ENVIRONMENTAL IMPACT ASSESSMENT FOR OLKARIA II THIRD UNIT EXTENSION PROJECT

ENVIRONMENTAL PROJECT REPORT

ENVIRONMENTAL IMPACT ASSESSMENT FOR OLKARIA II THIRD UNIT EXTENSION PROJECT

ENVIRONMENTAL PROJECT REPORT

CONTENTS

Annexes

Figures

Acronyms and abbreviations

DO	District Officer
EIA	Environmental Impact Assessment
EMCA	Environmental Management and Coordination Act
ER(s)	Emission Reduction(s)
ITCZ	Inter Tropical Convergence Zone
KenGen	Kenya Electricity Generating Company Ltd
KPC	Kenya Power Company
KPLC	Kenya Power and Lighting Company Ltd
km	Kilometres
KWS	Kenya Wildlife Service
LNGG	Lake Naivasha Growers Group
LNTG	Lake Naivasha Tourism Group
m asl	Metres Above Sea Level
MOU	Memorandum of Understanding
MW	Mega Watt
NEMA	National Environment Management Authority
NCG(s)	Non Condensable Gas(es)
OH&S	Occupational Health and Safety
ppm	Parts Per Million
TLV	Threshold Limit Value
UM	Upper Midland Zone
UNEP	United Nations Environment Programme
WB	World Bank
WHO	World Health Organisation

EXECUTIVE SUMMARY

E1 Introduction

The Kenya Electricity Generating Company (KenGen) currently owns and operates two geothermal power stations at Hell's Gate National Park. The first generating unit at Olkaria I was commissioned in 1981, and the second and third phases were commissioned in 1982 and 1985, respectively. Olkaria I has a total installed capacity of 45 MW, although its steam gathering capacity could produce up to 70 MW. Olkaria II was commissioned in September 2003. It has an installed capacity of 64 MW, but its steam gathering capacity could produce approximately 98 MW. Hence, the estimated steam surplus between the two plants is roughly 59 MW and to make use of this surplus steam, KenGen now intends to add a third generating unit (Unit 3) of 35 MW at Olkaria II.

In April 2004, KenGen approached GIBB Africa Ltd to undertake a study to address the environmental and social impacts of a third unit at Olkaria II together with an audit of the existing development at Olkaria II site.

E2 Study methodology

This Project Report has been prepared in accordance with the Environmental (Impact Assessment and Audit) Regulations of 2003 and the Draft Environmental Impact Assessment Guidelines and Administrative Procedures (NEMA, November 2002). It is also guided by the World Bank's requirements for industrial projects.

The study methodology comprised the following activities:

- Preliminary meetings;
- Document and data review;
- Site inspection and discussions with site personnel and stakeholders;
- Analysis;
- Reporting.

The Project Report has confined itself to the construction of a third unit at Olkaria II and associated infrastructure, although where necessary, issues that have implications on both Olkaria I and the new Olkaria II stations have been examined.

It should be noted, however, that as steam output from the existing wells falls, there will be a need to drill more production wells. This will require a separate EIA study to be conducted prior to drilling.

E3 Project location and setting

The Olkaria geothermal field is located 6 km to the south of Lake Naivasha in Kenya's Rift Valley, and occupies a circular area of roughly 68.25 km^2. Much of the Olkaria Geothermal Field lies within Hell's Gate National Park, which was gazetted in February 1984. The park has numerous scenic attractions and harbours over 20 species of mammals and over 100 species of birds.

Over the past ten years there has been a considerable amount of development around Lake Naivasha, particularly in floriculture and horticulture, for export.

The geothermal field is flanked on all sides by ranches and flower estates.

E4 Legal and regulatory framework

While the Environmental Management and Coordination Act of 1999 supersedes all other environmental legislation, numerous other laws and regulations influence the various aspects and activities of the power plant. These include, among others:

- Geothermal Resources Act (1982);
- Geothermal Resources Regulations (1990);
- Electric Power Act (1998);
- Local Government Act (1998 revision);
- Public Health Act (1986 revision);
- Factories Act (1972 revision);
- Wildlife (Conservation and Management) Act (1985 revision);
- Lakes and Rivers Act (1983 revision);
- Workmen's Compensation Act (1988 revision).

A number of World Bank documents are also relevant to this study, namely:

- OP 4.01 Environmental Assessment;
- OP 4.04 Natural Habitats;
- The Environmental Assessment Sourcebook;
- The Pollution Prevention and Abatement Handbook, 1998.

In addition, Kenya is a signatory to various international treaties and protocols which dictate environmental management approaches.

KenGen itself has an Environmental Policy, and still abides by the requirements of the old KPLC Occupational Health and Safety Policy.

E5 Description of the project components and process activities

Geothermal steam will be used to drive one 35 MW turbine. The process of generating geothermal electricity at the third unit at Olkaria II will be exactly the same as that for the existing two units at the plant.

The main raw material is geothermal steam, and a small quantity of geogas (comprising carbon dioxide, hydrogen sulphide, oxygen, nitrogen and methane).

Three main waste products will result from the process:

- Brine, which is separated from the steam at the production wells;
- Condensate, which will be produced when the steam passes over the turbine;
- Non condensable gases, which will be released through the cooling towers.

It must be noted that at this stage, the design of the new unit is still being conceptualised. However, the proposed third unit is an extension of the newly commissioned Olkaria II Power Station. The steam that is currently being tapped will be used for the process. No new steam wells will be drilled. No access roads will be constructed.

New steamlines will have to be installed to take steam from the main steamline to the new unit, as well as to transfer excess steam from Olkaria I to the new unit.

The physical structures to be constructed comprise a new cooling tower block, an extension to the existing turbine hall and a switchyard. Provision has already been made at the Olkaria II site to accommodate these structures. Hence minimal earthworks will be required.

Activities during operation will be the same as for Olkaria II, namely operation and maintenance of the plant and associated infrastructure.

E6 Stakeholder consultation

The most important social issues within the project area touch on impacts of Olkaria I on the labour force and job creation, and the interaction of the Power Station with the labour force in the flower industry in the surrounding farms and the local communities, in particular the Maasai.

During the 1980s and 1990s, the Maasai and KPC coexisted amicably. Today the situation seems to have changed and the relationship between the Maasai and KenGen is strained. Complaints have been lodged in relation to several issues including the effects of the geothermal effluents, conflicts that have not been resolved (in the last 2 years) between KenGen and the Maasai, health hazards posed by the power station, concealment of information and collapse of wells and subsequent spilling of hazardous material among other complaints. It is not clear whether these complaints point at Olkaria I or II, but in general the public do not differentiate between the two.

While there is a degree of interaction with several stakeholders (particularly Maasai communities and the Kenya Wildlife Service), it was observed that more dialogue with the various stakeholders is required. The Maasai communities have very high expectations of KenGen at Olkaria, but KenGen is limited in what it can legally provide to the communities. It is important that a Community Liaison Officer is appointed by KenGen at Olkaria to deal with all social issues

KWS does not recognise the Memorandum of Understanding of 1994, as it was withdrawn and a new one has not been prepared. This situation could have legal implications due to there being no formal agreement with KWS, and must therefore be resolved urgently. Efforts also need to be made to nurture the relationship with KWS, in order to re-establish the previous level of rapport.

Unit 3 at Olkaria II, as an entity in itself, is not likely to exacerbate the existing situation.

E7 Anticipated environmental and social impacts and their mitigation

The new unit is essentially an extension of the present Olkaria II, consisting of a new cooling tower block, extension of the turbine hall, expansion of the switchyard and additional steamlines. Provision for expansion has been made at the existing site to accommodate the first three components.

Hydrogen sulphide monitoring data indicate no significant change in cumulative H_2S levels in areas outside the immediate Olkaria II plant boundary due to the operations of the power plant. H_2S emissions from Olkaria II are also considerably lower than at Olkaria I due to the superior dispersion through its cooling towers. The new unit will result in a 50% increase in air emissions at Olkaria II. Although cumulative levels of H_2S after the commissioning of Unit 3 are expected to be acceptable, this can only be confirmed through continual monitoring.

The long term effects of hydrogen sulphide on the growth of flowers have not been investigated; but based on the lessons learned from the flower trials, it is unlikely that the development of the third unit will have any negative impacts on the flower growing industry adjacent to the project area.

Noise levels will exceed recommended levels during construction of the new unit, and also in some sections of the plant during operation. At the former it will be temporary, while at the latter it will be an ongoing phenomenon. However, in both cases mitigation is possible through the use of protective personal equipment, and continual monitoring.

Dust emissions will occur during construction, and there is a risk of oil pollution resulting from both construction and operational activities. Dust levels can be reduced by sprinkling work areas with water, and sensitising drivers of construction vehicles. The risks of oil pollution can be minimised through implementing proper storage and handling procedures.

There is no evidence to show that the drilling of geothermal wells, the installation and operation of Olkaria II have so far had significant impacts on the water resources or quality of Lake Naivasha. The installation of a third unit at Olkaria II will not necessitate any significant water abstraction from the Lake, nor is it likely to affect the Lake's hydrology or water quality. Nonetheless, it has been recommended that monitoring of the Lake water quality, and precipitation chemistry should continue.

Installation of the steamlines will cause minor disturbances to animals due to clearance of vegetation and increased human activity during the construction phase. These disturbances can be mitigated by controlled clearing and construction activities. The area earmarked for the third unit within the Olkaria II compound does not contain any wildlife populations. Consequently, development of the site will not cause any significant impacts on the faunal community.

However, the brine and steam condensate released from the drain pots into natural watercourses will have high concentrations of mineral, fluorides and arsenic. This can pose a threat to wild animals that may drink the brine. All brine and condensate discharges must therefore be reinjected into deep wells.

Vegetation will have to be cleared at the proposed site, as well as along the new steamline routes. In addition, the recently rehabilitated X2 Quarry may have to be reopened for the winning of construction materials. However, these impacts are minor and can be mitigated.

The proposed project will not affect the wetlands in the project area, as all brine and condensate that will be generated from Olkaria II Unit 3 will be disposed through deep well re-injection (as currently done for the Olkaria II). There will be no interaction between the brine originating in Olkaria II Unit 3 and the wetlands associated with the *Typha* dominated brine ponds/wetland near Olkaria I, nor with the papyrus dominated fresh water wetlands around Lake Naivasha.

Construction activities will encourage an influx of people into the project area, comprising the workforce as well as people seeking employment. A number of environmental and social impacts can result due the presence of the workforce. These revolve around the availability of housing and living conditions, sanitation and wastewater, solid waste disposal, competition with local populations for water and fuelwood, the spread of sexually transmitted diseases and HIV/AIDS, all of which have implications on public health.

Other issues which will arise during construction and operation, but can be mitigated, are associated with disturbance to the public, visual intrusion, general risks and hazards, handling and storage of construction and process materials, solid and construction waste.

E8 Environmental monitoring and management

The Environmental Section at Olkaria carries out monitoring activities for the entire geothermal development. It is recommended that monitoring of the following continues, as stipulated in the Environmental Operational Procedures:

- Precipitation chemistry;
- Significant environmental elements;
- Meteorology;
- Noise levels;
- Hydrogen sulphide.

In addition, the Environmental Section should monitor the following:

- Non-condensable gases;
- Groundwater contamination.

Furthermore, a number of independent studies have been proposed to provide baseline information which will prove valuable in later years to assess the impact of the two geothermal power plants on the area of influence. These studies would aim to establish:

- Point sources of pollution affecting water quality in Lake Naivasha;
- Vegetation patterns of Hell's Gate National Park;
- Long-term impacts of geothermal emissions on flowers, horticultural produce and the natural flora;
- Wildlife populations in Hell's Gate National Park and the surrounding areas;
- Incidence of skin ailments and abortions reported by the Maasai;
- Changes in land use around the Lake Naivasha Basin.

An environmental and social management plan has been prepared to cover all the phases of the project life: design, construction, defects liability, operation and maintenance. The plan describes each of the main mitigation measures to be implemented, their frequency, and who should be responsible during and after construction. Environmental and social monitoring, as integral parts of the environmental management plan, has also been included.

Prior to mobilisation, the Contractors should also prepare their own environmental management plans, including a schedule of works, for review by the Project Manager.

The responsibility for supervision and implementing all the proposed mitigation measures during construction and the defects liability period will lie with the Project Manager and the Contractors, respectively. After the defects liability period, responsibility for the maintenance of Unit 3 (as indeed with the Olkaria II Station) will rest with the Olkaria II Station Manager, while monitoring will be undertaken by the Olkaria Environmental Section.

E9 Conclusions and recommendations

The proposed project has great economic significance to the country, given the increasing demand for electrical power.

