders.

Phase 1 of the consultations involved interviews on one-on-one interaction basis with members of the public in their normal daily operations throughout the project area. The persons interviewed included landowners, farmers, villagers, business people, etc. Phase 2 of the consultations comprised a public participation forum organized at the Chief's office, Njumbi Location, with participation drawn from the community leaders, administration, business community, farmers, landowners, institutional management, individuals, etc.

5.2 CONSULTATIVE PUBLIC MEETINGS

5.2.1 Approach

In order to get balanced views from the public, focus group discussions as well as one-on-one interviews were conducted.

Initial public consultations were undertaken through rapid interviews throughout in the area. Short discussions were also undertaken with government technical departments and local administration officials.

Among the officials consulted were:

i. Mr. Michael Mwaniki - District Environmental Officer (Muranga and Maragua),
ii. Mrs. Jane Mwangi – Marketing (KPLC Muranga)
iii. Mr. Charles Awundo – Transmission and Distribution (KPLC Nyeri Office),
iv. Mrs. Mary Chege – District Agricultural Officer (Muranga)
v. Mr. Peter Kangangi - DELDO (Muranga)
vi. Mr. Francis Gachuga – Sub Regional Manager (WRMA Muranga Region)
vii. Mr. Samuel Gachowa – District Development Officer (Muranga)
viii. Mr. Douglas Mokuwa – District Land Valuer (Muranga)
ix. Kanyenyaini Tea Factory Unit Manager
x. Muranga District Surveyor
xi. Mr. Douglas Kihara – Chief Njumbi Location
xii. Mr. Simon Njuguna – Assistant Chief Gacharageini Sub Location, Njumbi Location
xiii. Mrs. Alice Macharia – Assistant Chief Kiamuturi Sub Location, Njumbi Location
xiv. Mr. Wilfred Gachanja – Clerifical Officer, Chiefs Office Njumbi Location
xv. Mr. Peter Muchiri – Pastor in the Project area.

xvi. James M Gikuru – Farmer and Chairman, Gacharageini Micro Hydro Scheme Plant.
xvii. Other interested and affected stakeholders (refer to Annex 3).

On Friday 14th November 2008 at 10am, a public consultation meeting was organized in collaboration with the Chief of Njumbi Location in Muranga North District Mathioya Division, Njumbi Location, Gacharageini Sub location. The meeting was held at the adult literacy class, Chiefs office block. The meeting was attended by 13 area residents including farmers, area leaders and religious leaders. The area chief chaired the meeting. The purpose of the meeting was to brief the local people on the project concept so as to enable them to express their appreciation, concerns and fears as well contribute ideas and opinions towards the project's sustainability.

The attendance list for the public consultation is presented in Annex 3.

5.2.2 Emerging Issues

While the majority of the local people interviewed expressed appreciation of the proposed small hydropower project, the main issue of concern was the perceived interference the proposed project will have on the existing Gacharageini hydro project. The respondents also recognized that there would be potential disruption of the normal social order, economic activities and environmental trends associated with the small hydro construction. The proposed small hydro project, however, was appreciated as a viable project in terms of enhancing economic opportunities for the immediate residents, the outlying districts and the country in general.

The major issues raised by the participants during these social interactions are summarized below.

5.2.3 Benefits

Members of public felt that the project would benefit the economy at both local and national level, and the benefits derived would be both social and environmental in nature. These included:

- Employment opportunities, especially for casual workers and several other specialized workers;
- Supporting the growth of the economy by contributing to the gross domestic product, through the use of locally sourced materials during the construction phase of the project such as cement, concrete and ceramic tiles, timber, sand, ballast, electrical cables etc;
- Promoting the informal sector, especially women from the local communities, through securing some temporary revenue and hence boosting their income (albeit temporarily);
- Stimulating economic activities like small scale industry in the area;

- Reduced fuel consumption especially from the utility grid (KPLC) by the tea factories in the area;

- Reduced air pollution, as hydropower produces no air pollution/greenhouse gases as compared to thermal power stations. It is very efficient, reliable, and once installed inexpensive.

5.2.4 Concerns

Among the main concerns raised during the consultation were:

- The tea factories demand for power is normally too high and therefore it is unlikely that the local community will benefit from any surplus power;

- The existing Gacharageini community micro hydropower plant should not be interfered with and the possibility of merger was not welcomed;

- The proposed intake for the proposed small hydropower project should be downstream of the existing community micro hydropower plant;

- The farms where the proposed canal route and powerline will be passing should be compensated;

- Casual and other unskilled should be sourced from within the local area upon commencement of the project;

- Community run projects in the area have done very well in the past unlike government funded and other donor funded projects; the same is expected for the upcoming community hydro project. However, an example of a failed merger between local people and a tea factory in the development of a small hydro in the area was given.

5.3 MEETINGS WITH OTHER STAKEHOLDERS

A meeting was also held with the Kenya Fly Fishers' Club. The Club was founded in 1919 and is centred around trout fishing. Although purely recreational, it has a close relationship with the Fisheries Department and initiated a Community Development Programme in 2007 which aims to conserve, protect and enhance the riparian land along the North and South Mathioya Rivers through involving the local communities in various activities such as fish farming, reafforestation, and tourism-based activities, and by providing support to the communities in the education, health, water, power and infrastructure sectors.

The Club waters extend for about 1 km downstream of the Kenya Fly Fishers Club (KFFC) Camp. The main concern raised by members of the Club is the obvious impact on trout and other fisheries – particularly breeding habits – caused by impeding movement upstream, disrupting river flow and disturbing breeding habitats.

Rainbow Trout (*Onchorhynchus mykiss*) and Brown Trout (*Salmo trutta*) are not indigenous to Kenya, and were introduced in 1905 into the Gura River. Subsequently the Fisheries Department established a number of hatcheries, and trout was introduced into other streams in the Aberdares. Nevertheless, trout fishing provides a means of income to some members of the local communities. Moreover, any disruption of the river flow will equally affect other fish and aquatic faunal species.

6 Analysis of Environmental and Social Impacts and Recommendations for Mitigation

Every attempt has been made to present an accurate assessment of anticipated impacts. Mitigation measures have also been proposed here. The study has focussed on the major environmental and social impacts that are likely to result during the construction and operation of the small hydro project.

6.1 BENEFITS OF THE PROJECT

The overall aim of this GTIEA Project is to reduce electrical energy use in the tea processing industry, preferably with an attached rural electrification component, and to initiate a process of reducing green house gas emissions whilst enhancing power supply reliability.

The primary objective of the North Mathioya Small Hydropower Scheme is to supply reliable and cost effective renewable electrical energy to the four tea factories of KTDA Region II, Zone 3, ie. Gatunguru, Kiru, Kanyenyaini and Githambo.

Subsidiary objectives of the project include:

- The provision of energy free of greenhouse gas emissions to consumers;
- The sale of surplus environmentally friendly energy to the national distributor (KPLC);
- The development of local energy resources to benefit the local community; and
- The establishment or expansion of rural electrification potential.

Benefits derived from the project, as perceived by the stakeholders, include a reduction in cost of the energy required for operating the tea factories (from KShs 24.0 per kWh to KShs 3.00 per kWh); a more reliable power supply with less interruptions leading to a more efficient tea manufacturing process, fewer breakdowns and lower equipment maintenance requirements; employment opportunities, especially for casual workers and several other specialized workers; support to the local economy, partly by the migrant workforce and demand for construction materials, but also as a result of locally generated income and revenues from the provision of services; and reduced air pollution. The project is also intended to make the Kenyan tea industry more competitive and sustainable.

In replacing power currently sourced from the national grid or by diesel fuelled generation, development of the power station will directly result in a reduction of carbon dioxide discharged to the atmosphere. The amount of this reduction will be 12,525 tonnes of CO_2 per annum. The project could therefore derive benefits from the Clean Development Mechanism (CDM) of the Kyoto Protocol.

The benefits of lower tea production costs will ultimately be reflected in more sustainable tea sales, lower overheads and higher profits at the KTDA Zone 3 factory

level. Any carbon credits obtained will be reflected in the operating accounts as a higher level of income and of operational profit. Within KTDA, profits are distributed to shareholders each year in the form of an annual bonus. The shareholders predominantly comprise the small scale tea farmers within the Zone. A major part of the additional factory profits will therefore be distributed directly within the Zone, resulting in a higher level of income for both the small scale tea farmers and the community as a whole.

The Division already has a relatively dense coverage of rural electrication distribution lines, installed and managed by KPLC. KTDA do not consider it practicable or desirable to set up an alternative or competitive rural electrification system in these circumstances. It is considered of more benefit to allow the net proceeds of the small hydropower station to be distributed in the form of the annual bonus to tea growers. This additional cash will allow recipients to pay for their own connections to the existing rural distribution system and prompt expansion of the system by KPLC to meet demand. Through tea growers, the community's access to power will also be enhanced by KTDA acting as guarantor for smallholders applying for KPLC connection loans. The mechanism for administering such KPLC loans is already well established. The rural electrification component of the project will therefore be achieved, but through indirect means.

6.2 ADVERSE ENVIRONMENTAL IMPACTS

6.2.1 Changes in Hydrology/Drainage

The proposed design of the power station is based on generating 2.925 MW of power, which will be developed on the basis of the 42% exceedence flow (ie. flow that is exceeded 42% of the time).

In the dry season, when tea production is low, the power requirements of the tea factories will also be low..This situation normally coincides with the river flows being low to the point that one or more of the turbines has to be stopped. The duration of the low season flow, during which one machine will be out of operation is estimated from the flow duration curve at being five months per year, whilst two machines will typically be out of operation for two to three weeks per year. Should a higher compensation flow be adopted, then the turbines would be out of operation for longer periods of time with a consequent reduction in energy production.

The impacts on hydrology and drainage due to the construction of the weir and diversion of water from the river include:

- A reduction in the river's natural discharge between the intake point and tailrace re-entry;
- Creation of an obstacle in the form of the weir and intake structures which may affect flow.

Water will be diverted after the Fishing Camp for up to 4.5 km downstream of the project weir along the river. Thus the hydrology of this length of river, between the point of diversion and the tailrace discharge at the power house, could change

considerably. As a result, the flora and fauna (especially fish) along that section of river could be affected.

In order to ensure that the change in the hydrological regime does not adversely affect faunal and floral species in and along the river, a compensation (or environmental) flow must be maintained at all times. The environmental flow is defined as "*the stream flow that is necessary to sustain habitats (including channel morphology and substrate), encourage spawning and the migration of faunal species to previously unpopulated habitats, enable the processes upon which succession and biodiversity depend, and maintain the desired nutrient structure in lakes, rivers, streams, wetlands and riparian areas*" (after *ACT, 2004*).

Part III Section 13 of the National Water Act (2002) requires that the Reserve for the whole or part of each water source be determined by the respective water authorities. The Water Resource Management Rules (2007) define compensation flow as "*the flow released from a dam or weir which is required for downstream uses and the Reserve*". Part XII of the Rules requires the Water Authority to establish the Reserve guided by the quantity of water required to satisfy the reserve water demand. The Rules describe the Reserve as being determined through consideration of:

a) *Ecological vulnerability;*
b) *Vulnerability of the population dependant on that water resource;*
c) *Local observations with respect to the naturalised flows of water levels of minimum values observed during periods of prolonged droughts;*
d) *Where water flow is known to be normally perennial, then the reserve flow shall be sufficient to ensure perennial flow; and*
e) *Consultations with the water resource users associations if such exists.*

In Kenya, there are no gazetted or approved guidelines for a compensation flow value, nor for determining environmental flow. Draft Guidelines for Water Allocation were drawn up in March 2009, which recommend that where water resource records are available for streams and rivers "*the Reserve Quantity shall not be less than the flow value that is exceeded 95% of the time as measured by a naturalised flow duration curve at any point along the water course*". However, this is a working paper and has not been finalised.

Numerous methods for determining compensation flow are available. The European Small Hydropower Association (ESHA) lists some forty (40) methods to determine compensation or environmental flow, but concludes that the different methods give very different values for environmental flow (ESHA, undated). Dfid's *Handbook for Catchment Water Demand and Use* (2003) describes eleven (11) methods that have been applied in Southern Africa, each having advantages and disadvantages. These comprise hydrological index methodologies, hydraulic rating methodologies, habitat simulation methodologies and holistic methodologies. All these methodologies depend on several criteria, for example, climate, vegetation, species and species sensitivity, the hydraulic geometry of the water channel, etc, but most importantly on the availability of hydrological data, specifically for base flows, low flows, flushing flows and special flows. For the North Mathioya River, only hydrological flow data are available, and this is dated (supplementary data has been collected for 10

months up to October 2009 as part of the study, but the most recent earlier data is 13 years old).