The World Bank and the United States Environmental Protection Agency regard geothermal energy as "clean energy", as it is generally less polluting than fossil fuels. In addition, geothermal energy is considered a renewable as well as sustainable resource.

A number of environmental and social impacts will result from the construction of a third unit at Olkaria II. The main issues of concern revolve around hydrogen sulphide emissions, brine discharges to natural watercourses, and issues related to the construction camps.

Recommendations have been proposed for the prevention and mitigation of all foreseen adverse impacts resulting from environmental or social aspects. Most of these mitigation measures can and should be included in the tender documents, specifically the Engineering Drawings, Specifications and Bills of Quantities.

Diligence on the part of the Contractor and proper supervision during construction and the initial operation period is crucial for mitigating impacts.

During operation, maintenance is a key factor in protecting the environment.

In conclusion, therefore, provided the recommended mitigation and environmental management measures are effectively implemented during the construction and operation phases of the proposed third unit at Olkaria, the anticipated environmental and social impacts will, for the most part, have low significance.

As the design of the proposed third unit is still in its conceptual stage, it is not possible to allocate specific mitigation costs at this point. In general, mitigation costs for such projects amount to roughly 5% of the total project cost. However, 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 quarry rehabilitation and for “making good” will be part of the construction costs to be determined by the Contractors.

Some activities, such as monitoring of emissions and noise, are already being carried out at Olkaria, and thus they will not entail additional costs.

The total cost that would be incurred by KenGen for incorporating the recommended mitigation measures, and for environmental and social and monitoring, is estimated at KSh 12,220,000 (US$ 152,750) for the first year of implementation of the environmental management plan.

The estimated project cost for construction of Olkaria II Third Unit Extension Project is US$ 50 million.

1 PROJECT DATA SHEET

Name of Proponent:	Kenya Electricity Generating Company Ltd PO Box 47936 Nairobi.
Title of Project:	Olkaria II Third Unit Extension Project
Objectives of Project:	To harness excess steam generated from the existing Olkaria I and II Power Stations in order to produce a further 35 MW of electricity.
Scope of Project:	• Installation of a new steamline from the main steamline to the new unit. • Installation of a new steamline from Olkaria I to Olkaria II. • Construction of a new cooling tower. • Extension of the existing turbine hall.
Location of Project:	Hell's Gate National Park
Land Registration No:	Part of LR No. 12881/2
Land Area:	Total area for LR No. 12881/2 is 6128.4 Ha
Designated Land Use:	Production of geothermal energy and national park
Consulting Engineer:	Sinclair Knight Merz
Project Budget:	US$ 50 million

2 NATURE OF THE PROJECT

2.1 Background

The Kenya Electricity Generating Company (KenGen) currently owns and operates two geothermal power stations at Hell's Gate National Park. The first generating unit at Olkaria I was commissioned in 1981, and the second and third phases were commissioned in 1982 and 1985, respectively. Olkaria I has an installed capacity of 45 MW (produced by three 15 MW turbines), although its steam gathering capacity could produce up to 70 MW. Olkaria II was commissioned in September 2003, and has an installed capacity of 64 MW, generated by two 35 MW turbines. Its steam gathering capacity could produce approximately 98 MW.

The estimated steam surplus between the two plants is roughly 59 MW, and to make use of this surplus steam, KenGen now intends to add a third generating unit (Unit 3) of 35 MW at Olkaria II.

Against this background, in April 2004, KenGen approached GIBB Africa Ltd to undertake a study to address the environmental and social impacts of a third unit at Olkaria II.

2.2 Project feasibility and justification

The Olkaria I power plant has an installed capacity of 45 MW. However, following the connection of wells OW-32 and OW-34, the steam available currently stands at an equivalent of about 70 MW, a surplus of 25 MW.

The Olkaria II power plant has a nominal capacity of 64 MW. However, the units are currently generating 70 MW. The new units have a better specific steam capacity of 7.8 Kg/kWh than those at Olkaria I at 9.2 Kg/kWh and therefore generate the power using less steam than originally envisaged. It is now estimated that the current steam available at the Olkaria II power plant is equivalent to about 98 MW. This indicates a surplus steam supply of 34 MW. The total estimated steam surplus between the two plants is therefore approximately 59 MW.

At the time of commissioning this assignment, the design concept for the third unit at Olkaria II had not been drawn up (Sinclair Knight Merz are currently working on this), nor had a feasibility study been undertaken.

Kengen proposes to undertake this project for the following reasons:

- The steam is available and no prospecting or drilling is required;
- Electricity generated by geothermal means is the cheapest of all generation, at base load;
- Geothermal energy is environmentally friendly;
- There is available space within the power plant for expansion (i.e. for extension of a power house, cooling tower, switch yard and for control rooms);
- No major civil works will be required for this project;
- The project ranks favourably among projects planned in KenGen's Least Cost Power Development Plan.

2.3 Study methodology

2.3.1 Approach

This Project Report has been prepared in accordance with the Environmental (Impact Assessment and Audit) Regulations of 2003 and the Draft Environmental Impact Assessment Guidelines and Administrative Procedures (NEMA, November 2002). It is also guided by the World Bank's requirements for industrial projects (ref: World Bank's Pollution Prevention and Abatement Handbook 1998). While the Regulations and the Draft Guidelines are not specific about the detail of study required for upgrading of existing industrial plants, the World Bank's Pollution Prevention and Abatement Handbook 1998 states that a project where significant upgrading of an industrial plant is being considered, such as the addition of the third unit at Olkaria II, is classified as a Category B project. This Project Report should therefore be read in conjunction with the Environmental Audit Report prepared as part of this assignment and submitted to KenGen in May 2004.

The ToR requires a review/update of the Environmental Impact Assessment Study carried out by Sinclair Knight et al in 1994. The 1994 EIA report took more than two years to complete. As part of that study:

- Dispersion models for emissions were developed, specifically for H_2S emissions from the cooling towers;
- Background noise levels at the existing plant and on Olkaria hill were determined;
- An aerial survey of the north east Olkaria field was undertaken to determine vegetation patterns, and an inventory of plant species was prepared;
- An inventory of large mammal species was prepared, and their distribution, density and movement routes mapped;
- An inventory of avifauna was prepared;
- Field trials were undertaken to investigate the effect of Olkaria I's cooling tower plume on flowers in the vicinity of the site;
- Historic meteorological data (rainfall, humidity, evaporation, wind distribution and frequency) were collected;
- An extensive hydrological and hydrogeological study (establishing the water balance, water abstraction, and water quality) was carried out;
- Socio-economic investigations were undertaken.

Given the extent of detail presented in the 1994 EIA study report, in the proposed methodology (as submitted to KenGen on 7th April 2004), GIBB indicated that it would not be able to update the 1994 EIA study report within the timeframe and resources available for this assignment. However, based on a review of the study, site investigations, a review of environmental reports and monitoring data for Olkaria I and II, and from GIBB's previous experience of the site itself and other power plants (Refer GIBB ERB audits of all power plants within Kenya, 2002), it would be possible to give KenGen a good indication of the significance of possible impacts arising from the commissioning of a third unit at Olkaria II.

In accordance with the Environmental (Impact Assessment and Audit) Regulations of 2003, the objective of this assignment is for GIBB to prepare a Project Report for KenGen for submission to NEMA. The aim of the Project Report is to present a comprehensive background to the proposed development, which is required as part of NEMA's project screening process. Should NEMA determine that the mitigation of adverse impacts have not been adequately addressed in the Project Report, KenGen may then have to undertake an EIA study. This EIA would not be done as part of this assignment.

The Project Report focuses on the construction of a third generating unit at Olkaria II, and associated infrastructure. At present, the steam that is tapped from the existing production wells will be used for the generation of electricity from this third unit. However, in the future it

is likely that steam output from the wells will decrease and more production wells will have to be drilled. This will require a separate EIA study to be conducted prior to drilling.

2.3.2 Conduct of this study

A preliminary meeting was held on site on 19th April 2002. The aim of this meeting was to introduce the team to the Chief Manager and the Environmental Scientists, establish counterpart contacts, identify and collect documentation, as well as acquire a preliminary view of the geothermal generation process. The list of references is given in Annex 1.

Documents and data were then reviewed, including the laws and regulations of Kenya as applicable to the site, site layouts, process flow charts, drainage layouts, topographic and geological details, as well as monitoring data.

Site visits were conducted from 10-13 May and on 25 May, 2004. Departmental and section heads were interviewed, and other relevant personnel (a full list of persons consulted and interviewed appears in Annex 2). The site tours covered Olkaria II Power Plant, the Eastern and Western Steamfields, as well as Olkaria I Power Plant, its brine discharge courses and the brine collection pond which is currently under construction. The KenGen clinic and Mvuke Primary School (which is supported by KenGen) were also visited.

Discussions were held with stakeholders, ranging from the Maasai communities around the site, residents and organisations within the Lake Naivasha area, the Naivasha Municipal offices, and divisional officers. The stakeholders consulted are listed in Annex 2.

2.4 Acknowledgements

GIBB Africa Ltd gratefully acknowledge the assistance accorded to them, and contributions made, by the staff of KenGen and all the people interviewed during the course of this study.

3 PROJECT LOCATION AND SETTING

3.1 Project setting

The Olkaria geothermal field is located 6 km to the south of Lake Naivasha in Kenya's Rift Valley, and occupies a circular area of about 68.25 km^2. The northeast field, from which Olkaria II derives its steam, covers approximately 12 km^2. The field has been under investigation since 1956. The first generating unit at Olkaria I was commissioned in 1981, and the second and third phases were commissioned in 1982 and 1985, respectively, to generate a total of 45 MW of electricity. Olkaria II was constructed between 2000 and 2003. The plant began generating electricity in September 2003, producing a total of 64 MW.

Much of the field lies within Hell's Gate National Park, which was gazetted in February 1984. The park is spectacularly scenic, its main attractions being the Hell's Gate cliff face, Hell's Kitchen and Ol Njorowa Gorge. Wildlife species inhabiting the park include zebra, impala, Thompson's gazelle, Grant's gazelle, eland, giraffe, waterbuck, dikdik, buffalo and warthogs, as well as predators such as lion and leopard. In addition, there are over 100 species of birds to be found in the park.

Over the past ten years there has been a considerable amount of development around Lake Naivasha, particularly in floriculture and horticulture, where produce is grown for the purposes of export. These industries have attracted a substantial labour force, resulting in the establishment of informal and unplanned settlements around the lake.

The Kedong/Akira, Longonot and Maiella Ranches are located to the east and south of the Eastern Steamfield. Oserian Estate lies to the north of the Northeast Steamfield and beyond Oserian to the west is Kongoni Farm. The ranches are essentially cattle ranches, although the Maasai have been seen to herd their livestock through the ranches as well as Hell's Gate National Park.

Thus the site is located in the midst of an array of environmental and social contexts.

Figure 1 shows the location of Olkaria geothermal power plant.
Figure 2 shows Olkaria II geothermal site plan.

3.2 Bio-physical environment

3.2.1 Topography, climate and rainfall

The project area, including Lake Naivasha and environs, is situated in the floor of the Great Rift Valley. The Lake Naivasha basin covers an area of 3,400 km^2 and the lake itself stands at around 1,885 metres above sea level (m asl). The lake basin is bound to the west by the Mau Escarpment (3,080 masl), and to the south and south east by the Olkaria and Longonot Mountains. To the east of the lake basin is the Kinangop Plateau. The Nyandarua (Aberdare) Range (3,900 masl) lies to its north and north east and the Eburru volcanic pile flanks the western side of lake basin. The general topography of the study area is characterised by a wide range of features associated with volcanic activity. They include craters, remnants of pre-existing craters, fault scarps, fissures and steam jets.

The Olkaria area where the geothermal station is located comprises volcanic features that consist of steep sided domes formed from pyroclastic rock and lava flows. The domes enclose an approximately circular depression that has been cut by the Ol Njorowa Gorge, which was formed by outflowing water from Lake Naivasha. The Olkaria I and II Power Stations are located in the centre of the depression. Within this complex, there are several small valleys

that drain the upper slopes and discharge runoff and sediments to the foot slopes and plains below.

To the north of Olkaria, the topographical features are dominated by depressions of four water bodies including the Crescent Island, the main Lake, Lake Oloidien and Crater Lake.

Climatic features in the Rift Valley, including the project area, are closely related to altitudinal changes and variations induced by the local topography. The floor of the Rift Valley experiences higher temperatures than the highlands. At Naivasha (1,829 masl) the mean monthly temperature has been recorded to range from 15.9-17.8^{0}C with a mean of 16.8^{o}C. The mean monthly maximum temperatures in Naivasha town range from 24.6-28.3^{o}C. In the project area, July is the coldest month while the hottest month is February.

Sombroek et al (1982) classify the area around Lake Naivasha as Agro-climatic Zone V, that is semi-arid. The monthly distribution of rainfall in the basin is governed by the movement of Inter-tropical Convergence Zone (ITCZ). This results in a bimodal pattern of rainfall distribution with long rains in March, April and May while the short rains are received in the months of October and November. Generally the floor of the Rift Valley has lower rainfall than the flanking highlands. This area experiences a double rain shadow effect from the west and east flanking escarpments (Mau and Aberdare Range / Kinangop respectively). Rainfall in the project area and its environs is generally low, recording an average of 634 mm annually at the Naivasha Town (1900 masl). Evaporation exceeds precipitation almost throughout the year. It ranges from approximately 1,700 mm per year at the lake to approximately 1,000 mm per year on higher ground, with variations from year to year. This combined with the very porous nature of soils accounts for the arid nature of the land.

3.2.2 Geology and soils

The geology of Lake Naivasha area has been described by Thompson and Dodson (1958). The geology is dominated by the formation of the Great Rift Valley when the volcanic material of Pleistocene Age was extruded forming the base material. Subsequent sedimentation and additional volcanic activity have resulted in a mixture of sedimentary material consisting of sands, clays, and air fall pyroclastics including pumice. Recent lava material is still visible on the surface towards the south of the Olkaria field.

Along the floor of the Rift Valley, the most common rocks are basically Quaternary deposits mainly the pyroclastic rocks, which consist of tuffs and ashes. The tuffs are usually medium to pale grey in colour but are sometimes green, yellow, pink or purple, occasionally calcified and brown when weathered. The tuffs are quarried for building purposes. The lavas are also a major geological feature of the Rift Valley. They range from undersaturated basic rocks (tephrites) to acid rocks (rhyorites and obsidians) with numerous gradations in between.

Close to the project area, the geology is complex and usually consists of several geological formations. Around the Olkaria area, rocks are volcanic with lake and fluvatile sediments. The volcanic rocks in the area consist of tephrites, basalts, trachytes, phonolites, ashes, tuffs, agglomerates and the acid lava rhyolite, commendite and obsidian. The lake beds are mainly composed of reworked volcanic material or sub-aqueously deposited pyroclastics.

Thus the soils of the Lake Naivasha basin are volcanic in origin, mainly derived from mixed assemblage of acid and basic lavas. The lake sediments are composed of a mixture of volcanic ash, reworked volcanic material and autochthonous organic matter. Along the south eastern shore of Lake Naivasha, diatomite up to 1-2 metres thick is present, while in the north and north-eastern shores, silts, clays and recent deposits are common.

a) Soil Contamination

The Environmental Section at Olkaria has monitored concentrations of elements of environmental significance in soil since 1993. The results, as presented in Table 3-1 below, shows that lead levels in the soils tested exceeded recommended guideline values at most sample locations, while mercury levels at the wells were far higher than recommended

guideline values. Zinc concentrations were also high in the soils at all locations where samples were taken. While levels for these elements at the wells, Olkaria I and the old X2 campsite may be attributed to geothermal activities, this may not be true for the other sampled locations, as other agricultural and industrial activities in the Lake Basin may also influence zinc concentrations in the soils. As yet no data is available to show that Olkaria II has contributed to pollution of the soil.

Table 3-1 Range of Chemical Parameters of Environmental Significance in Soil, 1993-2002

Location	Parameter							
	As (ppb)	**Ba** (ppm)	**Cd** (ppm)	**Cu** (ppm)	**F** (ppm)	**Pb** (ppm)	**Hg** (ppm)	**Zn** (ppm)
Wells	45.25	0 – 1.8	0 – 0.1	0 – 0.9	0.4	0 – 4.3	100.7-106.5	1.8 – 9.5
Olkaria I	-	0 – 0.4	0 – 0.01	0 – 0.1	-	0 – 0.4	-	2.4 – 2.8
Old X2 camp	-	0.09 – 0.5	0 – 0.49	0.06 – 0.5	0	0 – 1.5	0.5	2.43-7.01
Lakeside Hse Est	-	0.1 – 0.4	0 – 0.02	0.1 – 0.19	-	0.41 – 0.6	-	1.5 – 5.0
Lakeview Hse Est	-	0.4 – 0.8	-	0.1 – 0.2	-	0.5 – 0.6	-	2.9 – 4.9
L. Naivasha	-	0.8 – 1.2	-	0.1 – 0.2	-	0.1 – 0.5	-	2.3 – 2.4
Naivasha Town	-	-	0 – 0.02	0.01 – 0.6	-	0.06 – 1.9	-	3.8 – 4.43
WB g/lines ppm	**0.1**	**-**	**0.1**	**0.5**	**20**	**0.1**	**0.01**	**2**
Nat g/lines ppm	**0.002**	**2**	**0.05**	**0.05**	**2**	**0.1**	**0.005**	**0.5**

Source: KenGen Olkaria Geothermal Power Project, Environmental Section

3.2.3 Hydrology and drainage

The hydrology associated with the Rift Valley drainage system is characterized by internal drainage and generally scarce surface and underground water resources. The principal river in the floor of the Rift Valley drainage basin is River Malewa which drains into Lake Naivasha. The Rift Valley contains several basins of internal drainage including Lakes Naivasha, Nakuru and Elementaita.

Lake Naivasha consists of three morphometrically different bodies of water including the main lake (having a maximum depth of 8 m) which includes the Crescent Island lagoon (which is 18 m deep), Lake Oloidien to the south of the main lake and a distinct crater lake (Lake Sonachi) located to the southwest of the main lake. The lake level undergoes variations in response to river inflow, rainfall over the catchment area and ground water inflows. The maximum recorded water level stands at 1,891 masl while the minimum level recorded is reported to be 1,882 masl.

Lake Naivasha is remarkable in that although it is endorheic, it is a fresh water lake. The Naivasha basin has a catchment of 2,378 km^2 while the Malewa River has a catchment of 1,730km^2 and provides 90% of the inflow to Lake Naivasha. The lake also receives water inflow from the seasonal rivers of which the most important are Rivers Karati and Gilgil. Ground water seepage, particularly, along the north and north-eastern shores contribute a significant influx into the lake as well. Much of the subsurface water outflow from the lake catchment is to the south via Olkaria–Longonot towards Suswa and eventually towards Magadi (Clarke et al, 1990).

Around Olkaria, the area comprises a volcanic complex of domes, which enclose an approximately circular depression that has been breached by the Ol Njorowa Gorge. Within this complex, there are several small valleys that drain the upper slopes and discharge runoff and sediments to the foot slopes and plains below. Close to the Olkaria I site, the valleys connect to a common watercourse that runs past the power station into the Gorge. Where there have been no development activities in the area, the valleys and the drainage lines around Olkaria are well vegetated and erosion is minimal. However, where the soil is shallow

or disturbed, and where plant cover has been destroyed, significant runoff is expected during periods of heavy rainfall.

3.2.4 Land use

The land in this area and many parts of the Rift Valley originally was inhabited by the Maasai. In 1905 the Maasai were moved south of the railway line to make way for European settlement. Much of the land was subsequently used for livestock and agricultural farming. Today the project area and its environs support a multiple land use system consisting of ranching, flower and horticultural farming, tourism, wildlife conservation, human settlement, infrastructure and other uses.

To the south and south east of the project area, are situated large tracts of land covering mainly the Kedong and Longonot Ranches, which primarily rear cattle. These ranches also form important dispersal areas for wildlife from the Hell's Gate and Longonot National Parks. Other important ranches around the project area include Oserian, Kongoni and Ndabibi farms.

The Hell's Gate National Park is a unique conservation area gazetted in 1984 for the protection of wildlife and the scenic landscape of the area. It covers an area of 1,600 ha. In addition to being an area of scenic beauty, Hell's Gate and Longonot National Parks contain significant wildlife populations. The project area lies within Hell's Gate National Park, where Olkaria Geothermal Power Station acquired land for the construction of physical facilities including area taken for the installation of turbines, cooling towers, offices, workshops, stores, parking, roads, well pads, separators, pipelines, drains and brine ponds, among other facilities. Figure 3 illustrates the land ownership status around Olkaria. KenGen holds title deeds for two plots of approximately 800 ha, located in the midst of Hell's Gate National Park.

Although climatically zoned as suitable for ranching, the area around Lake Naivasha has now become an important centre for flower and vegetable production. In the last ten years this area has seen an extraordinary explosion of horticulture and floriculture for the European export market as well as for local consumption. At present, large tracts of land have been cleared to make way for green houses.

Other land use types in this area include tourism development especially around the Lake Naivasha where several tourist facilities, including hotels and lodges, cater for the growing industry.

A significant amount of land has also been used in the development of infrastructure and human settlement. This includes land used for the construction of residential houses for KenGen staff, and for the large population of workers involved in the flower and horticulture industries, and other growing concerns, around the lake.

3.2.5 Water resources

a) Surface water

Lake Naivasha bears tremendous importance in the project area as a source of freshwater. The wetland associated with the lake provides a habitat for a wide range of aquatic flora and fauna. The water from the lake and the associated aquifers is utilized for, among others, domestic use, watering of livestock, irrigation of agricultural land, and geothermal drilling activities.

According to Sayeed (2001), the total area of irrigated land stands at 5,000 ha, as shown in Table 3-2. However, Lake Naivasha Growers Group (LNGG) estimates the total irrigated area to be much less, probably ranging between 1,500-2,000 ha.

Table 3-2 Water Abstractions for Different Crops

Crops Irrigated	Area (ha) Irrigated	Irrigation Application (m^3/ha/day)	Total Irrigation Application (m^3/yr)
Flower (open)	952.2	63.34	22,014,007
Flower (greenhouse)	613.6	50.0	11,198,200
Vegetables	1623.1	34.67	20,539,600
Fodder	756.4	16.58	4,577,506
Wheat	164.3	25.12	1,506,434
Grass	561.3	16.58	3,396,819
Macadamia nuts	360.7	3.34	439,729
Total Agricultural Crops	5031.6	29.95	63,672,295
Water Abstraction other than Irrigation			1,508,439
Total Water Abstraction			65,180,734

Source: Sayeed (2001)

Abstraction of water for irrigation is taken through pumping directly from the lake, and accounts for 97.7% of the water abstracted from the lake (see Table 3-2).

The most important issue with regard to water resources of Lake Naivasha is the sustainable rate of water abstraction from the lake. In 1990 the total abstraction of water from the lake estimated on the basis of power consumption in pumping was 59.3 $x10^6$ m^3 (Sinclair Knight et al, 1994). Olkaria Power Station abstracts water from this lake for use in drilling wells and other uses in the power station operations, as well as for domestic use in the company offices and the housing estates. In 1990, KenGen (then KPC) abstracted an estimated 1,712,405 m^3 of water. This accounted for 3.1 % of the total abstraction.

Monthly water abstraction from Lake Naivasha for Olkaria geothermal station for the last eight years is presented in Table 3-3.

Table 3-3 Water Abstraction from Lake Naivasha for the Olkaria Geothermal Station (m^3)

Month	Year								Average Monthly Abstraction
	1997	1998	1999	2000	2001	2002	2003	2004	
Jan	203,750	15,000	96,000	83,760	63960	82,392	96,208	67,263	88,632
Feb	131,400	172,369	120,510	83,070	138,870	62,718	67,486	86,322	107,843
Mar	145,080	212,858	104,138	92,978	94,778	66,890	67,290	67,000	106,377
Apr	310,680	235,330	107,530		56,050	55,044	69,434	70,000	125,513
May	190,440	75,120	137,760	68,640	58,200	53,376	69,936	-	93,353
Jun	153,440	78,000	72,600	87,720	71,520	52,752	86,784	-	86,117
Jul	166,680	239,000	98,800	128,680	793,600	55,745	71,304	-	221,973
Aug	133,200	161,275	72,715	118,795	71,995	79,747	72,754	-	101,497
Sep	222,034	87,238	72,838	104,878	85,798	59,346	65,922	-	99,722
Oct	200,286	115,637	82,877	70,637	72,797	53,525	62,222	-	93,997
Nov	168,812	167,405	83,885	88,205	90,869	45,317	79,331	-	103,403
Dec		97,628	69,908	96,188	59,516	82,068	71,218	-	79,421
Annual Abstraction	2,025,802	1,656,860	1,120,281	1,123,521	1,657,953	748,920	879,889	290,651	

Source: Records from Olkaria Power Station

The current KenGen abstraction rates (2002 – 2004) are lower than water abstractions prevailing in 1997 and 1998. This is attributed to the drilling activity between 1997 and 1999. Subsequently water recycling techniques were incorporated, thus lowering the volume of water required for drilling. No drilling was done in 2002 and 2003. The average water abstraction since 1997 to date is 1,316,175 m^3/yr. This amounts to 2% of the total (65,180,734 m^3/yr) water abstraction as estimated by Sayeed (2001). Current figures (from

2002-4) render KenGen's annual abstraction rate as being equivalent to 1.3% of the total water abstracted from Lake Naivasha.