Discussions with the Water Resources Management Authority offices in Embu (telephone communication, Mr Jara, WRMA Embu, April 2009) revealed that compensation flow values are in the process of being developed for the North Mathioya River. Where compensation flows have not been determined, WRMA field officers are recommending that the reserve quantity should be not less than the 95% exceedence flow value as measured by a naturalised flow duration curve at the proposed intake. The North Mathioya River at the proposed intake site has a 95% exceedence flow of 2.0 m^3/s (cf the lowest flow recorded at RGS 4BD07 of 0.47 m^3/s – in September 2009).

Adoption of this standard would have significant implications on the economic viability of the proposed scheme. In addition, according to the Water Rules of 2007, "*permits to develop an amount of power less than the full hydro power potential of a site may be subject to special conditions if the Authority considers that the full power development of the site at a later date may be required*." After further discussions with WRMA HQ (Eng Waithaka, 13 October 2009), in which it was recognised that small hydro-electric power generation is a non-consumptive use of water, it was proposed that the Design Consultant put forward a compensation flow value that WRMA would then review.

In view of the above, a compensation flow based on 10% of the mean flow, that is 0.589 m^3/s, has been proposed. This flow corresponds to compensation flows provided for in a number of small hydropower schemes in Kenya over the past 80 years.

The project area receives on average 2000 mm of rain annually. Thus the river continues to receive rainfall within its own subsidiary catchment. While this is not to be considered as contributing to the compensation flow value, runoff from the natural catchment between the intake and the tailrace is estimated at an average of some 0.16 m^3/s annually, bringing the total volume of flow in the river channel to 0.85 m^3/s. Spilled flows from the weir will also pass down the river bed during the five months of the year that the river flow exceeds the maximum designed power flow.

The WRMA's Muranga Sub Region Office indicated that there is only one licensed water abstractor below the proposed intake. During site investigations, a small fish breeding pond was also identified beside the river. No irrigated agriculture was observed being practised along this stretch of the river. However, concern was raised by the Kenya Fly Fishers Club about the impact on fishing, particularly spawning habits, resulting from diversion of water into the headrace canal.

Climate change is another aspect that could affect hydrological flow in the North Mathioya River. Although there is little empirical data specifically on the effects of climate change on the Aberdare Forests, observations of the diminishing ice caps across the plateau on Mt Kenya, lower rainfall in the Naivasha area to the west of the Range, and the shrinking or drying up of rivers previously flowing into Lake Naivasha from the Aberdares imply that the Aberdare Water Catchment could also be threatened. Deforestation of the Aberdares Range would exacerbate this problem.

Road improvement/construction will cause some temporary (but overall minor) changes in hydrology during the construction phase, particularly where access roads and bridges/culverts will be newly constructed or rebuilt. In the case of existing access roads, subterranean and surface drainage will already have been altered. But where new access roads are to be constructed, then there will be a small overall change in surface hydrology, caused by altering the natural flow of runoff across the land. As for bridges and culverts, these tend to concentrate flow, and may result in eddying and ponding, and on occasion erosion of the riverbank on the downstream side of the river if provision has not been made for sufficient through flow.

The construction of the transmission lines is unlikely to have any hydrological impacts.

Mitigation:

Scheme Works

- There must be a specified compensation (environmental) flow residual in North Mathioya River at all times. According to the Water Act, 2002, WRMA is responsible for establishing the compensation flow in all water resources in the country. For the North Mathioya River, this is currently being established. In the meantime, WRMA has said that a compensation flow value be proposed by the Design Consultant, which it (WRMA) will review for acceptability. Based on optimising the economic viability of the scheme, provision has been made in the design of the intake weir for a compensation flow of 0.589 m^3/s (equivalent to 10% of the mean flow) to pass down the bypassed section of the river at all times. Based on this value for compensation flow, WRMA must now strike a balance between the merits of optimising the hydropower generation and the maintenance of an acceptable compensation flow. These two issues need not be in conflict.
- In the event that WRMA decides that the proposed compensation flow is not adequate, consideration would have to be given to designing a smaller power station that would require less water to drive the turbines or to reducing the periods that the turbines are operated. As mentioned above, this would have implications on the economic viability of the scheme, reducing the amount of green power generated and giving a lower internal rate of return. In environmental terms, it would require a comparison of the benefits of assessing the ecosystem contribution provided by the bypassed stretch of river against the benefits of generating an additional 20,908 MWh per year of green energy.
- As discussed in Section 3.1, the water diverted at the intake will be diverted from the river for a distance of approximately 4.5 km and all the water diverted will be discharged back into the river at the tailrace outlet with no abstractions en route. Lining the canal will prevent water losses through seepage. Being a run-of river scheme, it is considered that the flow of water will be "*automatically by-passed around the diversion weir without any storage or arresting of the flow of the water being effected*" as provided for in Article 63 of the Water Resources Management Rules, 2007.
- As noted in Section 2.3.5 there is only one authorised abstractor in the section of river bypassed, whose abstraction will be accommodated by the proposed compensation flow. For those relying on the river for household water supplies, these

will remain available from the compensation flow or from the canal running parallel to the river.

- Management of water must be ensured at all times during operation through maintenance of the plant and penstock in order to minimise leaks and wastage.
- In accordance with the Water Act (2002) and Water Resources Management Rules (2007), the volume of water diverted into the headrace must be measured and records maintained on a daily basis. This will be effected by the installation of gauge plates on the weir and sluice gates.
- Flow remaining in the river channel should also be measured on a daily basis when the power plant is operational.
- Turbine operations will be dictated by available river flow and required compensation flow, so that in periods of prolonged drought turbine operations will have to be adjusted accordingly.

Access Roads, Culverts, Bridges

- During the construction / improvement of access roads and rehabilitation of culverts and bridges, the design will ensure that the flow of water in the river (or any streams encountered en route) is not impeded.

6.2.2 Soil Erosion

The tea zone below the Aberdare gazetted forests has traditionally been considered to be relatively erosion free owing to the all year cover of soil provided by tea bushes. Generally this still appears to be the case; however landslides are now being reported in this zone. A thorough study of the causes of these has not been undertaken, but it is thought that removal of trees on steep slopes for domestic purposes (for construction and fuel wood) and for tea factories are contributing factors in some cases. Tea zones occupy some of the steepest cultivated lands with deepest soils. All afforestation land preparations, construction, tree felling and haulage activities present risks of increasing soil erosion at some stage of their cycle. *(Source: Scott Wilson, Rehabilitation and Upgrading of Hydro Power Stations-Kenya, Tana Catchment Report)*

The alluvial sediments at the intake consist predominantly of brown slightly clayey silts, gravels, cobbles and boulders. Along the proposed canal alignment, the thickness of the overburden, comprising mainly brown clayey silts with occasional boulders is expected to increase, such that at the headpond, the soil cover will probably be greater than 3m. Where the alignment crosses gullies and traverses around ridges, rocky outcrops consisting of weathered basalts and agglomerates will be encountered at a shallow depth.

The sediments at the proposed powerhouse site are composed of brown slightly clayey silts with occasional boulders that extend to a depth of approximately one metre. The alignment of the canal will pass through many cultivated fields, which will be subject to erosion that could lead to siltation. Where steep grassy slopes are encountered, soil creep may occur and preventive environmental measures will have to be taken to counter this.

The occurrence of hill creep as a result deforestation has been noted in the area. This generally affects the upper layers of the soil and progresses slowly over time. The excavation of the canal removes some of the support for the creeping soil and can thus cause a local increase in the rate of the creep. If there is significant percolation of water into the soil, the increase in pore water pressures is also likely to increase the rate of hill creep.

The tailrace channel is required to convey the water from the powerhouse back to the river. The flow of the water can potentially cause erosion.

Earthworks on the plant site, due to road construction/improvement and building footbridges, and the power transmission lines will also cause soil erosion, which may continue after construction. Improper drainage (eg of road runoff) could also lead to erosion, and subsequent increase in sediment loads in watercourses.

Mitigation:

General

- Proper management of excavation activities and organisation of spoil, eg by covering it, will reduce the amount of soil washing away. The spoil can then be reused (for backfilling or landscaping).
- Compaction of cut surfaces of the excavation will reduce the amount of percolation.
- Earthworks should be controlled during the construction phase, so that land that is not required for the works is left undisturbed.
- Revegetation of disturbed areas should be undertaken as soon construction is complete. Planting with species such as vetiver grass for stabilising embankments should be considered.
- Wherever possible, earthworks should be carried out during the dry season to prevent soil from being washed away by the rain.

Scheme Works

- The design of headrace and tailrace canal should take into account soil erodibility and gradient, and be such as to minimize the occurrence of erosion. This is also important in preserving the structures themselves. The design requires the canals should be lined or designed such that the speed of flow does not cause erosion.
- An assessment of the stability of the slopes along the headrace canal will be done, so that appropriate stabilization measures can be incorporated during construction. Bio-engineering techniques, such as terracing and use of vetiver grass should be employed to stabilise embankments.
- Completely accessible and uncovered anchoring blocks can reduce the impact of penstock civil engineering works. In steep sections it may be necessary to break the impact of runoff (which is the main cause of erosion). This can be done by terracing and planting in the upper catchment of the headrace, or by constructing a catchment drain.
- All embankments should be planted with shrubs and grasses to stabilise them as well as to reduce the chances of erosion. Here again, vetiver grass is recommended. Construction work should be organised such that, as each section of the scheme

works is completed, reinstatement and replanting activities for that section (including embankment stabilization) is undertaken immediately.
- The design of structures in the riverbed, including the tailrace channel, must be such that the structures do not promote erosion. Spillways should incorporate steps or baffles to dissipate the erosive energy of fast flowing water.

Access Roads and Transmission Lines

- Along access roads, provision should be made for directing road runoff away from the road, by installing side drains and mitre drains. These structures must be well designed, properly constructed and regularly maintained so that runoff does not accumulate by the side of the road, water that is drained off the road does not create gullies, and siltation of the structures does not occur. Steeper sections along the access roads (those having gradients greater than 4%) should have cascades and/or scour checks along the side drains.
- All drainage structures must ensure safe final disposal of water and must also be self-cleaning.
- All embankments should be planted with shrubs and grasses (vetiver) to stabilise them as well as to reduce the chances of erosion.
- Where the transmission lines traverse steep terrain, trash lines should be introduced along the route to break the impact of runoff.

6.2.3 Pollution

Air Quality

During construction, earthworks will be carried out at the principal elements of the hydropower scheme, as well as for the installation of the power transmission lines and road construction/improvement works.

The main pollutants during construction are dust (from excavators and earth moving vehicles, as well as materials delivery), particulate matter from dry materials (sand, cement, gravel, murram, etc), and emissions (smoke, hydrocarbons and nitrogenous gases among others from machinery exhausts). This will, however, have a localized effect confined to the immediate surroundings of the site.

When the power plant becomes operational, there will be no air or dust emissions.

Mitigation:

- The speed of construction vehicles on unsurfaced (gravel or earth) roads should be limited to reduce dust levels. This can be achieved by sensitising and supervising drivers of construction vehicles.
- Proper maintenance of construction plant and equipment (including trucks) will reduce emissions of noxious fumes (carbon dioxide, carbon monoxide, nitrogen oxides, and sulphur oxides).
- Water should be sprayed on working areas to reduce dust.
- Any stockpiles of earth should be enclosed / covered / watered during dry or windy conditions to minimise dust emissions.

Noise Pollution and Vibration

Noise and vibration are associated with all construction works and will result from activities such as drilling, trenching and earthworks, as well as from construction equipment and vehicles. These will be temporary impacts.

During operation, noise (in the form of a steady hum) will be generated from the turbine operations. This will be confined to the site, but can also be buffered.

Mitigation:

- Noise buffering technologies should be incorporated into the design of the powerhouse (by lining the walls / roofs with noise absorbing materials) and plant equipment (eg using silencers).
- Machine operators and truck drivers should be sensitized to keep noise levels down at all times. No construction works should be carried out at night.
- The tender documents should stipulate that the Contractor is to keep noise levels to levels specified in the Factories and Other Places of Work (Noise Prevention and Control) Rules, 2005, and the Environmental Management and Coordination (Noise and Excessive Vibration Pollution Control) Regulations, 2009, that have recently been gazetted. Noise abatement guidelines should be provided to the Contractor before works begin.
- During operation, the site will be required to monitor noise on an annual basis, in accordance with the Factories and Other Places of Work (Noise Prevention and Control) Rules, 2005 and the Environmental Management and Coordination (Noise and Excessive vibration Pollution Control) Regulations that will shortly be gazetted. Should levels exceed the guideline levels, in the powerhouse, and at the site boundary, then abatement measures will need to be implemented. Noise abatement guidelines should be provided to the Contractor before works begin.
- Where noise levels exceed maximum permissible limits in the powerhouse, protective personal equipment (PPE) must be provided.
- Plant and equipment should be maintained regularly and properly to ensure proper operation and keep noise levels down.

Water Quality

The quality of the river water is judged to be very clean, given that the river supports abundant fish life, particularly trout which are very sensitive to high sediment loads and other pollutants. A change in water quality could therefore affect fisheries.