Approximately 25% of water abstracted by KenGen is for domestic supply to the housing estates, that is in the region of 329,045 m^3/yr. The remaining 987,130 m^3/yr is used at both Olkaria I and II, but it was not possible to obtain a breakdown for consumption for each plant.

b) Groundwater

Underground water resources are also heavily utilized in the Lake Naivasha basin and the project area environs, through pumping from the boreholes around the lake. According to Rural Focus (2002), an estimated 250 boreholes have been drilled around the lake. These boreholes have been found to have the following characteristics:

- Two main aquifers have been exploited for commercial use. They include the lake bed aquifer (for domestic and irrigation uses) and a deep aquifer for geothermal production;
- Along the northern side of the lake from Korongo Farm to Naivasha Town, the lake bed aquifer has been found to be high yielding with water quality ranging from being fresh to partially saline;
- In Ndabibi Farm, ground water is reported to be saline;
- Along the South Lake Road, groundwater yield is reported to be variable and is of high salinity;
- The Olkaria geothermal boreholes are between 1,600-2,000 m deep and access a very deep geothermal aquifer, which is probably not connected directly to lake water;
- There is a high rate of abstraction of aquifers to the north of the lake that may have reversed the hydraulic gradient so that the flow direction is now from the lake to the north shore.

c) Water quality

Lake Naivasha is a fresh water lake located in the same basin as other lakes that have saline waters (Lake Oloidien and Lake Sonachi). The water quality of Lake Naivasha is reasonably good with electrical conductivity of approximately 300 µS/cm. The pH is 8 but is known to increase as the lake level goes down. Due to the good quality of the water, the lake has a wide range of uses, including domestic water, watering of animals and irrigation of the flower farms and other farming practices.

Although the chemical and physical properties of the Lake Naivasha water are of good quality, the lake water is contaminated with faecal material of human origin. Bacteriological examination of Lake Naivasha water at DCK has revealed heavy contamination levels with Coliform and *Escherichia coli* counts in excess of 1800 +/100ml (Public Health Office, Naivasha, 2003). Hence the lake water is unsatisfactory for human consumption unless it is treated accordingly.

Unlike lake water, water from the geothermal wells has a high concentration of salts and is referred to as brine. The brine contains Fluorides (at concentrations of 164 mg/l) and Arsenic (at concentrations of 0.14 mg/l), both of which exceed the recommended World Health Organization permissible limits of 1.7mg/l and 0.05 mg/l, respectively. Due to the potential toxicity, it was found necessary to dispose of the brine by re-injection into deep wells at Olkaria II. However, the disposal of brine in Olkaria I is surface based, flowing through natural drainage lines, (see Photographic Record, Annex 3). This has already led to serious soil erosion in some sections of the project area. Surface disposal of brine poses a threat to plants through uptake of minerals by the roots and subsequent incorporation in plant tissues. It is also a threat to animals that directly drink the brine or indirectly take up minerals through feeding on plants. Animals in the secondary and tertiary trophic levels may also get poisoned through the process of biomagnification as the poisonous minerals pass through the food chain. Moreover, the brine ponds are not fenced, permitting animals, especially the birds and warthogs to drink there. The brine disposal method as carried out in Olkaria I also poses a risk

to the wildlife in the park and human beings downstream beyond the boundaries of the geothermal power station along the Njorowa Gorge.

Parameters for precipitation chemistry (ie. pH, TDS, conductivity, chlorine and sulphates) are currently measured by the Environmental Section at Olkaria every quarter. However, data for review was only available for April and May 2003, and therefore could not be conclusively analysed.

Table 3-4 below summarises monitoring data for important environmental elements in water at various locations. The results show that fluoride, lead and mercury levels in water at the wells far exceeded recommended guideline values. Lead and mercury levels were noted to increase in Lake Naivasha water, although the source of pollutants cannot be identified as Olkaria alone, as the horticultural and floricultural industries, as well as other urban activities, also contribute to pollution.

Table 3-4 Range of Chemical Parameters of Environmental Significance in Water, 1993-2002

Location	**Parameter**							
	As (ppb)	**Ba** (ppm)	**Cd** (ppm)	**Cu** (ppm)	**F** (ppm)	**Pb** (ppm)	**Hg** (ppm)	**Zn** (ppm)
Wells	53 - 1580	-	0 – 0.12	0 – 0.43	0.25 – 171	0 – 3.0	0 – 11.28	0 – 3.2
Olkaria I		0 – 0.53	0 – 0.03	0 – 0.19	1.83 – 8.14	0 – 0.13	-	0 – 1.33
Old X2 camp	0 – 9.7	0 – 0.2	-	0 – 0.02	1.73 – 9.20	0 – 0.13	-	0 – 5.01
Lakeside Hse Est	-	0 – 0.3	-	0 – 0.02	1.80 – 9.30	0 – 0.13	-	0 – 2.48
Lakeview Hse Est	-	0 – 0.07	0 – 0.02	0 – 0.04	1.85 – 9.0	0 – 0.1	-	0 – 0.87
L. Naivasha	0 – 0.09	-	0 – 0.02	0 – 0.05	0 – 13.63	0 – 0.2	0 – 2.0	0 – 0.51
Naivasha Town	-	-	-	-	-	-	-	-
WB g/lines ppm	**0.1**		**0.1**	**0.5**	**20**	**0.1**	**0.01**	**2**
Nat g/lines ppm	**0.002**	**2**	**0.05**	**0.05**	**2**	**0.1**	**0.005**	**0.5**

Source: KenGen Olkaria Geothermal Power Project, Environmental Section

3.2.6 Air Quality

Hydrogen sulphide measurements are taken at least weekly (usually 3 to 4 times a week) at both Olkaria I and II, and at locations outside the immediate plant facilities. At Olkaria II monitoring began in June 2002 with measurements being taken at specific production wells (OW 701, OW 707, OW 708, OW 715, OW 727, OW M1), at the Contractor's compound, the Consultant's office and at the KWS Gate.

Now that construction is complete, in addition to the production wells, measurements are being taken at the office block, cooling towers, power station (turbine hall), and the seal pits. A summary of monitoring results is presented in Table 3-5 below.

Table 3-5 Hydrogen Sulphide Monitoring Data for Olkaria II (ppm)

Monitoring Site	Year		
	Jun-Nov 2002	Aug-Dec 2003	Jan-Apr 2004
OW 701	0 - 7.9	No measurements taken	
OW 707	0 – 1.7		
OW 708	0		
OW 715	0		
OW 727	0 – 0.1		
OW M1	0 – 0.3		
OW R1	10.2 – 17.8		
OW R3	14.8		
H Young Office	0	Contractor demobilised	
Consultant's Office	0	Consultant moved to main office	
KWS Olkaria Gate	0	0 – 0.1	0
Olkaria II Office	Power station under construction	0 – 0.9	0 – 0.4
Olkaria II power station		0 – 0.2	0 – 0.3
Seal pit 1		0 – 0.3	0
Seal pit 2		0	0 – 0.7
Cooling tower		0 – 0.3	0 – 0.7

Source: KenGen Olkaria Geothermal Power Project, Environmental Section

All emissions recorded in and around the power station were less than 10 ppm which is the WHO threshold limit value (TLV) for hydrogen sulphide (ie. the permissible concentration in the workplace, assuming an 8 hour shift over a 5 day week, World Bank guidelines indicate 15 ppm). At Olkaria II power station, the highest recorded value was 1 ppm, which occurred once at the cooling tower in January 2004. During a site tour on 12 May 2004, the H_2S meter at the seal pit in Unit II recorded concentrations of 0.9 ppm.

High concentrations of H_2S were noted at reinjection wells R1 and R2 in 2002. This is to be expected at the wellheads, particularly during testing and start up. Monitoring of the wells has not been done since 2003.

On the whole it appears that H_2S concentrations around the plant at Olkaria II are lower than at Olkaria I. For example since mid-October 2003, H_2S emission levels ranged from not detectable to 1.2 ppm at the Olkaria I power, and not detectable to 0.3 ppm at Olkaria II. The maximum level was recorded at Olkaria I on 24 March 2004, but on this day at around the same time H_2S levels at Olkaria II were not detectable, suggesting that wind, temperature and weather conditions did not influence concentrations of the gas for this measurement, but that emissions from Olkaria II are indeed lower than Olkaria I.

A review of data gathered between April 1997 and June 2004 shows that H_2S levels in areas outside the immediate power plant boundaries (that is at Lakeview and Lakeside Housing Estates and the KWS Gate) were not detectable (see Annex 4). This implies that the cumulative impact of H_2S emissions since the commissioning of Olkaria II on areas outside immediate plant vicinities is negligible. H_2S levels at the scientific laboratories, although detectable, are within ranges recorded before Olkaria II was commissioned.

No measurements are taken of the other non condensable gases. Geothermal plants emit, on average, about 5% of carbon dioxide emissions emitted from fossil fuel power plants of the same generating capacity. Measurement of carbon dioxide and methane may demonstrate greenhouse gas emission reductions (ERs), in line with the World Bank's carbon finance initiatives.

3.2.7 Noise Quality

Noise data monitoring is also carried out on a weekly basis at Olkaria. Data collected between 1998-2004 were analysed for Olkaria I, while data from Olkaria II were only available from May 2003. Noise data in decibel (dB) are presented in Annex 9, but a summary of the average annual noise range at specified locations is presented in Table 3-6 below.

Table 3-6 Average Yearly Noise Range (dB)

Year	Monitoring Site							
	Olkaria I Power House	Olkaria I Offices	KWS	Lakeview Housing	Lakeside Housing	Scientific Lab	Olkaria II Power House	Olkaria II Offices
1998	78-95	65-85	38-55	34-61	33-50	55-70	-	-
1999	70-95	45-81	25-56	30-55	30-52	38-98	-	-
2000	60-95	48-83	24-63	32-51	32-49	30-75	-	-
2001	69-93	49-81	30-41	28-41	31-48	40-61	-	-
2002	69-75[1]	44-68	28-39	20-38	20-40	38-53	-	-
2003	52-75	34-76	25-56	35-38	32-38	35-60	63-75[2]	43-70
2004	73-79	53-65	25-40	36-38	36-38	42-54	70-73	35-48
WHO TLV[3]	85	70	35	45 - 50	45 - 50	70	85	70
WB guide[4]	70	70		55	55	70	70	70

Source: KenGen Olkaria Geothermal Power Project, Environmental Section

1. Highest one off measurement = 87 dB at Olkaria I Power House.
2. Highest one off measurement = 90 dB at Olkaria II Power House.
3. WHO Guidelines for Community Noise and Occupational Exposure limits
4. WB Guidelines recommend a maximum limit of 55 dB for residential, institutional and educational facilities during the day, and 45 dB during the night; and for industrial and commercial premises, 70 dB daytime and night-time exposure limits.

As would be expected, during the construction of Olkaria II between 2000-3, noise levels were noted to increase at all the above mentioned areas. It is anticipated that these will now reduce, especially after the defects liability period is complete. In general, noise levels over the past 3 years have been within acceptable WHO limits, but World Bank limits are exceeded at the power houses. The data also indicates that cumulative noise levels do not vary significantly from those recorded before construction of Olkaria II commenced. Higher noise levels at Olkaria I Power Station and offices recorded in 1998 and 1999 may be attributed to the drilling of wells.

3.2.8 Flora of the project area

Generally the natural vegetation of the Lake Naivasha basin has been substantially disturbed by human activities. Most of the land in this area is used for human settlement, urban development, small and large scale arable farming, ranching, floriculture and other land uses. What has remained of the natural vegetation is basically a mosaic of various vegetation types interspersed with human settlement and farmlands. Remnants of natural vegetation are found in the protected areas especially in the Hell's Gate National Park. The prominent vegetation types around Lake Naivasha are woodland, bushland and wetlands.

a) Woodland

This is land supporting a stand of trees up to 20 m in height with an open or continuous, but not thickly interlaced, canopy. Woodland vegetation in the project area is rare. A good representation is, however, found to the north of the Lake Naivasha area. This woodland is dominated by the *Acacia xanthophloea* with trees up to 35 m tall.

b) Bushland

Bushland comprises an assemblage of trees and shrubs, which withstand seasonal drought. A bushland community is dominated by plants of shrubby habit although trees are always conspicuous. Trees, however, do not exceed 10m in height except for occasional emergents. Bushland is the most extensive vegetation of the project area. It is found in the Hell's Gate National Park and other areas in the Naivasha basin where the land use is basically ranching. The bushland in this area is dominated by the *Tarchonanthus camphoratus* (called "leleshwa" by the Maasai). *Tarchonanthus camphoratus* covers extensive areas of the Rift Valley basin and at times is the only surviving woody plant in the severely eroded areas. The

Tarchonanthus camphoratus bushland in many places is interspersed with *Acacia drepanolobium*, a plant with large inflated galls which shelter colonies of ants, *Crematogaster mimosae*. The galls produce a low whistling sound when the wind blows and hence the plant is referred to as whistling thorn.

Common grasses in the bushland community of the project area include *Cymbopogon nardus*, *Setaria sphacelata*, *Themeda triandra*, *Eragrostis cilianensis*, *Hyparrhenia hirta*, *Cynodon dactylon*, *Pennisetum clandestinum*, and *Digitaria abyssinica* among other grasses.

The vegetation of the Olkaria area is predominantly a bushland community although local differences on vegetation types have been reported. In 1992, the flora of the project area was reported to comprise seven major vegetation groups including bushland, bushed grassland, shrubbed grassland, grassland, rock outcrops and barren land (Sinclair Knight et al, 1994).

The flora of the Olkaria East area comprises eighty five families and a total of three hundred and four plant species as presented in Annex 5.

c) Introduced vegetation around the power stations

Although the project area is part of the Hell's Gate National Park, several exotic trees, shrubs and ornamentals have been introduced especially in the area around the offices and power stations. The most common of the introduced plants include the species of *Bourgainvillea* spp. *Oleander*, *Terminalia mantally* (Terminalia), *Callistemon citrinus* (Bottle brush), *Cassia spectabilis* (Cassia), *Eucalyptus saligna* (Blue gum), *Schinus molle* (Pepper tree), *Acalypha* spp (Acalypha), *Euphorbia pulcherrima* (Poinsettia), *Hibiscus rosa-sinensis* (Chinese rose) and, *Euphorbia splendens* (Crown of thorns) among other exotics. There are also native plants introduced from other parts of the country around the power stations that are not among the normal flora of the project area. The common native trees are *Croton megalocarpus*, *Albizia gummifera*, *Spathodea nilotica* and *Trichilia emetica*.

Olkaria Power Station supports a tree nursery that raises seedlings for planting around the power stations and for the support of afforestation extension programme in schools, hospitals and surrounding farms and beyond. Around the nursery there is a plantation area covered by trees planted by distinguished visitors. The common trees and shrubs found in the nursery and the immediate planted area are shown in the Table 3-7. Adjacent to the nursery, a planted forest has been established with a mixed tree composition of both exotic and indigenous tree species of *Eucalyptus saligna*, *Grevillea robusta*, *Cupressus lusitanica*, *Croton megalocarpus*, *Schinus molle*, *Cordia abyssinica* and *Acacia xanthophloea*.

Table 3-7 Trees and Shrubs in the Nursery and the Planted Area

Seedlings in the Nursery	Trees Planted by Distinguished Visitors
Acacia melanoxylon *Acacia xanthophloea* *Acrocarpus fraxinifolius* *Albizia gummifera* *Cordia abyssinica* *Casuarina equieitifolia* *Cupressus lusitanica* *Dalbergia melaxylon* *Dodonaea fioga* *Eucalyptus saligna* *Grevillea robusta* *Podocarpus falcatus* *Prunus africana* *Schinus molle* *Vitex keniensis* *Tarchonanthus camphoratus* *Teclea nobilis*	*Acacia melanoxylon* *Araucaria cunninghamia* *Albizia gummifera* *Calondendrum capense* *Casuarina equisetifolia* *Cassia spectabilis* *Cordia abyssinica* *Croton megalocarpus* *Dodonaea fioga* *Eucalyptus saligna* *Felicium decipiensis* *Jacaranda mimosifolia* *Markhamia lutea* *Olea africana* *Olea welwitschii* *Ploysciias kikuyuensis* *Podocarpus falcatus* *Prunus africana* *Spathodea nilotica* *Teclea nobilis* *Terminalia brownii* *Vitex keniensis*

Source: Field Observations

d) Wetlands

The wetlands in the project area are associated with Lake Naivasha and the brine ponds found in Olkaria I Power Station. Lake Naivasha is predominantly fringed by *Cyperus papyrus* while *Typha domingensis* is also found in some areas. There is large development of both submerged and floating aquatic plants. The former is dominated by *Ceratophyllum demersum*, *Najas pectinata* and *Potamogeton* spp. while the latter are dominated by the water hyacinth (*Eichhornia crassipes*).

The brine ponds associated with Olkaria I have been colonised by *Typha domingensis* that forms a well-developed fringing vegetation around the ponds perimeter and the channels leading to the ponds. Several sedges including *Cyperus immensus*, *C. papyrus*, *C. laevigatus* and other members of Cyperaceae are also associated with the brine ponds.

e) Contamination of Vegetation

Chemical elements of environmental significance have also been measured in vegetation around designated sample sites. The results are presented in Table 3-8 below.

Table 3-8 Range of Chemical Parameters of Environmental Significance in Vegetation, 1993-2002

Location	Parameter							
	As (ppb)	**Ba** (ppm)	**Cd** (ppm)	**Cu** (ppm)	**F** (ppm)	**Pb** (ppm)	**Hg** (ppm)	**Zn** (ppm)
Wells	26.01	0 – 1.75	0 – 0.03	0 – 3.35	-	0 – 1.37	28.88	0.3– 10.35
Olkaria I	-	0 – 0.10	0 – 0.03	0 – 0.3	-	0 – 0.45	-	1.0 – 2.78
Old X2 camp	-	0 – 7.15	0 – 0.04	0 – 0.2	-	0 – 0.4	-	0.9 – 7.01
Lakeside Hse Est	-	0 – 0.10		0.12 – 0.5	-	0 – 0.03	-	0.7 – 2.05
Lakeview Hse Est	-	0 – 9.25	0 – 0.04	0 – 0.3	-	0 – 0.15	-	1.1 – 3.5
L. Naivasha	5.13	0 – 0.80		0 – 0.12	-	0 – 0.02	13.4	0.7 – 5.2
Naivasha Town	0.6	0.2 – 0.3	0 – 0.04	0 – 0.3	-	0 – 0.09	0	1.3 – 5.02
WB g/lines ppm	**0.1**	**-**	**0.1**	**0.5**	**20**	**0.1**	**0.01**	**2**
Nat g/lines ppm	**0.002**	**2**	**0.05**	**0.05**	**2**	**0.1**	**0.005**	**0.5**

Source: KenGen Olkaria Geothermal Power Project, Environmental Section

The results show that levels of arsenic, lead and mercury in vegetation tested at the wells and in Lake Naivasha exceeded recommended guideline values. Again, it is difficult to pinpoint the source of pollutants due to the numerous and varied agricultural and industrial activities in and around the sample sites.

3.2.9 Fauna of the project area

a) Wildlife in the Hell's Gate National Park and surrounding areas

Wildlife in the project area and its area of influence is found in significant numbers in Hell's Gate National Park, Longonot National Park and other areas where the land use (mainly ranching) is compatible with wildlife ecology. This includes the riparian area around Lake Naivasha, private ranches such as Kedong and Longonot Ranches, and the newly established wildlife sanctuaries around the lake. Twenty three species of mammals including fourteen large herbivores and three small herbivores can be found in this area, a list of which is presented in Annex 6. The most common seen animals are zebra (*Equus burchelli*), kongoni (*Acelaphus buselaphus*), gazelles (*Gazella thomsonii* and *Gazella grantii*), Impala (*Aecpyceros melampus*), dik dik (*Rhyncotragus kirkii*), giraffe (*Giraffa camelopardis*) and buffalo *(Syncerus caffer*). Other animals include the jackal, olive baboon, rock hyrax, hedgehog, aardvark and leopard. Lake Naivasha supports large populations of the hippopotamus (*Hippopotamus amphibius*).

The general impression with regard to the animals in the Hell's Gate and Longonot National Parks is that of low numbers of animals and low biodiversity as compared to other national parks in the country. Animal movements are limited especially to the north of the Hell's Gate National Park. This is mainly due to human encroachment, particularly the flower farms that are proximate to the park, and which have occupied dispersal areas and blocked migratory corridors.

More than ten years ago, Sinclair Knight et al (1994) carried out animal counts in the Hell's Gate National Park as part of the environmental impact assessment study for Olkaria II. The Nakuru Wildlife Forum, and later the Nakuru Wildlife Conservancy, have both carried out subsequent animal counts at Hell's Gate National Park and the surrounding areas. Table 3-9 shows the trends in the wildlife populations in Hell's Gate National Park. The population sizes of many of the animals in the park, notably kongoni, Thompson's and Grant's gazelles, eland and buffalo are on the decline.

Table 3-9 Trends in Animal Population in Hell's Gate National Park

Animal Species	Population Size				
	1992	1996	1998	2000	2001
Kongoni	479	307	81	250	9
Zebra	295	453	342	320	214
T. gazelle	165	116	33	33	40
G. gazelle	136	99	44	72	11
Giraffe	40	21	11	11	25
Eland	102	150	28	59	24
Reedbuck	32	4	13	15	11
Wartog	50	97	40	40	39
Impala	30	90	52	79	28
Dik dik	25	8	3	13	2
Steinbuck	24	7	0	2	5
Klispringer	10	8	0	8	2
Buffalo	105	305	28	58	24
Wildebeeste	-	-	-	-	-
Waterbuck	5	16	0	2	6

Source: Sinclair Knight et al, and Census Reports by Nakuru Wildlife Forum and Nakuru Wildlife Conservancy.

b) Avifauna

Hell's Gate National Park and the surrounding areas have a wide diversity of avifauna. One hundred and eight (108) species of birds were recorded in the Hell's Gate National Park in 1992 (Annex 7). The diverse avifaunal community is attributed to the heterogeneity of the habitat and the close proximity to Lake Naivasha. The cliffs and gorges found in the park are important breeding grounds for some of the bird species, including the vultures and swifts.

Lake Naivasha is reknowned for its varied aquatic bird life, supporting more than 80 species which are regularly recorded during censuses. There are large concentrations fish eagles (*Haliaeetus vocifer*), kingfishers (*Ceryle rudis* and *Alcedo cristata*), sacred ibises (*Threskiornis aethiopicus*), coots (Fulica cristata) and ducks (*Anas* sp). Several bird species found on the lake are threatened. They include the Great Crested Grebe, the African Darter, Great Egret, Saddle-billed stork, White-backed Duck, the Baillon's Crake and the African Skimmer.

c) Fish fauna

Presently, Lake Naivasha supports several fish species. Prior to 1925, the lake supported a single endemic fish species, a zooplanktivorous small-tooth carp (*Aplocheilichthyes antinori*) that is probably extinct today. Since 1925 there have been several introductions of fish species which currently support the lake fishery. The main introduced fish species are the black bass (*Micropterus salmoides*), two types of cichlids (*Tilapia zilli* and *Oreochromis leucostictus*) and the common carp (*Cyprinus carpio*). The common carp, which was not among the commercial fisheries in the 1980 and 1990s, now dominates the fisheries of the lake. A fresh water lobster, the Louisiana Red Cray Fish (*Procambarus clarkii*) was introduced in 1970 and has since persisted in the lake.

Over the last twenty years (1980-2000), there has been a great variation in the fisheries of Lake Naivasha. The general trend, however, was a net recession in the fisheries of the lake mainly attributed to over fishing. Subsequently in the year 2001, the stakeholders decided to put a moratorium on the fishing activities of Lake Naivasha. Two years after moratorium, limited fishing trials are being carried out on the lake with 40 boats and ten nets of 4 inch mesh. Results of the fish trials showing the types and production of fish landed at the two major landing bays (Kamere Beach and Central Landing Beach near Naivasha Town) are presented in Table 3-10 below.

Table 3-10 Fish Production in Lake Naivasha

Fish Species	Production (Kg)					
	October 2003	November 2003	December 2003	January 2004	February 2004	March 2004
O. leucostictus	391	840	584	852	599	801
M. salmoides	1,287	801	280	195	201	417
T.zilli	907	597	260	187	142	117
C.carpio	633	2,721	2,357	2,620	2,266	3,057
Total	**3,217**	**4,958**	**3,481**	**3,854**	**3,207**	**4,391**

Source: Fisheries Department, Naivasha

3.3 Human Environment

3.3.1 Administrative set up

Nakuru District is one of the eighteen districts of Rift Valley Province. It lies within the Great Rift Valley and borders eight other districts. The district covers an area of 17,242.3 km^2. Nakuru District has 16 divisions; Naivasha Division being the largest, followed by Gilgil Division, while Molo Division is the smallest. The Olkaria Geothermal Power Project is located in Naivasha Division.