All the project components will involve construction activities that may result in siltation of the river system resulting from building debris and soil erosion. Soil from the earthworks may be washed into the river, consequently reducing the water quality. Sewage from latrines at the construction site is another possible contaminant of water sources.

Sediment loading due to soil erosion could continue after construction, and will be dependent on the effectiveness of soil protection and conservation measures employed.

Once constructed, the weir may act as a silt trap and sedimentation would occur. This has both positive and negative effects, in that it would improve the quality of water downstream of the weir in terms of suspended particulates, but it could reduce the effectiveness of the weir, and, in addition, reduce the amount of silt that settles on the floodplains downstream and provides nutrients to floodplain farmlands.

As part of the permanent works, provision has been made for one wc-type latrine for the project operational staff. This will drain into a septic tank. The volume of sewage generated will be small, so the risk to water quality is negligible.

There is some risk to water quality in the river from spillage of oil products, either by construction vehicles or when servicing plant equipment. This is discussed in the section on Contamination by Oil below.

Mitigation:

Sediment Loading

- Proper management of spoil and diligence on the part of the Contractor during earthworks will reduce the risk of contamination by sediment loading of the river. If possible, earthworks should be done during the dry season.
- The incorporation of erosion protection measures (see above) would reduce the amount of soil reaching water bodies.
- The Contractor must ensure that construction debris is disposed of in a sensible manner and not thrown into the river. This should be stipulated in the tender documents.
- Silt traps should also be installed in stormwater drains from the power house before discharge into the environment, to ensure compliance with national standards.
- During major plant maintenance works, silt that has built up behind the weir should be removed and disposed of by spreading on adjacent land. This should be done during the dry season.

Foulwater Contaminants

- The tender documents should state that there must be proper sanitation facilities on the construction site, as well as at the Contractor's yard. Pit latrines should be provided at each operational site and located at least 50 m from any water body.
- The design and construction of the septic tank facility at the powerhouse and staff housing should be such that the discharge conforms to national standards for discharge into aquatic environments.

Contamination by Oils and Chemicals

Sources of oil contamination will mainly be from lubricants used for the turbines and transformers, and from diesel that may be kept for start up and standby operations, and any resulting waste oil.

Apart from oils, no other chemicals will be used in the power generation process. It is assumed that all transformers that are bought for the project will be new. PCBs are no

longer used as lubricants in new transformers, so this does not pose a chemical hazard or health risk. Furthermore, KPLC has implemented a programme to replace PCBs in all their old transformers as well.

Mitigation

- During construction, a specially designated area should be allocated on site for maintenance of construction vehicles, and plant vehicles so that oil spills can be controlled and localised.
- An oil trap/interceptor should also be installed in stormwater drains from the power house before discharge, to ensure compliance with national standards for discharge into the environment.
- During both construction and storage, oil products are to be stored in a specified area, and all oil containers/drums should be stored on sump pallets, while tanks must be placed in concrete bunds whose dimensions are equal to 110% of the volume of the tanks they hold.
- Procedures for the storage, handling and disposal of oil products and oil wastes, as well as other flammable liquids, should be drawn up by the Contractor during construction, and by the Power Station Manager when the plant is functioning.
- Oil spills should be prevented through implementing operational procedures. If spills occur, they should be mopped up immediately. Spill kits should be provided at the powerhouse.
- During both construction and operation, drip trays should be used when oil is being drained from vehicles and equipment/machinery, and waste oil should be properly stored until it can be disposed of in an acceptable manner.
- Proper maintenance of plant and equipment, and vehicles will minimise oil leaks and therefore contamination by oil.

Solid Waste and Construction Debris

The construction phase will generate debris, plastics, steel and metal residuals, wrappers and papers, glass, wood, etc. It is anticipated that the effects of these wastes will be felt away from the site - most likely at the disposal sites.

Solid waste will be generated when the plant is operational, this being mainly in the form of paper, plastics, packaging, etc, disposed of by the plant personnel.

Apart from visual impacts, debris can affect water quality.

Mitigation:

- The tender documents should specify the proper disposal of all solid and construction waste.
- Diligence on the part of the Contractor during construction activities will minimise the amount of construction debris generated, and also will ensure that debris is disposed of in a sensible manner, at a specified and approved dump, and in accordance with the national Waste Management Regulations (2006).
- During plant operation, waste should also be disposed of in accordance with the national Waste Management Regulations (2006). These require waste to be segregated and inventorised, and appropriate disposal routes to be identified.

6.2.4 Materials Sources

Due to the density of population in the vicinity of the site and the agricultural value of the land it is assumed that construction materials such as coarse and fine aggregate, and building stone, will be sourced from established commercial quarries. The fill material for forming the berms alongside the canal and backfilling structures will be won in situ.

The Contractor may need to identify gravel sites for the construction of access roads. Once the sites have been identified, the Contractor will be required to undertake environmental impact assessment studies on the sites. Alternatively he may choose to purchase gravel from an existing source – this latter option would be simpler in terms of adhering to environmental regulations and managing environmental and social impacts.

The soils in the project area are prone to erosion, and have a history of instability. Should the Contractor undertake to open up gravel sites, excavation activities as well as the gradient of excavated slopes of the gravel sites may affect erodibility of the soils. When gravel sites are being excavated, that land cannot be used for cultivation or grazing. After excavation it may still not be possible to cultivate that land because the topsoil will have been removed. A substantial portion of the cropping or grazing land therefore becomes unproductive. Furthermore, excavation often leaves an uneven land surface, which makes it difficult to cultivate later.

Drainage is another major issue associated with the excavation of gravel sites, as water tends to accumulate their lowest point. When the pits become saturated with water, it is difficult to remove material. Pits that are left open after excavation also tend to collect water. Accumulated water provides a breeding habitat for mosquitoes, thus propagating malaria. Other concerns relating to the winning of gravel include dust, disturbance during excavation, access (including destruction of structures), and hazards posed to children and livestock. Often trucks collecting material from such sites will use several routes to access one gravel site. This has severe implications on environmental degradation outside the immediate boundary of the excavated area. Homesteads that are located close to gravel sites will be affected by dust and noise during excavation. Provision of access and traffic to the gravel sites may also pose a nuisance to people living around them.

There are numerous other types of construction materials that can be deleterious to the health of construction workers and/or to persons working in completed buildings where these materials have been used. These include materials or substances made of asbestos, silica, heavy metals (such as lead and cadmium), and certain chemical substances that are used for the treatment of wood and timber. The sources of construction materials are yet to be established. However, the Contractor should be instructed in the use of all materials that may have negative environmental (including health) effects. As far as possible, environmentally friendly and sustainable materials should be used.

Mitigation:

Gravel sites

In the event that the Contractor undertakes to excavate gravel himself, rather than source it from an existing commercial site, the following will need to be carried out:

- An environmental impact assessment will have to be carried out for the site(s) for submission to NEMA.
- People living at, or near, the materials sites must be informed of the environmental implications of excavation at the time of selection of the sites. The owners of the sites should be told at the earliest opportunity whether or not testing has revealed that material from their plot is acceptable for use by the project; the owners of material from the sites found to be acceptable, and which the Contractor selects for excavation, must be compensated. Gravel site owners must also be told of the options available to them after excavation, for example rehabilitation/landscaping, or fencing. The tender documents should instruct the Contractor to maintain fences and "make good" afterwards, in accordance with the written agreement with the landowner.
- All access routes to gravel sites should be planned ahead of construction and described in the tender documents. This will stop several routes being created to one materials site which would have severe implications on environmental degradation around the excavated area.
- Gravel pits must be excavated such that drainage is controlled, and water is not allowed to accumulate. Any water that does collect has to be pumped out and disposed off sensibly.
- The area to be excavated should be cordoned/fenced off, to keep livestock and children away.
- Gravel pits must be landscaped, then reinstated or backfilled with overburden/topsoil. For this to be done, separate stockpiles of material should be put aside at the time of opening up the pits for topsoil, overburden, gravel, etc. Terracing and replacement of fencing is part of the rehabilitation process. The tender documents should instruct the Contractor to plant trees to replace those that have been removed during excavation.
- Dust emissions can be controlled by wetting the working surfaces.
- No garbage, spoil or oil wastes should be disposed of in the gravel site.

Other Construction Materials

- The sources of all materials should be certified by the Contractor; for example, stones for building and gravel for the access roads should be obtained from bona fide commercial quarries, and hardwoods should not be used at all.
- Materials that should NOT to be used for construction of the power plant and its associated infrastructure include:
  - High alumina cement;
  - Wood wool slab in permanent formwork to concrete;
  - Calcium silicate bricks or tiles;
  - Asbestos in any form;
  - Asbestos substitutes or any naturally occurring or man-made mineral fibres;

  - Lead, lead paint or any other materials containing lead which may be inhaled, ingested or absorbed;
  - Any products containing cadmium that are regarded as being injurious substances;
  - Any other substances regarded as being deleterious building materials, which are not in accordance with statutory requirements, or with current accepted good building practice at the time of specification or construction.
- If any material or substance is used that is at any point in the future deemed to be deleterious to health, then it must be replaced with an acceptable alternative.

6.2.5 Natural Vegetation / Flora

The natural vegetation on the project site and in its surrounding area has been substantially altered from its original state. Although not of significant scientific value, this vegetation serves to protect the soil and retain soil moisture.

Before the construction process begins and also during the construction activities, clearing of some of the existing vegetation, shrubs, trees and aquatic vegetation will have to be done within the areas where the headrace and tailrace canals, power house, sub-station, staff housing, parking bays, access roads and transmission lines are to be constructed.

Clearing activities could encourage soil erosion.

The extent to which aquatic flora will be affected in the section of the river that will be deprived of water will depend on the amount of compensation flow that is be allowed to flow in the river channel (see Section 6.2.1 above). In addition, the weir will impound water to a small extent, causing a minor section upstream to be inundated and thus encouraging silt deposition. This could result in changes in the aquatic flora composition, as it would encourage marshland species such as *Typha* to establish, and consequently faunal diversity may also alter. In addition, the weir may cause eddying which in turn could erode the weir base or create a pool.

Mitigation:

Clearing Activities

- Clearing of vegetation and trees should be limited to what is absolutely necessary, and should not be carried out indiscriminately.
- After road improvement/construction and powerline construction is complete, disturbed areas should be rehabilitated by planting grass and trees.

Changes in Aquatic Flora

- The specified compensation flow must be maintained in the river at all times.
- The weir height should be such as to minimise the effect of damming.
- The weir foundation should be sound so that erosion of the base is avoided.

- A survey of aquatic flora that may be affected in the river due to changes in river flow should be undertaken as a baseline, with a follow up study after 5 years to establish impacts of the project on aquatic flora. The study should be carried out by a consultant specialising in aquatic ecology, and should be funded by EATTA or KTDA.

6.2.6 Forests

The Aberdare Forests lie some 4 to 6 km directly to the west and northwest of the proposed location of the scheme intake. These make up one of Kenya's five major water catchments. While the project itself is not likely to affect the forests or forest resources, the state of the forest will impact on the river hydrology, and therefore could affect the operations of the proposed scheme. Although the forest is gazetted, there is evidence of it being subject to some destruction (see Section 2.3.6). Should this water catchment continue to shrink, the amount of water flowing in the rivers and streams emanating from the forests will reduce. On the other hand, poor land management practices, deforestation and removal of vegetation can also result in increased runoff, together with high sediment loading of the river systems. Overall, however, a reduction in the river flows can be expected in the medium to long term, if the forest is left unprotected and reafforestation programmes are not implemented. This will mean that less water can be diverted into the intake canal if environmental and social demand downstream is to be maintained, and therefore the amount of power that can be generated will also be reduced.

In the absence of reliable and consistent hydrological data, it is not possible to accurately predict how much, and when, flows in the North Mathioya River will be affected by continued destruction of the Aberdare Forests, though it is hoped that the recent completion of the Rhino Ark fence will reduce the rate of the latter significantly.

Mitigation:

Catchment Management

- Proper management of the Aberdare Forests is required urgently. However, this is the responsibility of the Kenya Forest Service (KFS) and other government offices, and as such beyond the remit of this project.
- However, the project proponent (EATTA) together with the local communities within the project area should seek commitment from decision makers to implement conservation and protection measures for the Aberdare Forests. The Kenya Fly Fishers' Club is also prepared to assist in this respect.
- Hydrological data should continue to be collected for the North Mathioya River by KTDA, so that trends in river flow in the coming years can be predicted, and power generation activities/operations can be modified accordingly. Again, the Kenya Fly Fishers Club and other local institutions can be asked to assist in this respect.

6.2.7 Wildlife / Fauna

It is expected that during the construction period, several terrestrial faunal species and their habitats will be disturbed especially during activities involving the clearing

of vegetation. As the area along the river from the proposed intake to the discharge point is well cultivated and well settled, the species typically found along this section are birds, reptiles, rodents, insects, etc. The conservation or economic value of these species has not been determined, but the level of disturbance will be small and comparable to other agricultural activities taking place in the vicinity.