There are six constituencies in the district, namely Nakuru Town, Subukia, Naivasha, Kuresoi, Rongai and Molo. These constituencies do not follow the divisional administrative boundaries. Naivasha constituency comprises Naivasha and Gilgil Divisions. There are four local authorities in the district. These are:

- The Nakuru Municipality, which has nineteen wards;
- Nakuru County Council, with thirty-three wards;
- Naivasha Municipal Council, with twelve wards;
- Molo Town Council, with eight wards.

The total number of wards is seventy-two.

3.3.2 Land tenure

The project area was occupied by the Maasai peoples for several decades prior to settlement by the white settlers at the turn of the last century. The land under the Maasai occupation was community owned. This included the rivers, lakes and salt licks. The plains were used for grazing during the wet seasons while the highlands were used for grazing during the dry seasons.

Following the building of the Uganda Railway across the Rift Valley in 1900, the Maasai were moved south of the railway in 1905 to make way for European settlement. Much of the land around Lake Naivasha was subsequently settled by the European farmers who practised mixed livestock and agricultural farming. In 1932, an agreement was reached between the Colonial Government and the Lake Naivasha riparian owners that stipulated the modalities of utilizing land below 1,906 masl.

Following independence, some of the land within the Naivasha basin and much of the land on the eastern flank of the Rift Valley (especially around Kinangop and Kipipiri) was taken over by the landless local community. Some of the large farms belonging to former settlers were sold to the land buying companies and subsequently subdivided.

The land in the project area including Hell's Gate National Park and the Lake Naivasha falls within the Naivasha Municipal Council boundaries. Land ownership in the project area and the surroundings falls under two broad categories: Government Trust Land and private ownership.

The former is land owned by the Government through Government ministries, state corporations, local authorities and other public institutions. Included in this category are the Hell's Gate National Park, Longonot National Park, Lake Naivasha, and land occupied by the Olkaria I and II Power Stations and the associated facilities. Private land includes land privately owned and registered with a title deed under freehold or leasehold system. This includes ranches (Kedong and Longonot Ranches), large farms (Kongoni, Oserian, Ndabibi Farms), land under flower farms (Oserian, Homegrown, Sher Agencies etc) and other privately owned land around the lake.

An interesting observation with regard to the land tenure of the project area is the access to the lake. Although the lake is a public property, access to the lake water is mainly through private property. The issue of the establishment of corridors that facilitate the community to access the lake has not yet been adequately resolved.

3.3.3 Population and demographic characteristics

Demographic data for the project area were obtained from the 1999 Population Census (CBS, January 2001). Table 3-11 below shows population figures and densities for the year 1999, for areas that will be directly influenced by the project. For comparison purposes, figures for Naivasha Division, Nakuru District and the country as a whole are also presented.

Table 3-11 Demographic Characteristics for the Project Area and its Environs

Location	Sublocation	Area (sq km)	Male Population 1999	Female Population 1999	Total Population 1999	Population density 1999 (persons/ sq km)	No. of households	Av. size of household*
Naivasha Town	-	77.8	18,963	18,301	37,264	479	11,598	3
Longonot	Longonot	189.3	5,372	5,792	11,164	59	2,484	4
Maiella	Maiella	40.9	3,912	4,135	8,047	197	1,949	4
	Kongoni	91.6	1,600	1,571	3,171	35	1,098	2
Ndabibi	Ndabibi	120.7	1,825	1,801	3,626	30	791	4
Hell's Gate	Olkaria	339.4	11,324	10,022	21,346	63	8,874	2
	Mirera	96	9,931	10,215	20,146	210	6,227	3
Naivasha Division	-	1,782.3	80,323	78,356	158,679	89	46,735	3*
Nakuru District	-	7,242.3	598,703	588,336	1,187,039	164	296,451	4
Kenya	-	581,667.2	14,205,589	14,481,018	28,686,607	49	6,371,370	4.50

Source: *Population and Housing Census, 1999*

* The average household size here is obtained by dividing the total population by the number of households. However, information obtained for 1999 from the Naivasha Divisional Agricultural Office gives a total population of 158,220, and the number of households as 47,095, but the average household size as being 7 persons, and density as being 98 persons/sq km.

The intercensal growth rate for Naivasha Municipality from 1989-1999 was 15.3% (cf. national intercensal average growth rate of 2.9%). This growth rate is attributed to the phenomenal development in horticultural and floricultural activities around Lake Naivasha, which has encouraged the in-migration by people in search of employment. However, population projections obtained from the District Statistics Offices for 2002 for Naivasha Division indicate a total population of 175,457, indicating a growth rate of 3.4% from 1999-2002. This dramatic decline in growth rate is to be expected as markets for floricultural and horticultural produce are becoming saturated, and availability of land for these activities is now limited. The growth rate is therefore likely to stabilize, and then decrease slightly over the next decades. Figures for projected growth rates were not available at the District Statistics Offices, nor in the various volumes of the CBS *1999 Population and Housing Census*.

The Nakuru District Development Plan (2002-2008) projects the total population of the District for 2002 at 1,312,555, implying a growth rate of 3.4% since 1999. The number of households for 2002 is projected at 327,797, while the average household size was 4 persons.

In Table 3-12 below, population projections are presented for 2005, 2010 and 2020 based on growth rates of 3.2%, 3.0% and 2.8%, respectively, throughout Naivasha Division, as well as for Nakuru District.

Table 3-12 Population Projections of the Project Area and its Environs

Location	Sub location	Popn 1999	Popn 2005	Popn 2010	Popn 2020
Naivasha Town		37,264	45,451	52,690	60,491
Longonot	Longonot	11,164	13,486	15,633	17,947
Maiella	Maiella	8,047	9,721	11,269	12,937
	Kongoni	3,171	3,830	4,440	5,097
Ndabibi	Ndabibi	3,626	4,380	5,077	5,828
Hell's Gate	Olkaria	21,346	25,786	29,893	34,319
	Mirera	20,146	24,337	28,213	32,390
Naivasha Division		158,679	191,689	222,220	255,122
Nakuru District		1,187,039	1,433,980	1,662,375	1,908,510
Kenya		28,686,607	32,161,825	44,046,338	56,383,036

Source: Projections based on data from *Population and Housing Census, 1999*

The most sparsely populated areas in Nakuru District are Gilgil Division and parts of Naivasha Division, these being classified as the marginal areas of the District. The people here are involved in small scale farming. In general these areas have the highest proportion of people living below the poverty line.

The government has been fighting poverty since independence. According to the Welfare Monitoring Survey of 1997, absolute poverty in the District was 45% of the rural population and 41.06% for urban population; food poverty was 42.1% for the rural population and 21.38% for urban population. This is consistent with figures obtained from the Nakuru District Development Plan (2002-2008), which indicates that 45% (313,275) of the population live in absolute poverty in the rural areas of the District, while 41% (251,719) of the urban population fall into this category. This situation has continued to decline further over the years.

In spite of the fact that food in the district is relatively cheap compared to neighbouring districts, the population living in marginal areas of the district has a high proportion of people living below poverty line. Urban centres, which have recorded high urban growth rates, have also recorded very high numbers of poor people. In Naivasha Municipality, the most affected are the casual workers in the flower farms and those looking for jobs in the same farms.

The land clashes in the 1990s played a big role in the current state of poverty by creating tension, insecurity, forced migration and destruction of life and wastage of time, which would have been otherwise directed towards productive activities. The HIV/AIDS pandemic has also contributed significantly to high levels of poverty.

3.3.4 Migration and settlement

Nakuru has one of the highest rates of external and internal migration in the country. External migration involves movement of people from other districts into Nakuru, while internal involves movement of people from one division to another within the District.

Many of the migrants have moved into towns within the District. As a result, the urban population growth rates for some of the urban centres in the District are higher than the national urban growth rate. Naivasha recorded a growth rate of 15.3 % between 1989-1999. As mentioned above, in Naivasha Municipality, this has been due to the increasing floricultural and horticultural activities. These high urban growth rates have also increased the demand for services such as education, water, sanitation, health, housing and other services, which has put a strain on the local authorities who are responsible for these services.

As a result of the migration trends, the District's population has been increasing steadily, resulting in the establishment of new settlements. These centres, namely Kasarani, Karagita, DCK, Kongoni and Kamere Estate, are inhabited by people from a mixture of tribes from different parts of Kenya, many of whom are working at the numerous flower and horticultural farms.

3.3.5 Agricultural activities

The natural land potential of the floor of the Rift Valley including the Naivasha Basin has been described by Jaetzold and Schmidt (1983). According to this document, the project area falls under the Upper Midland (UM5-UM6) zone where rainfall is low (600-950 mm per year) and unreliable.

Traditionally, the main agricultural activity of the area has been ranching. However, the area around Lake Naivasha has now become an important centre for flower and vegetable production in the country for export to the European market. The favourable climate and soils and ample supply of irrigation water from the Lake Naivasha are ideal conditions for intensive production of cut flowers and horticultural crops such as green beans. Large tracts of land have been cleared to make way for green houses, and expanses of woodland and fringing swamps have been cleared with cultivation sometimes extending right down to the lake edge. Today, the total area of commercial scale irrigation for cut flowers and vegetables around Lake Naivasha is estimated to be 3,000-5,000 hectares. Major companies involved in flower cultivation include, among others, Oserian Company, Sher Agencies, Homegrown, Gold Smith Seeds, Kijabe Ltd and Wild Flowers Ltd.

To the west, south and east of the Olkaria Power Station beyond the boundaries of Hell's Gate National Park, the land is mainly used for ranching. The major ranches are the Kedong Ranch and Longonot Ranch situated to the south and east of the National Park, and Kongoni Farm to the west of the Park. A summary of agricultural activities in the district according to Nakuru District development plan (2002-8) is as follows:

- Average farm size (small scale) - 2.5 acres
- Average farm size (large scale) - 1,100 acres
- Main food crops produced - Maize, Beans, Irish potatoes, and vegetables
- Main cash crops produced - Pyrethrum, Flowers, and Wheat
- Total acreage under food crops - 130,098.2 ha
- Total acreage under cash crops - 23,481.7 ha
- Population working in the agricultural sector - 224,051 persons
- Population of fish farmers - 90 persons
- No. of landing beaches - 3 number

3.3.6 Tourism

Tourism is an important activity around Lake Naivasha, as well as in the project area. Presently, several tourist facilities including hotels and lodges have been developed to cater for the growing industry. With spectacular scenery, presence of charismatic wildlife and avifauna, a fine climate, tranquil surroundings and easy access, Naivasha area has become an important centre for local and international tourism. Conditions that favour tourism in the project area include proximity to Nairobi, the presence of Hell's Gate and Longonot National Parks, and the fact that the project area is part of the Rift Valley, which has many other tourism sites such as Lake Nakuru National Park, Lake Elementaita and other attractive areas. The presence of Olkaria geothermal power station also serves as a tourist attraction for the local people. In Hell's Gate National Park visitors can view game while in Lake Naivasha, bird watching, hippo viewing and water sports are popular tourist activities.

The monthly distribution of visitors in the Hell's Gate and Longonot National Parks is presented in Table 3-13. The monthly distribution of visitors show a peak in the months of June, July and August which corresponds with higher collection of revenue (Table 3-14).

Table 3-13 Monthly Distribution of Visitors in Hell's Gate and Longonot National Parks

Year	Month												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
2001	2,304	3,140	4,405	3,296	2,747	3,910	4,345	4,809	4,262	3,921	2,753	3,380	**43,272**
2002	1,417	1,991	3,437	1,756	2,442	4,329	4,952	5,789	2,966	3,055	2,754	2,712	**37,600**
2003	1,649	2,868	3,390	3,464	3,017	3,327	3,468	5,063	4,643	5,510	4,584	2,793	**43,776**

Source: Kenya Wildlife Service, Nairobi.

Table 3- 14 Monthly Revenue Collection at Hell's Gate National Park 2001-2 (KShs)

Month	Year	
	2001	2002
January	752,202	604,036
February	879,860	842,330
March	851,712	894,200
April	949,472	544,502
May	718,592	534,712
June	915,966	938,556
July	1,421,898	1,524,426
August	1,417,459	1,687,053
September	1,263,076	1,055,230
October	1,034,194	987,346
November	758,866	756,125
December	865,090	926,815

Source: Records from the Olkaria Power Station

Due to increasing tourist appeal of the area, several stakeholders have now taken initiatives to diversify land use to enhance wildlife conservation. These include Kedong Ranch, Longonot Ranch, Kongoni Farm, Marula Farm, Delamere Estates, KWS Training Institute, Kijabe Limited, Oserian, Mundui, and Nderit Farms. Some of the above farms and ranches have also developed accommodation and other facilities to attract tourists.

Indicators point to an upsurge in tourism development in this area. These include several upcoming tourism facilities such as the Great Rift Valley Lodge (on the way to Eburru), Naivasha Simba Lodge, Naivasha Sopa Hotels (part of Mara Sopa Group) and other tourist facilities. In addition, there are local initiatives (although not targeting the same calibre of clientele) that meet a wide range of local demands, such as the Yellow Green, Cray Fish and Fischers Tower Hotels all situated along Moi South Road. In Naivasha town there have been recent developments, including Wambuku Hotel, Comfort Hotel, Lake Tourist Lodge, Ken Vash Hotel.

Based on the above discussion, it is evident that there is a future for tourism in this area and the community around the lake has recognized this potential. As a result they have now formed a local tourism initiative (Lake Naivasha Tourism Group - LNTG) that is an integral component of the Lake Naivasha Management Committee. The Tourism Group gives advice to stakeholders on planning, sustainable management of tourism and natural resources, wise use, waste management, lobbying and networking for the sustainable tourism development in this area. The Tourism Group is able to promote sustainable tourism through the Lake Naivasha Management Committee which has now been recognized by the National Environmental Management Authority (NEMA) as the institution charged with the responsibility of implementing the Lake Naivasha Management Plan.

Although there is undoubtedly a future for tourism in the Naivasha area, playing against this potential is the haphazard development of unplanned centres and housing facilities, for

example, Kasarani, Karagita, DCK, Kongoni, Kamere Estate (near KenGen) and other unplanned housing facilities. These unplanned developments have no basic facilities for water supply, sanitation or waste disposal.

3.3.7 Employment patterns

The district's labour force (ie. the 15-64 age group) is expected to increase from 703,234 persons in 2002 to 859,802 persons in 2008. This represents 53.6% of the total population at the start of the plan period. According to the 1999 Population and Housing Census Report, 175,625 people in the labour force were unemployed, implying that unemployment rate in the district was about 28%. Most of the unemployed are young people who have moved to urban centres. Only 22% of the labour force is engaged in family businesses or farms.

Most of the people in Naivasha Town are employed. The largest employees are Sulmac and Oserian, which operate flower farms. Other commercial activities are tourism, ranching and horticultural business.

3.3.8 Health profile

There is one District Hospital located in Naivasha Town, and a number of health centres within the Division. The flower farmers operate private clinics, and KenGen too has its own clinic (Mvuke Clinic).

According to the Public Health Officer (Ministry of Health, Naivasha), the most common diseases in the Naivasha area include skin diseases, upper respiratory tract infections, malaria, amoebiosis and diarrhoea. The Nakuru District Development Plan (2002-2008) cites the same diseases. Cases of skin diseases and upper respiratory tract infections are on the increase, and according to the Officer it is suspected that this is due to either the geothermal power plant or the fertilizers and chemicals from the flower farms.

The daily outpatient morbidity for the major illnesses recorded at Naivasha District Hospital from January - April 2004 are presented in Table 3-15 below:

Table 3-15 Incidence of Morbidity at Naivasha District Hospital (Jan to Apr 2004)

Illness	Jan	Feb	March	April
Diarrhoeal diseases	95	184	149	239
Mumps	15	6	1	3
Chicken pox	26	18	4	35
Malaria	715	863	840	998
Urinary Tract Infection	50	82	197	69
Intestinal worms	17	28	11	56
Eye infections	195	206	217	223
Ear Infections	18	25	19	30
Disorders of the respiratory system	632	810	777	945
Pneumonia	12	23	49	43
Abortion	15	6	16	12
Dental Disorders	494	401	464	391
Disorders of the skin (incl.ulcers)	253	285	157	171
Rheumatism, joint pains etc	31	34	52	43
Accidents	95	59	91	78

At KenGen's Mvuke Clinic, the most common diseases from 1990s to the present time are upper respiratory tract infections, malaria and headaches (personal communication with Sister-in-Charge, Mvuke Clinic). The clinic serves staff from KenGen, but there was no evidence that these diseases related to the power plant. Although there could be an increase in HIV/AIDS, this could not be confirmed as there is no laboratory at the clinic, and such cases would go to private hospitals in Naivasha or Nairobi.

According to the Sister-in-Charge, the Maasai community do not visit the clinic, as this is a company clinic. They therefore go to Naivasha Hospital.

3.3.9 Education profile

Schools around Lake Naivasha are divided among four zones: Naivasha, Maragisho, Longonot and Maiella Zones (personal communication with Inspector of Schools, Naivasha Division). Maiella Zone covers the schools around the lake, and has 18 public schools and 8 private primary schools, 1 public secondary school and 1 Catholic sponsored secondary school. Mvuke Primary School is in Maiella Zone, and is assisted by KenGen. The school was placed 4th out of 18 schools in the national primary school examinations, after Sher, Oserian and Loldia respectively. This has been attributed to lack of motivation on the part of the teachers at Mvuke as compared with the other three schools, which are also company-sponsored (albeit by private enterprises).

Enrolment at Mvuke Primary School in year 2004 was 195 boys and 194 girls with 12 teachers. In year 2003 the enrolment was 340 pupils. 90% of the children come from staff of KenGen, 10% from other communities and about 1% from the Maasai community. The school is facing the challenge of the free primary education directive, as a result of which there has been an influx of children, so that a class now typically has 45 children compared to the previous 25 children.

KenGen has assisted in the education sector in the area; it provides transportation for children of the Maasai communities, and during the national exams it has provided transport for other students as well. However, the staff of KenGen have high expectations for their children and many parents take their children to private schools after Standard 4, making it difficult to assess the teacher's performance. The Inspector of Schools recommended that the school be extended to have double streams so that other communities can also take their children to school, and to provide secondary education.

4 LEGAL AND REGULATORY FRAMEWORK

4.1 Policy and legal framework

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. However, 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. The Second Schedule lists all undertakings for which environmental impact assessments (EIAs) are mandatory. Item 4 of the Second Schedule includes drilling for the purposes of utilising geothermal energy, while electricity generation stations fall under Item 10.

The Environmental (Impact Assessment and Audit) Regulations, 2003, provide the basis for procedures for carrying out environmental impact assessments and environmental audits. NEMA's draft EIA Guidelines and Administrative Procedures (November 2002) identify the first step in the EIA process as being the submission of a Project Report. NEMA may then approve the Project Report, with or without additional conditions, and issue an EIA Licence on the payment of 0.1% of the total project fee. Alternatively it may require a full EIA study to be undertaken before an EIA Licence is issued, or reject the Project Report.

4.2 Kenyan laws relevant to the site

The Environmental Management and Coordination Act supersedes all other environmental legislation. The Act provides for "*the establishment of an appropriate legal and institutional framework for the management of the environment*."

In addition, numerous other laws and regulations influence the various aspects and activities of the power plant:

- Geothermal Resources Act (1982);
- Geothermal Resources Regulations (1990);
- Electric Power Act (1998);
- Public Health Act (1986 revision);
- Factories Act (1972 revision);
- Water Act (2002);
- Wildlife (Conservation and Management) Act (1985 revision);
- Lakes and Rivers Act (1983 revision);
- Building Code (1997);
- Local Government Act (1998 revision);
- Local Government Regulations (1963);
- Trade Licensing Act;
- Physical Planning Act (1996);
- Penal Code (1985 revision);
- Radiation Protection Act (1985);
- Food, Drugs and Chemical Substances Act (1992 revision);

- Scrap Metal Act (rev. 1972);
- Petroleum Bill (2002);
- Use of Poisonous Substances Act (1983 revision);
- Exchequer and Audit (Procurement) Regulations (2001);
- Public Procurement and Disposal Bill (2003);
- Workmen's Compensation Act (1988 revision).

The provisions of these laws and regulations are summarised in Annex 8.

4.3 Licences and permits

Several of the pieces of legislation listed above require licences or permits to be issued for activities undertaken at Olkaria I and II. These are tabulated below:

Table 4-1 Permits and Licenses

Legislation	Permits / Licences Required
Geothermal Resources Act (1982)	• Geothermal resources licence
Electric Power Act (1998)	• Electricity generating licence
Building Code (1997)	• Notice of Inspection card required for new unit • Naivasha Municipal Council approval required for plans for Unit 3
Public Health Act (1986 revision)	• Naivasha Municipal Council approval of plans for Unit 3
Factories Act (1996 revision)	• Registration certificate
Local Government Act (1998 revision)	• Trade / Business Licence
Trade Licensing Act	• Trade Licence
Physical Planning Act (1996)	• Development application to be made for Unit 3 • Development permission for Unit 3
Environmental Management & Coordination Act (1999)	• EIA Licence for Unit 3 • Emissions licences for Olkaria I and II • Effluent discharge licence for Olkaria II for reinjection of brine • Licence to operate waste disposal site at Olkaria and at housing. • Licence to generate hazardous waste at Olkaria
Radiation Protection Act (1985)	• Licence for possessing and using irradiating devices
The Water Act (2002)	• Abstraction permit for use of lake water • Olkaria requires a letter of 'no objection' from the appointed water undertaker of the area as it provides water to more than 20 households (for both domestic and community supplies)
Scrap Metal Act (1972 revision)	• Licence for removal and sale of scrap metal
The Petroleum Bill (2002)	• Petroleum licence
Use of Poisonous Substances Act (1983 revision)	• Licence for disposal/storage of poisonous substances

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

4.4 World Bank environmental and social safeguard policies

The conduct of this assignment has also been guided by various World Bank safeguard policies and guidelines. The World Bank has several operational policies that aim to guide World Bank funded projects so that they are environmentally and socially sound and sustainable. Operational Policies bearing particular relevance to Olkaria II are:

- OP 4.01:- Environmental Assessment provides guidelines for environmental assessments of projects that are proposed for funding by the World Bank.

- OP 4.04:- Natural Habitats describes considerations for the conservation of natural habitats, through the protection and enhancement of the environment.

The World Bank's Environmental Assessment Sourcebook (Volumes I, II and III) is intended to provide practical guidance for designing environmentally sustainable bank-assisted projects. The Sourcebook collates various bank policies, procedures and guidelines into a single source.

In addition, the Bank's Pollution Prevention and Abatement Handbook 1998 describes pollution prevention and abatement measures, as well as emission levels, that are acceptable to the Bank.

4.5 International treaties and protocols

Kenya has ratified or acceded to numerous international treaties and conventions. Those that have implications on Olkaria II are described here.

The ***Convention on Wetlands of International Importance especially as a Waterfowl Habitat***, signed in Ramsar, Iran, in 1971, is an intergovernmental treaty which provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources.

Intergovernmental negotiations for an international agreement to phase out ozone depleting substances concluded in March 1985 with the adoption of the ***Vienna Convention for the Protection of the Ozone Layer***. This Convention encourages intergovernmental cooperation on research, systematic observation of the ozone layer, monitoring of CFC production, and the exchange of information. The ***Montreal Protocol on Substances that Deplete the Ozone Layer*** was adopted in September 1987, and was intended to allow the revision of phase out schedules on the basis of periodic scientific and technological assessments. The Protocol was adjusted to accelerate the phase out schedules. It has since been amended to introduce other kinds of control measures and to add new controlled substances to the list.

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. Following on from this Convention, and in accordance with the precautionary approach contained in Principle 15 of the Rio Declaration on Environment and Development, the ***Biodiversity Protocol*** contributes to ensuring an adequate level of protection in the field of the safe transfer, handling and use of

living modified organisms resulting from modern biotechnology that may have adverse effects on the conservation and sustainable use of biological diversity, taking also into account risks to human health, and specifically focusing on transboundary movements.

4.6 KenGen policies

KenGen's Environmental Policy was initiated by the Environmental Section at Olkaria, and has now been adopted by all KenGen facilities. The policy requires the Company and its facilities to:

- Adopt eco-technology;
- Promote new and renewable energy sources;
- Comply with environmental legislation and regulations;
- Raise environmental awareness through training;
- Support environmental protection and conservation;
- Establish a waste management system;
- Monitor all environmental, health and safety aspects of its operations;
- Take environmental considerations into account during the procurement of goods and services;
- Formulate environmental emergency response plans.

An Occupational Safety and Health Policy was prepared in 1990 by KenGen's predecessor, the Kenya Power and Lighting Company Ltd. KenGen is in the process of preparing its own occupational health and safety policy. But in the interim the Olkaria site follows the existing KPLC one, which emphasises the safety and health of its employees in all operational activities and stipulates the Company's responsibility to provide safe working conditions and to train employees on safe working procedures. The policy makes all levels of supervision and management accountable for a safe and healthy work environment.