However, there will be a change in the hydrological regime of the river between the intake and the discharge point, a distance of about 5 km. Fishing is an important activity in the project area, and therefore reduced river flow for part of the river length is an issue of concern[2]. The reduced flow will no doubt affect fish species, as well as other aquatic fauna.

It is therefore critical that the environmental or compensation flow is maintained in the bypassed section of river. Environmental flows have been discussed in Section 6.2.1 above.

Fish and other aquatic fauna may find that the headrace canal provides a favourable breeding area. They may then find their way into the penstock and subsequently pass through the turbines, and so may be killed.

Mitigation:

Terrestrial Habitat Destruction

- Vegetation and trees should not be cleared/cut down indiscriminately, so that the habitats of these small creatures are preserved as much as is possible.
- Revegetation and reafforestation (preferably with indigenous species) of the site and any areas that are cleared will provide new habitats for this wildlife.

Changes in Aquatic Fauna

- The specified compensation flow must be maintained in the river at all times.
- The weir height should be such as to minimise the effect of damming.
- A survey of aquatic fauna that may be affected in the river due to changes in river flow should be undertaken as a baseline, with a follow up study after 5 years to establish impacts of the project on aquatic fauna. The study should be carried out by a consultant specialising in aquatic ecology, and should be funded by the proponent.

[2] The KFFC invests some KShs 1.8 million annually into the community through salaries and local trade (ref. KFFC River Development Plan, Feb 2007)

Impact on Fish

- Fish (and other aquatic fauna) move up and down streams and rivers. The design of the weir must therefore include a fish bypass or fish ladder so that movement of fish is not hindered. Fish passes are generally more favourable, but require more land, which is a limiting factor in this case. Fish ladders are made by creating a series of stepped pools, so that the fish can jump from pool to pool, eventually coming out on the other side of the weir. The aim is to allow the fish to move upstream and downstream. Several designs for fish ladders can be considered. Consideration must also be given to smaller fish which need to get down the ladder. Annex 7 provides some designs for fish ladders and fish passes.
- A screen should be placed at the inlet to the penstock to stop fish (and other creatures and objects) from entering into the penstock and passing through the turbines.

6.2.8 Demobilisation

During construction the Contractor will construct various facilities, which will have to be dismantled and removed on completion of works. In addition, there will be a quantity of scrap and waste material on site.

Mitigation:

- The tender documents should state that the Contractor leaves the site in a clean and sightly condition on completion of works. The Contractor should be required to do this in accordance with national regulations on waste management, water quality and noise. In addition, the tender documents should instruct the Contractor to restore and landscape all areas to the satisfaction of the Supervising Engineer.

6.3 ADVERSE SOCIAL / SOCIO-ECONOMIC IMPACTS

6.3.1 Settlement and Immigration

The project is unlikely to stimulate unplanned development or settlement, since it is a small project, and does not necessitate a large permanent workforce.

However, the construction of the small hydro scheme will offer employment opportunities, and depending on the number of people that will be employed, there may be a temporary but small influx of people into the project area. This is perceived as being a positive impact, albeit short term. But this influx could potentially cause some antagonism and raise suspicions, as unemployment rates are high in the project area. In addition, transient workforces are often associated with a rise in the incidence of sexually transmitted diseases. Moreover, people moving into the project area would put pressure on water and fuel wood resources. Also, the in-migrants might acquire much coveted farmland.

Mitigation:

- Before construction, an awareness campaign should be initiated to sensitise the local communities on the risks of STDs and AIDS. Condoms should be distributed during this exercise.
- An influx of people into a community raises the issue of security. The local chief/assistant chief of Njumbi Location and Gacharageini Sub location should be made aware of this, so that they can plan to address the security situation.

6.3.2 Loss of Land/Property

The project area and its environs support substantial agricultural activity, with approximately 80% of the households in the district depending on agricultural production. The population density in Mathioya Division is estimated at 533 people per km^2, which is considered fairly high. Human settlement is generally limited to flat areas, but can also be found along steep slopes. Average farm holdings are small with some households occupying less than one acre of land.

Specific project components will necessitate the acquisition of land, namely:

i. The diversion weir, intake and 4.9 km long headrace canal;
ii. The forebay and 660m long penstock route;
iii. The powerhouse and tailrace canal;
iv. The 16.5 km total length of powerline connecting the power plant sub-station to the tea factories; and
v. The access roads to the site, comprising some 1.0 km of new road, some 7.0 km of road improvement and some 5.0 km of access track alongside the canal in all.

Land will also have to be rented or temporarily acquired for the Contractor's Yard.

Drawings of plot boundaries, owners' names and acquisition requirements have been prepared by the design consultant (GWA) and are presented in Annex 4. The most recent updates can be inspected at the consultant's offices.

In all, apart from land requirements for the Contractor's Yard, it is estimated that 15.5 ha (38 acres) of land will have to be acquired. The cost of land in the project area ranges from KShs 300,000 - 350,000/- per acre near the river, and KShs 500,000/- beside the road. Taking an average estimate of KShs 400,000/- per acre, the cost of land to be acquired for the scheme will be in the region of KShs 15.2 million. In addition, up to 30 people from four houses in three homesteads will be displaced and have to be resettled as a result of land acquisition (within their own plot boundaries). An abbreviated resettlement plan will have to be prepared to ensure that displace persons are properly resettled and fairly compensated.

Land within existing road reserves and wayleaves need not be compensated for.

Mitigation:

- A compensation and resettlement plan will have to be prepared for project affected persons who will be relocated as a result of their land being acquired. As the number of people affected is less than 200, an abbreviated compensation and resettlement plan will suffice, but this must cover all costs of relocation, housing, transportation, loss of income, etc.
- Compensation must be paid at the market value to all persons whose land will be permanently acquired for the project.
- Compensation must also be paid for any land acquired on a temporary basis, such as for the Contractor's Yard.
- In order to minimise land take, as far as possible, the powerline must follow existing wayleaves and rights of way.

6.3.3 Loss of Crops

The alignment of the headrace canal will pass through many cultivated fields, and crops will have to be cleared. Crops along the access roads and power transmission routes that are within the right of way will need to be cleared. Any crops that need to be removed from land lying outside the road reserve, along the canal route, along the transmission routes and in private property will have to be compensated for.

Mitigation:

- All crops on private land that must be removed for the purposes of the canal, power plant, road construction/ improvement or the transmission lines should be compensated for. Legally, compensation is not required for crops within the road reserve; however, for the sake of goodwill, this should be considered.
- Crops to be cleared should be limited to the amount that is absolutely necessary to maintain the road width or for works on the canal, power plant and transmission lines.
- Where possible, farmers should be given the chance to harvest their crops before the land is acquired.

6.3.4 Employment Opportunities

The project will provide employment (albeit temporary) to about 150 workers (see Section 3.6.2). It is expected that much of the labour force will be sourced from the immediate project area within Njumbi Location. Various types of skilled and unskilled workers will be required to work on the site for varying periods during construction, for example, engineers, masons, carpenters, joiners, electricians and plumbers.

The project may also attract some immigrants who would come into the area in search of work. This is expected to inject cash into the economy of the area and the surrounding villages, as small businesses/enterprises (eating houses, hotels, shops, etc) will be stimulated. Consequently, productivity and income levels in the area of influence are likely to increase while construction is ongoing.

Moreover, if labour based methods are used for construction, then more employment opportunities will be available. These factors could also contribute to increased levels of income and better health in the area, which is a benefit.

Mitigation:

- The construction methodology should, as much as possible, adopt labour based works.
- The Contractor must take care to ensure that the maximum possible number of employees hired is sourced from the settlements within the project area and its immediate area of influence.
- Women must also be given opportunities within the project, and a specific quota (eg 20%) should be reserved for women.

6.3.5 Agricultural Activities

Mathioya Division receives the highest income in the District, this being from agricultural activities, mainly tea. The objectives of the project are, among others, to:

i. Increase the availability and reliability of power provided to tea factories and in parallel reduce their electricity costs, and
ii. Increase access to electricity services to tea growers residing in the proximity of tea factories.

It is therefore anticipated that the project will benefit tea farmers in the wider project area, and will stimulate tea cultivation and processing activities.

The alignment of the canal will pass through many cultivated fields occupied by tea, patches of bananas, maize, beans, Irish potatoes, cabbages, and various fruits. The construction of the canal will lead to destruction of crops in the cultivated lands and the farmers will have to be compensated.

However the project's overall effect in the long run will have a major positive impact on the Division's agricultural output and income. Not only will the high production cost of tea be reduced but the farmers and associated businessmen such as maize millers should also benefit from a more reliable power source.

Mitigation:

- As mentioned in Section 6.3.3, compensation must be paid to all persons whose crops will be destroyed to make way for the construction activities. In addition, as far as possible, road improvement and construction of the powerlines, should follow existing wayleaves and rights of way, in order to minimise land take and crop loss.

6.3.6 Fisheries

Fisheries are an important commercial activity (refer Section 2.4.5). One of the main concerns with diverting river water into the headrace canal is that flow in the river

between the intake and the discharge point downstream will be reduced, which could severely affect the aquatic ecology, predominantly fish such as trout. (This has been discussed above under Sections 6.2.1 and 6.2.7). Consequently, there could be an impact on fisheries.

Mitigation:

- An adequate compensation flow must be maintained in the river at all times.
- In order to protect fish and permit their free movement, it is recommended that fish ladders or fish passes are installed to bypass the weir (see Section 6.2.7 and Annex 7).

6.3.7 Public Health

During construction and operation, a number of aspects may impact on public health. There will be increased dust, noise and air pollution levels, which are considered to be negative impacts, although for the general public this would be minor to minimal. The workforce would be more exposed to these hazards. Oil wastes can also impact on public health if they find their way into water sources. These have been discussed earlier in Section 6.2.3.

There is also the danger of children and livestock falling into the headrace canal or penstock inlet.

Transient workforces are associated with the spread of STDs and HIV/AIDS. An awareness campaign should therefore be initiated to sensitise the local communities on the risks of STDs and HIV/AIDS.

Sanitation and hygiene in the Contractor's Yard and other work sites during construction are also issues of concern, and if not properly addressed, may lead to outbreaks of illnesses such as hepatitis, typhoid, intestinal worms, etc.

There is concern about the health risks associated with electro-magnetic field (EMF) radiation. Adverse health effects have been scientifically established for high level short term exposures to EMF (ICNIRP, 2003). In October 2005, the World Health Organisation convened a Task Group of scientific experts to assess any risks to health that might exist from exposure to extremely low frequency electric and magnetic fields in the frequency range >0 to 100,000 Hz (100 kHz). While IARC examined the evidence regarding cancer in 2002, this Task Group reviewed evidence for a number of health effects, and updated the evidence regarding cancer. Following a standard health risk assessment process, the Task Group concluded that there are no substantive health issues related to extremely low frequency electric fields at levels generally encountered by members of the public. Health risks are associated with transmission lines of 110 kV and higher voltages. The 11 kV and 33 kV transmission lines to be constructed for power distribution in this project are unlikely to have health effects associated with EMF.

Mitigation:

- STD awareness campaigns should be conducted, and condoms distributed, to the workforce as well as in the villages proximate to the site.
- Domestic sewage generated on site must be treated in a satisfactory manner, eg through conventional septic tanks and soakaway pits.
- During construction and operation, arrangements should be made for the proper disposal of solid waste.
- The intake, headrace canal, forebay and power house area should all be fenced in to enhance safety and security.
- A screen should be placed before the penstock inlet to prevent children or livestock being sucked into the penstock. It is anticipated that the trash screen will serve this purpose.
- The plots along the river at the intake should be fenced off along the river bank to discourage children and livestock entering the river at that point.
- The local communities must be made aware of this potential source of danger, and the sensitising process should start as soon as the Contractor mobilises.

6.3.8 Occupational Health and Safety

Construction sites always present an element of danger. Occupational health and safety of the workforce will have to be monitored by the Contractor's supervisors and foremen. As long as proper procedures are followed and personal protective equipment (PPE) is provided and its use enforced, risks of accidents and incidents can be substantially reduced.

Occupational health and safety issues relevant to the transmission lines, substation and transformers include the risk of electrocution by live powerlines and working at height.

Mitigation:

- All workers, whether construction workers, KTDA or KPLC staff working on the site and along the transmission lines, should be provided with suitable protective gear (such as nose masks, ear muffs, helmets, overalls, industrial boots, etc) as required. All workers must be forced to wear PPE, and a penalty system should be implemented where they receive a verbal warning for the first infraction, pay is withheld for the second infraction and they are released from work for the third infraction. This penalty system should be described in their individual work contracts.
- Potable water should be available to the construction workforce and operations staff at all times.
- All personnel involved in installing, maintaining or repairing electrical equipment must be thoroughly trained and also certified. Live power distribution lines must be deactivated and properly grounded before work is performed on them, or if work is carried out in close proximity to them.
- All safety standards must be strictly adhered to. The ERC published guidelines for environmental health and safety in September 2005. Furthermore, ERC has an industry safety code (October 2004) which covers

electrical safety and mechanical safety for electricity generation, transmission and distribution. These must also be complied with.

- There must be a fully equipped first aid kit on site.
- While working at height, fall protection programmes must be in place, hoisting equipment must be properly tested and rated, operators properly trained, appropriate tools provided and safety equipment provided (eg belts, ropes, back up straps/harnesses). All obstructions should be removed.
- As a requirement of the Occupational Safety and Health Act, 2007, the Contractor (during construction) and KTDA (when the plant is operational) must employ a Health, Safety and Environment Officer who has first aid training and knowledge of safety regulations.
- A detailed occupational health and safety handbook should be prepared for the site.
- By law, the Contractor, and operator must have workmen's compensation cover (Workmen's Injury Benefits Act, 2007).

6.3.9 Contractor's Yard

It may be necessary to temporarily acquire or rent land for the Contractor's Yard. The Contractor may approach the Chief and Assistant Chiefs or any other authorized person for assistance in this matter.

The Contractor's Yard will require a potable water supply, proper sanitation and washing facilities, and a garbage disposal system.

Mitigation:

- Possible sites for the Contractor's Yard should be identified in liaison with the District Officer and the Chiefs/Assistant Chiefs of Njumbi Location and Gacharageini Sub location.
- Solid waste should be disposed of in a sensible manner. Waste should be separated into saleable, reusable and burnable categories. Non-degradable wastes should be taken to approved council dumps.
- The tender documents should specify conditions for hygiene standards, sanitation, solid waste disposal and health services for the workforce. Pit latrines at the Contractor's Yard and other work sites should be located downhill of potable water sources, or 50 m from any water body.
- An awareness campaign should be initiated to sensitise the workforce and local communities on the risks of STDs and AIDS.

6.3.10 Disturbance to the Public

Disturbance to the public may occur due to various construction activities, such as noise, vibration, traffic movement; disruption of routine activities may result.

Once the power station is established and operating, there will be little change in terms of disturbance from the current situation.

Mitigation:

- Levels of pollution should be minimised – as discussed above in Section 6.2.3.
- The communities should be sensitised about potential disruption to their normal activities caused by construction works. This can be done with the assistance of the local administration (chief and assistant chiefs).
- Warning/informative signs should be erected wherever construction works are in progress, and where there may be disruption to pedestrian or vehicular traffic. Signs should indicate when works are likely to begin and end, and what alternatives are available for access.
- To minimise disturbance to villagers in the locality of the project site, construction activities should not be carried out at night.

6.3.11 Access and Egress to the Site

As described in Section 3.7, construction traffic is expected to use the existing gravel road off the Kangema-Othaya road leading to Gacharageini and the Fishing Camp, as well as the tea road running parallel and immediately north of this in the North Mathioya valley. This may cause some disturbance to the public, and will lead to increased deterioration of the road surfaces.

During construction there will be additional danger to road users (motorists, pedestrians and non-motorised traffic) along the access roads to the site, due to construction traffic and the transportation of equipment, etc. After construction, the volume of traffic along the access roads to the site will decrease considerably. Indeed, once the power house machinery and equipment has been installed it is unlikely that there will be any heavy traffic travelling to or from the power plant, except if a machine or piece of equipment needs replacement. However, after construction, the access roads and the footbridge will be a great benefit for the people living near or adjacent to the roads in that they will have better access to administrative centres, markets (and consequently farm inputs), schools, health centres, etc.

Mitigation

- As soon as the Contractor has mobilised, he must initiate an awareness campaign, through the local administration, to sensitise the local communities to the possible risks and road safety.
- Movement of all construction vehicles must be strictly controlled, and access and egress routes clearly specified to the Contractor and workforce, so that specific entry/exit points are allocated for construction traffic.
- Construction traffic should be strictly controlled, particularly with regard to speeding, as the access roads to the site will be narrow gravelled roads with an appreciable volume of pedestrian and non-motorised traffic, and the site is located in an agricultural zone.
- As mentioned above, warning / information signs should be erected wherever construction works are in progress (particularly near schools, health centres

and village/market centres), and where there may be disruption to pedestrian or vehicular traffic.

- Alternative access routes must be specified if, for any reason, the construction works block a certain route.
- After construction of the power station, affected roads should be rehabilitated so that their condition is at least as good as it was at the start of construction. This would also serve to create goodwill amongst the local communities.

6.3.12 Archaeological or Cultural Sites

No sites of archaeological or cultural importance are likely to be affected by the construction of this small hydro project.

6.3.13 Visual Impact

During construction, the main visual impacts will occur during earthworks for the foundation of the plant, digging of trenches and laying foundations for the pipe work support, and excavation of the canal. Trees, shrubs and other vegetation will have to be cleared for the headrace canal, penstock and the power house, as well as the access roads and powerlines. This would leave the site looking comparatively bare. Earthworks will only have a temporary impact if the construction schedule is properly organized and grassing undertaken at an early stage. The power house itself can be designed to be integrated into the surroundings.

On account of its small size, the completed power plant will be a minor visual intrusion, despite appearing as a change in the natural landscape.

The transmission lines will cause a visual impact which cannot be mitigated. The lines will follow the penstock route and the roads to the tea factories where appropriate. The visual impact is subjective and may be welcomed by some as a sign of progress by the local community.

Mitigation

- Power house buildings and the penstock must should be designed to blend into the surrounding environment. For example, the penstock can be painted to blend in with the surrounding greenery.
- Mitigation can be achieved through clearing construction debris and keeping dust levels down.
- Once earthworks have been completed, restoration of the worked area not forming part of the construction should be carried out immediately, by backfilling, landscaping and planting of grass or shrubs.
- Afforestation of the site would also serve to mitigate visual impacts.

6.3.14 Other Risks and Hazards

All construction projects have some risk of hazards caused by fire, earthquakes, etc. This is mitigated in the design by compliance with building regulations and provision of the necessary facilities.

There may be a need to blast some rock surfaces, for example if boulders/rocks obstruct excavation of the headrace canal. The site investigations would indicate that such blasting activities will not be substantial and they will be kept to an absolute minimum.

During power station operation, ruptures and leaks may occur at any time due to malfunctioning valves, corrosion of the pipes, earth movements, etc. This should be pre-empted by routine inspections and maintenance.

There is a risk of illegal tapping of the water from the canal, or of sabotage or vandalism, and damage to the penstock, valves, joints, etc, by children or livestock using the site.

Mitigation:

- Blasting must be carried out by a licenced blaster, and regulatory safety precautions followed. The area to be blasted must be cordoned off, and the local administration as well as the neighbouring communities must be informed well beforehand where and when blasting will take place.
- The tender documents should require the Contractor to take precautions against fire.
- During construction as well as operation, the site should be properly equipped to prevent and fight fire, in accordance with the Factories and Other Places of Work (Fire Risk Reduction) Rules, 2007
- During operation, emergency response plans for earth movements, floods, fire and spills must be prepared and must include details for containment, clean up and restoration/rehabilitation.
- Stress analysis tests must be done on all pipes and structures.
- Regular inspection and maintenance of the entire power plant and its associated infrastructure is essential. This will reveal the locations of illegal offtakes and where there may be a risk of sabotage.
- All project infrastructure must be fenced off and/or protected.
- As a project established within the community for their betterment, community members should be kept informed and asked to report any untoward activities and problems.

7 Environmental and Social Impact Monitoring

7.1 MONITORING PROCESS

Monitoring is a long-term process, which should begin during construction and continue throughout the life of the project. Its purpose is to establish benchmarks so that the nature and magnitude of anticipated environmental and social impacts can be continually assessed. So monitoring involves the continuous or periodic review of construction and maintenance activities to determine the effectiveness of recommended mitigation measures. Consequently, trends in environmental degradation or improvement can be established, and previously unforeseen impacts can be identified or pre-empted. Environmental monitoring allows measures to be implemented in order to prevent or avert negative impacts.

At this point it would be apt to distinguish between monitoring and the management plan. Monitoring focuses on specific parameters that can be measured to determine environmental or social change (ie. improvement or degradation) during and after the construction of the project. On the other hand, environmental and social management plans provide a complete overview of the considerations to be taken during planning, design, construction, defects liability, operation and maintenance. That is, it covers the entire project life. Environmental and social monitoring must therefore be incorporated into the environmental and social monitoring plan.

The overall objective of environmental and social monitoring is to ensure that activities carried out during construction and operation are environmentally and socially acceptable, and therefore sustainable.

7.2 ENVIRONMENTAL MONITORING PLAN

The environmental monitoring plan in Table 7.1 below covers the three phases of the project: design, construction and operation. It describes indicators that can be monitored, and suggests how monitoring should be done, how frequently, and who should be responsible for monitoring and action.

Aspects to be monitored have been selected so that they can realistically be monitored, and monitoring need not require great expenditure.

Table 7.1: Environmental and Social Monitoring Plan

Environmental/Social Aspects / Impacts	Proposed Aspects for Monitoring	Performance Indicator	Baseline data	Responsibility for intervention and/or monitoring during design, construction and defects liability period	Responsibility for mitigation, monitoring and/or maintenance after defects liability period	Monitoring means (c) = construction (o) = operation	Recommended frequency of monitoring
ENVIRONMENTAL MONITORING							
Impeded flow	- Culverts and bridges allow unimpeded flow through structure.	- No. of culverts silted up / blocked - No. of bridges causing ponding	- Zero culverts silted / blocked - Zero bridges causing ponding	Supervising Engineer / Contractor	Power Station Manager	(c) inspection (o) inspection	(c) continuous (o) continuous
Water management	- Daily measurements of volume of water diverted into headrace canal. - Daily measurements of flow remaining in the river channel.	- Flow measurement - Flow measurement	- Amount of water allowed to be abstracted as per WRMA abstraction permit - Specified compensation flow volume	Supervising Engineer / Contractor	Power Station Manager	(o) inspection; flow records	(o) daily
Soil Erosion	- Efficiency of soil erosion measures	- Erosion observed at specified locations	- Zero erosion	Design Engineer Supervising Engineer / Contractor	Power Station Manager	(c) (o) Inspection	(c) (o) continuous
Noise pollution	- Noise levels at site boundary. - Noise levels inside powerhouse.	- Noise levels in dB(A)	- Ambient noise levels - Permissible limits as per national regulations (Noise Rules and NEMA Noise Regulations)	Design Engineer; Supervising Engineer / Contractor	Power Station Manager	(c) (o) noise measurement records (o) noise measurement records	(c) Daily/random (o) fortnightly monitoring of noise;
New gravel sites opened by Contractor	- Rehabilitation of gravel site(s)	- Site rehabilitated	- Zero rehabilitation	Supervising Engineer / Contractor	n/a	(c) inspection.	(c) continuously.
Clearing activities	- Rehabilitation of cleared areas	- Established vegetation	- Zero vegetation	Supervising Engineer / Contractor	n/a	(c) Inspection	(c) Daily
Changes in aquatic flora and fauna	- Baseline survey of aquatic flora and fauna, and follow up study 5 years later.	- Changes in aquatic flora and fauna composition	- To be identified during baseline study	n/a	EATTA/KTDA to hire consultant to carry out baseline and follow up after 5 years	(o) study reports	(o) baseline immediately, follow up study in 5 yrs
Catchment management	- Provision of support to KFS, KWS, and the local communities in the management of the Aberdare Forests to establish current status	- Changes in forest cover	- To be identified during baseline study	n/a	KFS – forest management, supported by EATTA/KTDA with assistance from the KFFC and local communities.	(o) survey of forest cover and recovery	(o) forest status study immediately; follow up study in 5 years.
Fish	- Efficiency of fishway/bypass	- Fish passing	- Zero fish passing	Design Engineer	Power Station Manager	(o) observation	(o) daily

Environmental/Social Aspects / Impacts	Proposed Aspects for Monitoring	Performance Indicator	Baseline data	Responsibility for intervention and/or monitoring during design, construction and defects liability period	Responsibility for mitigation, monitoring and/or maintenance after defects liability period	Monitoring means (c) = construction (o) = operation	Recommended frequency of monitoring
		through structure					
SOCIAL MONITORING							
Risk of STD/ HIV/ AIDS	- STD/HIV/AIDS rates of infection	- no. of reported cases	- Base year data from MoH	n/a	Local administration, District Medical Officer of Health	(o) medical records	(o) every month
Compensation and resettlement	- Success of compensation plan	- No. of people relocated - No. of people compensated	- Zero relocation - Zero compensation	KTDA/EATTA – Compensation and Resettlement Plan Design Engineer Contractor	KTDA/EATTA – monitoring of resettlement and compensation process	(o)receipts of compensation payments	(o) continuous, with quarterly reporting
Recruitment	- Recruitment of people from local communities. - Recruitment of women.	- % of workforce from local communities - % of women in workforce	- 0% workforce from local community - 0% women in workforce	Supervising Engineer / Contractor	n/a	(c) Certificate of employment.	(c) monthly.
Site Safety	- Security and safety level of site infrastructure	- No. of accidents and incidents	- Zero accidents and incidents	Design Engineer Supervising Engineer / Contractor	Power Station Manager	(c) (o) records of accidents and incidents	(c) (o) continuous
Site / workers safety	- Use of PPE	- No. of workers using PPE	- All workers using PPE	Supervising Engineer / Contractor	Power Station Manager	(c)) PPE & first aid kit - inspection / observation; workmen's insurance – cover details (o) PPE & first aid kit - inspection / observation; workmen's insurance – cover details	(c) continuous (o) continuous

8 Environmental and Social Management Plan

8.1 ENVIRONMENTAL AND SOCIAL MANAGEMENT

A number of activities have to be carried out during the various phases of the project to ensure adequate environmental and social impact management. These include, but are not limited, to the following:

Project Preparation

- Collection of baseline data for monitoring purposes (eg. river flows, ambient noise);
- Training of power station staff in environmental management;
- Verification of design details.
- Inclusion of environmental specifications in Tender Documents, and development of Code of Conduct for the Contractor.
- Preparation of an occupational health and safety manual for use during project operation.

Construction

- Incorporation of mitigation measures;
- Enforcement of occupational health and safety requirements (conditions at the Contractor's Yard, materials storage, condition of equipment, protective clothing, etc);
- Collection of data on river flow, and noise and vibration levels;
- Disposal of construction, solid and sanitary wastes in an acceptable manner and in conformance with regulations;
- Ensuring that the Contractor is following the Code of Conduct and environmental specifications in the Tender Documents;
- Training the Contractor's workforce in environmental and social awareness and responsibility (including STD/HIV/AIDS awareness).
- Liaison with local administration and community leaders in matters of disturbance to the public, security issues, and siting of the Contractor's Yard.

Operation

- Maintenance, calibration and checking of all equipment as specified in respective manuals or regulations;
- Monitoring leakage and spills;
- Collection of data on water flow, and noise and vibration levels, to be used for analysis and remediation where necessary;
- Disposal of solid and sanitary wastes in an acceptable manner and in conformance with regulations;
- Compliance with occupational health and safety manual to be prepared during by scheme management during the project preparation phase;
- Environmental performance reporting (based on evaluation of data collected, investigations, etc).

Table 8.1 below presents the environmental and social management plan. It describes how each of the main mitigation measures proposed in Chapter 6 should be implemented, how frequently, and who should be responsible during and after construction. Monitoring indicators and means of monitoring have also been included the table.

It is imperative that this Environmental Project Report is made available to the contractors bidding for the project during the tendering process so that they can appreciate what is involved in implementing proposed mitigation measures and will be able to include mitigation measures in the bills of quantities.

Prior to mobilisation, the Contractor should also prepare his own environmental management plan for review by the Supervising Engineer. In his schedule of works, the Contractor must include all proposed mitigation measures, and the Supervising Engineer should ensure that the schedule and environmental management/monitoring plan are complied with. This will also lend a sense of ownership to the Contractor, in addition to instilling in him a thorough understanding of the pertinent issues.

The responsibility for supervision of the implementation of all the proposed mitigation measures during construction and the defects liability period will lie with the Supervising Engineer, while the Contractor will be responsible for day to day operational matters of construction, which will include implementation of mitigation measures that he is responsible for. After the defects liability period, responsibility for the operation and maintenance of the scheme will rest with the Power Station Manager, who will be an employee of owner/operator (KTDA).

Table 8.1 also presents an estimate of the costs of environmental management and mitigation.

Table 8.1: Environmental and Social Management Plan

Environmental/ Social Aspects / Impacts		Proposed Mitigation and Aspects for Monitoring	Responsibility for intervention and/or monitoring during design, construction and defects liability period	Responsibility for mitigation, monitoring and/or maintenance after defects liability period	Monitoring means (d) = design/ preconstruction (c) = construction (o) = operation	Recommended frequency of monitoring	Estimated Cost (KShs)
ENVIRONMENTAL MANAGEMENT PLAN							
Changes in Hydrology	Impeded flow	- Design of culverts and bridges to ensure unimpeded flow through structure.	Design Engineer Supervising Engineer / Contractor	Power Station Manager	(d) verification of design (c) inspection	(d) once after design of bridges / culverts complete (c) continuous	Included in construction cost
	Compensation flow	- Provision for proposed compensation flow in the North Mathioya River (10% of mean flow). - WRMA to determine compensation flow criteria, and ascertain adequacy of proposed compensation flow vis a vis optimum hydropower potential.	WRMA – to determine adequacy of proposed compensation flow	Power Station Manager	(o) flow records	(o) daily	(o) Flow records - part of routine O&M costs.
	Water management	- Management of water use through maintenance of the plant and penstock. - Daily measurements of volume of water diverted into headrace canal. - Daily measurements of flow remaining in the river channel. - Turbine operations to be adjusted depending on available river flow and required compensation flow.	WRMA – overall responsibility for water allocation. Design Engineer Supervising Engineer / Contractor - management and quality aspects	Power Station Manager	(o) inspection; flow records; records of power generated.	(o) daily	(o) Included in routine O&M costs
Soil Erosion	Earth works	- Controlled clearing of vegetation and re-vegetation of disturbed areas as required. - Management of excavation activities, and reuse/ storage / disposal of spoil. - Undertaking of earthworks during dry season.	Supervising Engineer / Contractor	n/a	(c) Inspection	(c) Continuous	(c) Construction cost.

Environmental/ Social Aspects / Impacts		Proposed Mitigation and Aspects for Monitoring	Responsibility for intervention and/or monitoring during design, construction and defects liability period	Responsibility for mitigation, monitoring and/or maintenance after defects liability period	Monitoring means (d) = design/ preconstruction (c) = construction (o) = operation	Recommended frequency of monitoring	Estimated Cost (KShs)
	Scheme design	- Headrace and tailrace canal, and penstock design to include measures to minimize erosion during and after construction. - Re-vegetation of all embankments to be coordinated with completion of different elements of the works. - Canal and embankment stabilization measures to be incorporated and maintained.	Design Engineer Supervising Engineer / Contractor	Power Station Manager	(c) (o) Inspection	(c) (o) continuous	(c) Construction cost. (o) routine O&M costs.
	Access roads and transmission lines	- Incorporation of properly designed drainage structures along access roads. - Re-vegetation of road embankments. - Trash lines to be constructed and maintained where the transmission lines traverse steep terrain.	Design Engineer Supervising Engineer / Contractor	Power Station Manager	(d) verification of design of drainage structures (c) (o) Inspection	(d) on completion of design (c) (o) continuous	(c) Construction cost. (o) routine O&M costs.
Air Quality	Air and dust emissions	- Control speed of construction and other vehicles on site. - Equipment/machinery operators and drivers of construction vehicles to be sensitised. - Maintenance of construction plant and equipment. - Watering to keep dust levels down - Stockpiles to be enclosed / covered.	Supervising Engineer / Contractor	n/a	(c) inspection / observation	(c) Daily/random	(c) Construction cost.
Noise Quality	Noise pollution	- Noise buffering measures to be incorporated into powerhouse building design. - Noise levels to comply with national standards - Construction workers and drivers sensitised. No movement of heavy vehicles after dark. - Maintenance of plant and equipment. - PPE (ear plugs/muffs) to be provided and use enforced.	Design Engineer Supervising Engineer / Contractor	Power Station Manager	(d) equipment specifications (c) Inspection / observation; noise measurement records (o)inspection/observation; maintenance records; noise measurement records	(c) Daily/random (o) fortnightly monitoring of noise; maintenance as required by manufacturers specifications	(c) Construction cost. (o) Noise meter KShs 30,000/-; PPE costs – see below. Maintenance - part of operation costs

Environmental/ Social Aspects / Impacts		Proposed Mitigation and Aspects for Monitoring	Responsibility for intervention and/or monitoring during design, construction and defects liability period	Responsibility for mitigation, monitoring and/or maintenance after defects liability period	Monitoring means (d) = design/ preconstruction (c) = construction (o) = operation	Recommended frequency of monitoring	Estimated Cost (KShs)
Water Quality	Sediment loading	- Management of earthworks and spoil. - Incorporation and maintenance of erosion control measures - Installation and maintenance of silt trap. - Removal of silt building up behind the weir.	Design Engineer Supervising Engineer / Contractor	Power Station Manager	(d) verification of design of erosion control measures (c) inspection (o) Inspection	(d) on completion of design (c) continuous (o) monthly or as needed; annual maintenance.	(c) construction cost (o) routine O&M costs
	Foul water contamination	- Provision of proper sanitation facilities. - Design and construction of sanitation facilities ensures compliance with national standards.	Design Engineer Supervising Engineer / Contractor	Power Station Manager	(d) verification of design of sanitation facilities (c) inspection (o) inspection	(d) once when designed (c) sanitation facilities: completion of works certificate; other aspects monitored daily (o) daily	(c) construction cost (o) routine O&M costs
Contamination by Oil	Oil pollution	- Specified area allocated for maintenance of construction plant and equipment. - Provision of proper contained facility constructed for storage of oil and oil products. - Oil interceptor to be installed at stormwater drain outlet, and maintained - Procedures for proper storage, handling and disposal of oil products, and spill response - Provision of spill kit - Maintenance of power plant equipment	Design Engineer Supervising Engineer / Contractor	Power Station Manager	(d) verification of design of oil storage facilities and interceptor (c) Inspection (o) inspection	(d) once when designed (c) oil storage facility / interceptor: completion of works certificate; other aspects monitored continuously (o) continuously; maintenance as required.	(c) Construction cost. (o) Spill kit KShs 15,000/-; other costs are routine O&M costs.
Solid Waste and Construction Debris	Solid waste management	- Contractor's practices to minimise amount of debris and waste generated. - All waste to be properly disposed of. - During plant operation, waste to be segregated, inventorised and disposal methods recommended, as required by Waste Regulations	Supervising Engineer / Contractor	Power Station Manager	(c) Inspection (o) inspection	(c) Daily. (o) Daily	(c) Construction cost. (o) routine O&M costs

Environmental/ Social Aspects / Impacts		Proposed Mitigation and Aspects for Monitoring	Responsibility for intervention and/or monitoring during design, construction and defects liability period	Responsibility for mitigation, monitoring and/or maintenance after defects liability period	Monitoring means (d) = design/ preconstruction (c) = construction (o) = operation	Recommended frequency of monitoring	Estimated Cost (KShs)
Materials Sources	New gravel sites opened by Contractor	- EIA of gravel sites to be carried out. - Properly planned excavation activities, including proper drainage, fencing, access and egress to the site, and rehabilitation of gravel site as agreed with gravel site owner. - Prohibition of dumping of oil, garbage and spoil in the gravel site area. - Dust reduction through water sprinkling.	Supervising Engineer / Contractor	n/a	(c) EIA report, inspection.	(c) EIA study done when sites are identified and before excavation begins. Other aspects to be monitored continuously.	(c) EIA Study: KShs 200,000/- ; other costs are included in Construction costs
	Other construction materials	- Specified standards to be applied to all materials and appliances. - Specified materials not to be used for construction. - Verification of sources of all construction materials.	Supervising Engineer / Contractor	n/a	(c) certificates, Inspection.	(c) continuously	(c) Construction cost.
Vegetation / flora	Clearing activities	- Controlled clearing of vegetation and trees. - All disturbed areas to be rehabilitated and re-vegetated.	Supervising Engineer / Contractor	n/a	(c) Inspection	(c) Daily	(c) Construction cost.
	Changes in aquatic floral composition	- Weir design to minimise damming effect. - Baseline survey of aquatic flora, and follow up study 5 years later.	Design Engineer	Power Station Manager – weir condition EATTA – baseline and follow up	(d) verification of weir design	(d) on completion of weir design (o) baseline immediately, follow up study in 5 yrs	(d) included in design fee (o) Baseline study to cover flora and fauna and follow up study: KShs 1,000,000/- each
Forests	Catchment management	- Provision of support to KFS, KWS, and the local communities in the management of the Aberdare Forests to establish current status - Hydrological data should be collected for the North Mathioya River	n/a WRMA	KFS – forest management, supported by EATTA/KTDA with assistance from the KFFC and local communities. WRMA	(o) survey of forest cover and recovery; consistent records of daily hydrological flow	(o) forest status study immediately; follow up study in 5 years.	(o) to be determined.

Environmental/ Social Aspects / Impacts		Proposed Mitigation and Aspects for Monitoring	Responsibility for intervention and/or monitoring during design, construction and defects liability period	Responsibility for mitigation, monitoring and/or maintenance after defects liability period	Monitoring means (d) = design/ preconstruction (c) = construction (o) = operation	Recommended frequency of monitoring	Estimated Cost (KShs)
Wildlife / fauna	Terrestrial habitat destruction	- Controlled clearing of vegetation and trees. - Re-vegetation and re-afforestation and of the site and any areas that are cleared.	Supervising Engineer / Contractor	n/a	(c)	(c) continuous	(c) Construction cost
	Changes in aquatic fauna composition	- Weir design to minimise damming effect. - Baseline survey of aquatic fauna, and follow up study 5 years later.	Design Engineer	Power Station Manager – weir condition EATTA – baseline and follow up	(d) verification of weir design	(d) on completion of weir design (o) baseline immediately, follow up study in 5 yrs	(d) included in design fee (o) Baseline study covering flora and fauna – see above.
	Fish	- Construction of fishway / bypass. - Installation of a screen at the inlet to the forebay and penstock to stop fish.	Design Engineer	n/a	(d) verification of design	(d) on completion of fishway / bypass design	(c) construction cost
De-mobilisation		- Site to be left in a clean, sightly and restored condition on completion of works.	Supervising Engineer / Contractor	n/a	(c) certificate of completion	(c) once when construction is complete	(c) construction cost
SOCIAL MANAGEMENT PLAN							
Settlement and Immigration	Risk of STD/ HIV/ AIDS	- STD/HIV/AIDS awareness campaign to be conducted	Supervising Engineer / Contractor	Local administration, District Medical Officer of Health	(c) minutes of awareness raising meetings	(c) every month (o) every 6 months	(c) HIV/AIDS awareness KShs 300,000/- (o) none
	Contractors Yard Site	- Liaison with local administration for identification of possible sites for Contractor's Yard.	Supervising Engineer / Contractor	n/a	(c) minutes of meetings, Letter of approval from authorities	(c) upon mobilization before Yard is set up	(c) construction cost
	Security	- Security arrangements to pre-empt influx of workers		Local administration	(o) number of criminal incidents reported involving outsiders	(o) biannually	none

Environmental/ Social Aspects / Impacts		Proposed Mitigation and Aspects for Monitoring	Responsibility for intervention and/or monitoring during design, construction and defects liability period	Responsibility for mitigation, monitoring and/or maintenance after defects liability period	Monitoring means (d) = design/ preconstruction (c) = construction (o) = operation	Recommended frequency of monitoring	Estimated Cost (KShs)
Loss of Land, Property and crops	Compensation and resettlement	- Preparation of an abbreviated compensation and resettlement plan covering permanent and temporary land take, and including all costs of land (at market value), property/housing, crops, relocation, transportation, loss of income, etc. - As far as possible, powerline to follow existing way leaves and rights of way, to minimise land take and crop loss. - Controlled clearing activities to ensure minimum crop loss.	KTDA/EATTA – Compensation and Resettlement Plan Design Engineer Contractor	KTDA/EATTA – monitoring of resettlement and compensation process	(c) Compensation and Resettlement Plan report; powerline route map (o) minutes of pubic meetings, receipts of compensation payments; RP implementation and progress reports	(c) Plan to be prepared Pre construction; powerline construction to be monitored continuously (o) continuous, with quarterly reporting	(c) CRP preparation KShs 600,000/- Compensation and relocation costs KShs 15.2 million, plus admin and monitoring costs
Employment opportunities	Recruitment	- Preferential recruitment of people from local communities. - Recruitment of women.	Supervising Engineer / Contractor	n/a	(c) Certificate of employment.	(c) monthly.	(c) Construction cost.
Agricultural Activities	Compensation for loss of crops	- Compensation and Resettlement Plan to take into account compensation for loss of crops	EATTA – Compensation and Resettlement Plan	EATTA – monitoring of compensation process	(c) Compensation and Resettlement Plan report; powerline route map (o) minutes of pubic meetings, receipts of compensation payments; CRP implementation and progress reports	(c) Plan to be prepared Pre construction; powerline construction to be monitored continuously (o) continuous, with quarterly reporting	(c) included above
Fisheries		- Maintenance of compensation flow based on 10% of mean flow (0.589m3/s) until precise values for the compensation flow are determined. - Detailed investigations of the hydro-morphology of the river and the aquatic ecology to determine actual compensation flow required.	Design Engineer	Power Station Manager	(d) study report (o) flow records	(d) once on completion of study (o) daily	see above
	Impact on fish stocks	- Construction of fishway / bypass. - Installation of a screen at the inlet to the forebay and penstock to stop fish.	Design Engineer	n/a	(d) verification of design	(d) on completion of fishway / bypass design	(c) construction cost

Environmental/ Social Aspects / Impacts		Proposed Mitigation and Aspects for Monitoring	Responsibility for intervention and/or monitoring during design, construction and defects liability period	Responsibility for mitigation, monitoring and/or maintenance after defects liability period	Monitoring means (d) = design/ preconstruction (c) = construction (o) = operation	Recommended frequency of monitoring	Estimated Cost (KShs)
Public Health	Risk of STD / HIV/ AIDS	- STD/HIV/AIDS awareness campaign to be conducted	Supervising Engineer / Contractor	Local administration, District Medical Officer of Health	(c) minutes of awareness raising meetings	(c) every month (o) every 6 months	(c) see above (o) none
	Waste and Wastewater disposal	- Proper treatment and disposal of sewage generated on site to comply with national regulations - Proper arrangements for disposal of solid waste to comply with national regulations -	Design Engineer Supervising Engineer / Contractor	Power Station Manager	(d) verification of design of sanitation facilities (c) inspection (o) inspection	(d) once when designed (c) sanitation facilities: completion of works certificate; other aspects monitored daily (o) daily	As above (c) construction cost (o) routine O&M costs
		- Fencing of intake, headrace canal, forebay and power house area. - A safety net to be placed before the penstock inlet. - The plots along the river at the intake to be fenced off.	Design Engineer Supervising Engineer / Contractor	Power Station Manager	(d) verification of design of structures, and fencing details (c) inspection (o) inspection	(d) once when designed (c) completion of works certificate; other aspects monitored daily (o) daily	As above (c) construction cost (o) routine O&M costs
	Site Safety	- Awareness raising among local communities.	Supervising Engineer / Contractor	Power Station Manager	(c) minutes of meetings with local communities (o) minutes of meetings with local communities	(c) monthly (o) initially monthly, then after 6 months	(c) constr const (o) routine O&M costs
Occupational Health and Safety	Site / workers safety	- All workmen / visitors to be provided with suitable protective gear (such as nose masks, ear muffs, helmets, overalls, industrial boots, etc) - A fully equipped first aid kit on site, - Workmen's compensation cover required as per regulations.	Supervising Engineer / Contractor	Power Station Manager	(c)) PPE & first aid kit - inspection / observation; workmen's insurance – cover details (o) PPE & first aid kit - inspection / observation; workmen's insurance – cover details	(c) continuous (o) continuous	(c) PPE – incl in Construction cost (o) PPE: KShs 100,000/-; First aid kit – KShs 5,000/-
	Potable water	- Workers to be provided with water for drinking	Supervising Engineer / Contractor	Power Station Manager	(c) inspection (o) inspection	(c) continuous (o) continuous	(c) Construction cost (o) routine O&M costs
	HSE Officer	- Health, Safety and Environment Officer to be employed	Supervising Engineer / Contractor	Power Station Manager	(c) (o) contract / letter of employment	(c) upon mobilization and thereafter every 6 months (o) every 6 months	(c) salary – to include in Contractors cost (o) salary – estimated at KShs 40,000/- per month

Environmental/ Social Aspects / Impacts		Proposed Mitigation and Aspects for Monitoring	Responsibility for intervention and/or monitoring during design, construction and defects liability period	Responsibility for mitigation, monitoring and/or maintenance after defects liability period	Monitoring means (d) = design/ preconstruction (c) = construction (o) = operation	Recommended frequency of monitoring	Estimated Cost (KShs)
	OHS Handbook	- OHS Handbook to be prepared.	n/a	Power Station Manager	(o) handbook available	(o) once after 3 months	(o) operation cost
Contractor's Yard	Contractors Yard Site	- Liaison with local administration for identification of possible sites for Contractor's Yard.	Supervising Engineer / Contractor	n/a	(c) minutes of meetings, Letter of approval from authorities	(c) upon mobilization before Yard is set up	(c) constr cost
	Waste and Wastewater disposal	- Proper treatment and disposal of sewage generated at the Yard to comply with national regulations - Proper arrangements for disposal of solid waste to comply with national regulations -	Supervising Engineer / Contractor	n/a	(c) inspection	(c) daily	As above (c) construction cost
	Risk of STD / HIV/ AIDS	- STD/HIV/AIDS awareness campaign to be conducted	Supervising Engineer / Contractor	n/a	(c) minutes of awareness raising meetings	(c) every month	(c) see above
Disturbance to the public	Pollution	- Minimise pollution as above	Supervising Engineer / Contractor	n/a	(c) inspection	(c) continuous	(c) Construction cost.
		- Notify community leaders of possible disturbances during construction.	Supervising Engineer / Contractor	n/a	(c) minutes of meetings	(c) Community sensitization – before mobilization. Daily.	(c) Construction cost (mobilization)
	Sensitisation of community	- Erect warning/informative signs.	Supervising Engineer / Contractor	n/a	(c) Inspection.	(c) When erected.	(c) Construction cost.
	Nuisance	- Prohibition of construction activities at night.	Supervising Engineer / Contractor	n/a	(c) Observation/ inspection.	(c) continuous.	(c) Construction cost.
Access and egress to site	Safety issues	- Controlled movement of all construction vehicles, and specified routes. - Adherence to speed limits by construction vehicles. - Warning / informative signs to be erected wherever construction works are in progress, - Alternative access routes to be specified as necessary. - All roads used by construction traffic to be rehabilitated.	Supervising Engineer / Contractor	n/a	(c) Observation/ inspection.	(c) continuous.	(c) Construction cost.

Environmental/ Social Aspects / Impacts		Proposed Mitigation and Aspects for Monitoring	Responsibility for intervention and/or monitoring during design, construction and defects liability period	Responsibility for mitigation, monitoring and/or maintenance after defects liability period	Monitoring means (d) = design/ preconstruction (c) = construction (o) = operation	Recommended frequency of monitoring	Estimated Cost (KShs)
	Sensitisation of community	- Notify community leaders of possible risk to road safety.	Supervising Engineer / Contractor	n/a	(c) minutes of meetings	(c) Community sensitization – before mobilization. Daily.	(c) Construction cost (mobilization)
Visual intrusion		- Powerhouse buildings and penstock to be designed to blend into the surrounding environment. - Clearing of construction debris, and reducing dust levels. - Restoration of the worked area upon completion of works. - Planting and afforestation of the site.	Design Engineer Supervising Engineer / Contractor	n/a	(d) verification of design (c) debris/dust - inspection and observation ; restoration / afforestation - completion of works certificate /	(d) when design completed (c) continuous; restoration at end of construction	(d) design cost (c) construction cost
Other risks and hazards	Blasting	- Blasting to be carried out by a licenced blaster, - regulatory safety precautions to be followed - The area to be blasted to be cordoned off - Local administration and neighbouring communities informed well beforehand where and when blasting will take place.	Supervising Engineer / Contractor	n/a	(c) blasting licence; visual inspection of cordoned area; minutes of meetings with local administration and community leaders	(c) once when blasting is to take place	(c) construction cost
	Fire Precautions	- Site to be properly equipped to prevent and fight fire, in accordance national regulations	Supervising Engineer / Contractor	Power Station Manager	(c) inspection (o) inspection, fire drills and reports	(c) daily (d) daily	(c) construction cost (o) routine O&M cost
	Emergency Response Plan	- Emergency response plans for earth movements, floods, fire and spills to be prepared. - ERPs to include details for containment, clean up and restoration/rehabilitation.	Supervising Engineer / Contractor	Power Station Manager	(c) ERP available (o) ERP available	(c) once at beginning of construction phase (o) annually	(c) construction cost (o) routine O&M cost
		- Stress analysis tests to be done on all pipes and structures. - All project infrastructure to be fenced off and/or protected.	Supervising Engineer / Contractor	Power Station Manager	(c) test reports (o) test reports	(c) when pipes / structures installed (o) during major maintenance	(c) construction cost (o) routine O&M cost
	Safety / sabotage	- Regular inspection and maintenance of the entire power plant and associated infrastructure.	n/a	Power Station Manager	(o) inspection reports	(o) as stipulated in equipment specs and procedures	(o) routine O&M cost

8.2 OTHER MEASURES TO ENHANCE ENVIRONMENTAL MANAGEMENT

8.2.1 Training

It will be necessary to give the staff who will manage the power station relevant training in environmental management. The level and contents of training required will depend on the qualifications of the members of staff, and their particular responsibilities.

Training should focus on imparting an understanding of the rationale for incorporating mitigation measures recommended by the EIA study, and the importance of implementing the monitoring plan.

Certain members of staff may have to undergo specialised training so that they are capable of implementing the monitoring plan, as well as sorting, storing, analysing and evaluating all the data that is collected.

8.2.2 Safety Manual

Before commencement of operations, an Operational Health and Safety Manual should be prepared which will describe, amongst others, day to day precautions which must be taken in order to render the power station and powerlines safe to both workers and the public, and the necessary safety equipment and protective gear.

8.2.3 Emergency Preparedness and Response Plan

Also before operation commences, an emergency preparedness response plan should be prepared to cover emergencies resulting from earth movements (landslides or earthquakes), floods, fire and spills. The plan should focus on, inter alia:

- Safety training;
- Evacuation procedures;
- Public relations during an emergency.

8.3 COST OF MITIGATION AND MANAGEMENT

The estimated cost of incorporating and implementing mitigation measures have been indicated in Table 8.1.

Many of the mitigation measures to be incorporated during construction do not entail physical costs, but are a matter of supervision and diligence. Costs such as gravel pit rehabilitation and for “making good” will be part of the construction costs to be determined by the Contractor.

Other mitigation measures are to be carried out or incorporated during the operational phase, and many will be part of routine operation and maintenance activities.

Table 8.2 below gives a breakdown of the estimated environmental and social mitigation and management costs for the pre-construction, construction and operation phases of the project.

Table 8.2: Environmental and Social Mitigation and Management Costs

Costed Mitigation Measure	Estimated Cost during Construction (KShs)	Estimated cost during 1st Year of Operation (KShs)
Monitoring noise quality		30,000
Oil spill management		15,000
EIA study of gravel sites	200,000	
Baseline survey of aquatic flora and fauna. (Cost of follow up study after 5 years not included)		1,000,000
STD/HIV/AIDS awareness campaign	300,000	
Preparation of an abbreviated compensation and resettlement plan covering permanent and temporary land take, and including all costs of land (at market value), property/housing, crops, relocation, transportation, loss of income, etc. Estimated compensation costs (excluding administration and monitoring costs)	600,000 15,200,000	
PPE First Aid Kit		100,000 5,000
HSE officer's annual salary		480,000
TOTAL COST OF MITIGATION **Kenya Shillings** **US dollar equivalent** **(RoE 1$ = 75 KShs)**	**KShs 16,300,000** **US$ 217,340**	**KShs 1,630,000** **US$ 21,740**

Costs that are not included in the above table are those for the management of the Aberdare Forests, as this is outside the scope of the project. However, EATTA and KTDA can consider supporting the Kenya Forest Services or other organisations involved in reafforestation programmes in the Aberdares.

9 Recommendations and Conclusions

9.1 MAIN FINDINGS

Run-of-river small hydro schemes are deemed to be environmentally friendly. This is generally true of the North Mathioya Small Hydro Project. Various environmental and social impacts have been discussed in this report, the majority of which are easily mitigated.

There are number of benefits to be derived from the proposed scheme. The overall aim of this GTIEA Project is to reduce electrical energy cost and use in the tea processing industry, preferably with an attached rural electrification component, and to initiate a process of reducing green house gas emissions whilst enhancing power supply reliability.

The primary objective of the North Mathioya Small Hydropower Scheme is to supply reliable and cost effective renewable electrical energy to the four tea factories of KTDA Region II, Zone 3, namely Gatunguru, Kiru, Kanyenyaini and Githambo.

Subsidiary objectives of the project include:
- The provision of energy free of greenhouse gas emissions to consumers;
- The sale of surplus environmentally friendly energy to the national distributor (KPLC);
- The development of local energy resources to benefit the local community; and
- The establishment or expansion of rural electrification potential.

Benefits from the project as perceived by the stakeholders include employment opportunities, especially for casual workers and several other specialized workers; support to the local economy, partly by the migrant workforce and demand for construction materials, but also as a result of locally generated income and revenues from the provision of services; reduced consumption of fuel by the tea factories; and reduced air pollution.

However there are a number of specific issues that are considered significant and need urgent attention.

The first relates to ensuring a compensation flow that is necessary to sustain aquatic habitats, and subsequently aquatic fauna, as well as user demand downstream. Although virtually 100% of the water that is diverted for the hydropower plant will be returned to the river channel, there is a stretch of river some 4.5 km long that will have diminished flow, and this may affect aquatic flora and fauna (especially fish) downstream of the weir. The Water Act of 2002 mandates WRMA to establish compensation flows for all water resources in the country. However, at present compensation flow values for the North Mathioya River have not been established, nor have guidelines for determining compensation flow been gazetted or approved. In the absence of an accurate compensation value derived from an assessment of hydro-morphological and ecological needs, WRMA recommends using the 95% exceedence flow as the basis for developing a guideline. For the North Mathioya

River, this is 2.0 m^3/s, and would jeopardise the economic feasibility of proposed small hydropower scheme. The Water Rules (2007) also stipulate that WRMA may impose special conditions on a licence if the amount of power generated by a hydro project is less than the full hydro power potential of a site. At a meeting with WRMA personnel at their Headquarters in Nairobi, it was agreed that the Design Consultant should propose a compensation value for WRMA's assessment in terms of ecological and human demand. Thus a compensation flow of 0.589 m^3/s has been proposed for the North Mathioya scheme, which is equivalent to 10% of the mean flow. WRMA must therefore determine the acceptability of this proposed compensation flow on the basis of optimisation of hydropower generation and maintenance of an ecologically acceptable compensation flow.

River flow may also be affected by factors external to the project, namely climate change and deforestation of the Aberdare Forests. Both have implications on hydrological flow in the Mathioya River, and consequently on the amount of water that can be diverted for power generation.

Finally, the construction of the headrace canal, forebay, penstock and powerhouse, and some sections of the transmission lines, will necessitate the permanent acquisition of land. As these structures will be located in cultivated areas and some crops will be destroyed. In addition, land will be required temporarily for the establishment of the Contractor's Yard. It is not anticipated that any resettlement will be necessary, although four households will need to relocate to other parts of their existing plots. However, land and crops will have to be compensated for in accordance with national procedures and requirements.

9.2 RECOMMENDATIONS

Recommendations have been made for mitigation in Chapter 6 of the report, and these measures have been included in the environmental management plan.

Recommendations for significant adverse impacts are as follows:

- WRMA must establish standards for various catchments within the country for the applicable amount of compensation water to be provided for at diversion weirs for small hydropower projects, given the special characteristics of such projects and their facility to provide clean renewable energy
- For the North Mathioya scheme, WRMA must review the proposed compensation flow value of 0.589 m^3/s in order to establish its adequacy in terms of satisfying ecological and human water demand
- In the event that WRMA deems that the proposed compensation flow is not adequate, then the scheme should be downsized, or its operations restricted to higher flows for shorter periods of time, in order allow a higher compensation flow.
- KTDA must support KFC in forest protection and conservation programmes in the Aberdare Forests
- Once it has been decided that the proponent (KTDA) will proceed with the project, an abbreviated compensation and resettlement plan will have to be

prepared and implemented which will address concerns related to temporary and permanent loss of land, property and crops.

Diligence on the part of the Contractor and proper maintenance during scheme operation are key to ensuring sound environmental and social management during the construction and operation phases, respectively.

9.3 CONCLUSIONS

The proposed small hydropower project is expected to achieve its intended objectives, as well as realise the identified benefits for the local communities, provided that:

- The compensation flow approved by WRMA is maintained in the North Mathioya River in the bypassed section of the river between the intake and the tailrace re-entry point
- All land acquired for the purposes of the project is promptly and fairly compensated for, and that any relocation of affected persons or property is carried out in accordance with national legislation and international guidelines
- The mitigation measures proposed in this report for addressing adverse environmental and social impacts are implemented, and
- Recommendations made for monitoring and management adhered to.

ANNEXES

Annex 1: References
Annex 2: Persons Contacted/Consulted
Annex 3: Stakeholder Consultation Notes / Attendance
Annex 4: Maps of the Site Location and Plot Boundaries
Annex 5: Photographic Record
Annex 6: Hydrological Report
Annex 7 Design Details
Annex 8: Terms of Reference
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Annex 1: References

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Annex 2: Persons Contacted/Consulted

Mr Jara	Water Resources Management Authority, Embu
Mr Rupert Watson	Environmental Lawyer, Trout Specialist
Mr Mike Thomas	Consultant, Water Resources Management Authority
Mr Chris Harrison	Kenya Fly Fishers Club
Mr Dominic Grammaticas	Kenya Fly Fishers Club
Mr. Michael Mwaniki	District Environmental Officer (Muranga and Maragua),
Mrs. Jane Mwangi	Marketing (KPLC Muranga)
Mr. Charles Awundo	Transmission and Distribution (KPLC Nyeri Office),
Mrs. Mary Chege	District Agricultural Officer (Muranga)
Mr. Peter Kangangi	DELDO (Muranga)
Mr. Francis Gachuga	Sub Regional Manager (WRMA Muranga Region)
Mr. Samuel Gachowa	District Development Officer (Muranga)
Mr. Douglas Mokuwa	District Land Valuer (Muranga)
Mr. Ernest Waweru	Kanyenyaini Tea Factory Unit Manager
??	Muranga District Surveyor
Mr. Douglas Kihara	Chief Njumbi Location
Mr. Simon Njuguna	Assistant Chief Gacharageini Sub Location, Njumbi Location
Mrs. Alice Macharia	Assistant Chief Kiamuturi Sub Location, Njumbi Location
Mr. Wilfred Gachanja	Clerifical Officer, Chiefs Office Njumbi Location
Mr. Peter Muchiri	Pastor in the Project area.
Mr James M Gikuru	Farmer and Chairman, Gacharageini Micro Hydro Scheme Plant.
Mr Joseph Ngari	Gacharageini Micro Hydro Scheme Plant.

Annex 3: Stakeholder Consultation Notes / Attendance

GUIDELINES FOR PUBLIC CONSULTATION - NORTH MATHIOYA RIVER

1. Describe the purpose of the scheme and the scheme components:
    - The scheme has been proposed as part of the East Africa Tea Trade Association initiative to provide power to tea factories serving small holder tea growers.
    - The scheme components are a diversion weir/intake, headrace canal, penstock, power house, tailrace/outfall.
    - Describe the three options being considered, and the one that is favoured by the engineers because of economics.
    - There will be a distance of 4.411 km between the intake and outfall.
    - If the scheme is selected, it will take 6 months to a year before construction will begin (check with Graeme).

2. Ask the gathering for any information on the history of river flow in the North Mathioya River:
    - Is there always water in the river?
    - Has the river ever been completely dry?
    - When (which months) is the river flow low?
    - How long for?
    - Is there a big difference in water levels during the wet season and the dry season?
    - How much of a difference (get an answer in terms of the number of feet or meters)?
    - Generally in the dry season how high is the water level in the river?
    - How often do they have flash floods?
    - Are there any projects upstream (planned or ongoing) that may take water from the river?
    - What sort of activities downstream (between the intake and outfall) would be affected by lower river water levels?

3. Ask the gathering what their views on the project are:
    - Is it a good thing or bad thing? Why?
    - Which scheme option would they prefer? Why?
    - What do they think the positive impacts will be?
    - What are the benefits to them?
    - What do they think the negative impacts will be?
    - How will the project adversely affect them?
    - What would they propose as solutions for any negative impacts?
    - What other suggestions do they have?

Ask the gathering if they have any questions to ask you?

STAKEHOLDER CONSULTATION RECORD

PROJECT: RIVER MATHIOYA NORTH SMALL HYDRO

	NAME	DESIGNATION / ORGANISATION	ID NO.	SIGNATURE	DATE
1	JOHN G. GACHUHI	CARPENTER	9271764		14/11/2008
2	G.M GACHERU	FARMER	0619216		14/11/2008
3	JAMES M. GIKURU	"	5981725		14/11/2008
3	PAUL CHEGE K	"			"
4	B. W. KAMINJU	"			"
5	H. N MUBAYA	"			"
6	Elud Buku	FARMER	5909621		14/11/008
7	MAINA ALBERT	"	7293779		"
8	James Maina				
9	PETER MUCHIRI	PASTOR	8633451		" "
10	ALICE N. MACHARIA	ASS CHIEF KIAMUTUNI I	7910283	0721.110218	14/11/08
11	SIMON C. NJAMUNYA	ASS CHIEF GACHAZAGEINI	5958749	0724299455	14/11/08
12	WILFRED K. GACHARIA	CLERICAL OFFICER NJUMBI LOCATION	14652520		14/11/08
13	DOUGLAS N. KIHARA	CHIEF NJUMBI LOC	23078064		14/11/08

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Annex 4: Maps of the Site Location and Plot Boundaries

Annex 5: Photographic Record

Annex 6: Hydrological Report

Annex 7: Design Details

Annex 8: Terms of Reference

Annex 9: Study Team

The study team for this Environmental Project Report comprised:

Arundhati Inamdar Willetts	–	EIA Specialist (NEMA Registration No. 0051)
Haroub Ahmed	–	Environmental Scientist
Graeme Watson	–	Civil Engineer, Project Manager
Patrick Ndumia	–	Civil Engineer
Richard Carrington	–	Geotechnical Engineer
Joseph Karanja	–	Hydrologist
David Gichuki	–	Surveyor