KenGen policies and procedures are given in Annex 9.

5 DESCRIPTION OF THE PROJECT COMPONENTS AND PROCESS ACTIVITIES

5.1 Generation of geothermal electricity

Geothermal energy is continuously created beneath the Earth's surface from the extreme heat contained in liquid rock (magma) within the Earth's core. When this heat naturally creates hot water or steam, it can be piped to the surface and then used to turn a steam turbine to generate electricity.

The process of generating geothermal electricity at the new unit at Olkaria II will be exactly the same as that for the existing plant. It will basically consist of the following steps:

- Steam from the production wells will pass through a separator, where water (or brine) will be separated from the steam.
- The brine will be re-injected into a deep well.
- The steam will pass through steam scrubbers before being transmitted to a 35 MW impact reaction turbine, which will generate electricity.
- After passing over the turbine, the steam will be condensed.
- Hot condensate will be pumped through the cooling towers. Non condensable gases will be emitted from the cooling towers, while cool condensate will be re-circulated to the condenser.
- As the circulating condensate will be acidic, it will be dosed with soda ash (sodium carbonate). In addition, the condensate will be dosed with biocide (hypochlorite) to prevent bacteria growing in the fins of the cooling tower.
- Any additional condensate will be pumped into different re-injection wells.

A process flow diagram is presented in Annex 10.

5.2 Power plant design

At this stage, the design of the new unit is still being conceptualised. However, through discussions with representatives of the design consultant, Sinclair Knight Merz, we were able to obtain an idea of the structures and infrastructure that may be required for the new unit.

The proposed third unit will be an extension of the newly commissioned Olkaria II Power Station. The steam that is currently being tapped will be used for the process. No new production wells will be drilled. Nor will any access roads be constructed.

A new steamline will have to be installed to take steam from the main steamline to the new unit. In this case the new steamlines will follow the existing steamline route, necessitating the widening of the steamline route. It is also possible that a new steamline will have to be installed from the steamfields to Olkaria II if more of the existing wells are to be connected.

In addition, the excess steam from Olkaria I will have to be transferred to the new unit. This will require the installation of a steamline from Olkaria I to Olkaria II. At the top end, this new steamline may be able to follow the main access road to Olkaria I; however after a few hundred metres, the steamline will have to cut across land adjacent to the road in order to avoid the cuts along the road.

5.3 Raw materials and process chemicals

The main raw material is geothermal steam. At present, some 495,000 kg of steam is consumed by the two existing turbines per hour; the new unit will probably use approximately 250,000 kg of steam. Non condensable gases (NCGs) will make up between 0.30 - 0.34% by weight of the main steam. The measured composition by volume of the main steam flowing through each of the existing turbines is:

- Steam - 99.85 – 99.87%;
- Carbon dioxide (CO_2) - 0.108 - 0.123 %;
- Hydrogen sulphide (H_2S) - 0.010 - 0.013%;
- Oxygen (O_2) - 0.001 – 0.002%;
- Nitrogen (N_2) - 0.011- 0.012 2%.

This composition will remain much the same for Unit 3. Small quantities of sulphur oxides (SO_x), methane (CH_4), ethane (C_2H_6) and radon (Rn) will also be present in the geogas.

Table 5-1 below shows the actual composition of the non condensable gases in the main steam, compared with levels as predicted in the 1994 EIA study.

Table 5-1 Composition of Non Condensable Gases (% by Volume)

NCG	Predicted Composition	Actual Composition
Carbon dioxide (CO_2)	91 – 96%	82.0 – 83.1%
Hydrogen sulphide (H_2S)	1.2 – 4.9%	7.7 – 8.7%
Oxygen (O_2)	-	0.77 – 1.3%
Nitrogen (N_2)	-	8 – 8.5%
Hydrogen (H_2)	0.7 - 3.3%	not measured
Methane (CH_4)	less than 2%	not measured

The table indicates that the amount of hydrogen sulphide in the NCG is 2-7 times more than initially estimated, but the amount of carbon dioxide was 9-14% lower than anticipated. A similar composition is expected for Unit 3.

Water from Lake Naivasha is used as a coolant in the cooling towers. This is a closed system, where there is a balance between condensed steam and emissions released through the cooling towers. Each cooling tower requires a start up volume of 1,458.6 m^3 of water. Thus the total volume of water circulating in the two cooling towers at present is 2,917.2 m^3, and the new unit will require 1,458.6 m^3 of fresh water at start up. Thereafter for about three years, only a very small quantity of water is necessary for topping up.

No other water requirements are foreseen (eg. for the purposes of washing and sanitation on the site).

An amount of approximately 150 kg of soda ash (sodium carbonate) will be used per day to dose the condensate produced by the new unit in order to maintain a pH value between 7-9, to eliminate algal and bacterial growth. Water for the new cooling towers will be shock-dosed with sodium hypochlorite (roughly 80 litres will be required per day) and biocide (approximately 200 litres of biocide will be needed per month) to prevent algae and other bacteria clogging up the cooling tower fins. Some water from the new cooling tower will also be cold reinjected, and this too will have to be neutralised with soda ash.

Other chemicals currently used on site include diesel oil for the standby generator, silica gel to dry air going into the transformers, greases and lubricants for maintenance of the plant and equipment, paints, detergents and solvents. Mercury is stored at the Instrumentation

Laboratory for calibrating plant control instruments. It is not anticipated that the volumes required of these chemicals will increase substantially for use at the new unit.

5.4 By products, effluents and emissions

Three main waste products that will result from the process are as follows:

- Brine;
- Condensate;
- Non condensable gases.

The production wells, well pad infrastructure and steamline reticulation system were all installed for the existing Olkaria II power station. For the expansion of the plant, a new steamline will take steam from the main steamline to Unit 3, and another will transfer the excess steam from Olkaria I to the new unit.

Some of the steam flowing along the steamlines will condense. In addition, a small quantity of brine will also flow along the steamlines. The steam condensate contains some dissolved silica. Silica deposits will precipitate in the steam pipelines, and will have to be removed periodically from the steamlines. The silicates will be disposed of by burying them at the Olkaria dumpsite.

The steam that condenses after passing through the turbines will be highly acidic due to the presence of carbon dioxide and hydrogen sulphide. It will therefore be disposed of by cold reinjection into two existing deep wells.

Non condensable gases will pass through the process system more or less unchanged in terms of volume and character. They will be released through the cooling towers into the atmosphere.

Finally, a certain amount of sludge which consists mainly of lubricating oils/ used oils will be generated in the condenser and cooling towers. This will be dried and encased in concrete, then buried.

5.5 Construction activities

The physical structures to be constructed comprise a new cooling tower block and an extension to the existing turbine hall. These will be accommodated in areas adjacent to (and to the north of) the existing cooling tower block and the turbine hall, which have been set aside for expansion purposes. During the construction of Olkaria II, the foundations for the future extension of the plant were laid. Hence no substantial earthworks will be required for the new unit.

The switchyard will also have to be extended in order to accommodate and transmit the extra electricity generated by the new unit. The existing switchyard has adequate space and basic infrastructure facilities have already been installed for the purposes of expansion. This area has also been asphalted.

Activities during construction are likely to include:

- Clearing of vegetation for a new steamline from Olkaria I to the new unit;
- Clearing of vegetation to widen the corridor along existing steamline to accommodate another new steamline;
- Piling for steamline supports;

- Clearing and preparation of rehabilitated area for the extension of the cooling tower block;
- Clearing and preparation of rehabilitated area for the extension of the turbine hall;
- Clearing of rehabilitated areas for the Contractors' laydown area;
- Excavation at X2 quarry site for construction materials;
- Establishing construction/Contractors' camps;
- Establishing labour lines for the Contractors' workforce;
- Civil works for the new cooling tower block;
- Installation of necessary electrical equipment for cooling tower block;
- Civil works for extension of the turbine hall;
- Installation of mechanical and electrical equipment for new turbine;
- Installation of mechanical and electrical equipment at the switchyard;
- Rehabilitation of all disturbed areas.

5.6 Contractor and workforce camps

Three types of camps will have to be established: camps for the Contractors, camps for the each of the Contractors' labourers, and laydown areas for each Contractor where their offices are also likely to be located. It is anticipated that four different contractors will be employed to deal with civil works, power station mechanical and electrical plant, switchyards and steamlines respectively. In addition, the Project Manager(s) will require accommodation and offices.

Laydown areas and Contractors compounds will be the same as for Olkaria II. These have recently been rehabilitated and grassed, but will need to be cleared for construction activities for the new unit.

The total workforce is estimated at about 400 people.

5.7 Activities during operation

Activities during operation will be the same as for Olkaria II, namely operation and maintenance of the plant and associated infrastructure as detailed in the Audit Report dated May 2004.

6 STAKEHOLDER CONSULTATION

This section highlights discussions held with KenGen staff and neighbouring Maasai communities on social issues of Olkaria Geothermal Power Project. Information from project files, documents and reports has also been incorporated. Notes on the stakeholders consultation are given in Annex 11.

6.1 Social issues and concerns

6.1.1 The Maasai

Currently, KenGen provides support and assistance to the Maasai communities around Olkaria in several ways:

- 4 water points were provided to the Maasai communities. This was done in collaboration with Oserian Company;
- A bus has been provided by KenGen to take Maasai children to Mvuke Primary School;
- KenGen has been involved in health camps for the Maasai communities by offering transport during inoculations;
- KenGen has helped in fundraising whenever they are called upon;
- Transport is provided by KenGen every Saturday for the Maasai communities to go shopping in Naivasha;
- Whenever there is an emergency among the Maasai communities (eg. a sick person or a woman about to give birth) KenGen offers transport to take them to hospital in Naivasha.

Discussions with the Maasai communities at Kedong Ranch[1] revealed that they clearly have very high expectations from KenGen. The same issues were noted, which were raised in 2001 during the demonstrations, implying that these have yet to be resolved. In order of priority, the Maasai communities expect KenGen to assist them in the following areas:

- More Maasais should be employed at Olkaria by KenGen;
- Bursaries should be provided for children from poor families;
- Wastewater from the geothermal plant is harming the community and their livestock;
- The access road from Olkaria to their manyattas and beyond which has been destroyed by the wastewater should be repaired by KenGen;
- Minutes of the meetings between KenGen and the Maasai committee should also be given to them so that they also have records;
- KenGen should build a clinic for the Maasai.

The largest contingent of current staff at the project was engaged between 1980-1990 and employees were hired depending on their qualifications for skilled jobs. After the 1995 retrenchment, there has been little employment, and it was during this time that KenGen decided to contract out non-core business (such security and cleaning services) to private companies. Thus Olkaria (or KenGen) cannot dictate to a contractor who to employ as each contractor has its own employment policy. Nevertheless, the security company currently engaged through the normal tendering procedure employs 12 Maasai out of 72 staff on site (about 16%). When ad-hoc casual jobs are available, the project management recruits from the local community (which includes the Maasai) and company staff dependants.

Mvuke Primary School was opened in 1983 and although the school was built for KenGen staff, it has been open to the public, and all children are admitted unconditionally. The local

[1] The Maasai communities with whom discussions were held belonged to the Landoine, Siroma and Narasha areas, as well as from the Maasai Cultural Centre at Kedong.

Maasai have been encouraged to take their children to the school. The nursery school is also open to them. School records show that 13 Maasai children have attended Mvuke Primary School since 1989; six sat for their KCPE, four dropped out and three were in Standard 1 in year 2001.

Regarding the issue of wastewater from the Power station eroding the access road, KenGen claimed that it was not the wastewater, which was eroding the road but the loose nature of volcanic soils, exacerbated by the El-Nino rains of 1997/98. KenGen further said that the wastewater (brine and steam condensate) from the plant is not likely to be affecting the health of the Maasai communities as there has been no incident affecting KenGen employees (even those who have been at Olkaria for more than 20 years). No reports of death of livestock, wildlife or children due to the wastewater or steam condensate from the plant have been received by KenGen. Moreover, the environmental staff monitor the disposal of the geothermal waste and brine.

KenGen has provided the Maasai communities with water points for drinking water but the communities complained that it is irregular and occasionally it is shut off to frustrate them. According to KenGen, the water project has been the most beneficial assistance to the Maasai communities. Four (4) supply locations have been sited, providing them with a total of 189,000 litres per day. The communities operate the 4 water points themselves but the problems are due to leaking gate valves resulting in great wastage of water. Occasionally KenGen has had to shut off the supply lines when there is huge wastage until repairs have been carried out.

As for the building of a health centre for the Maasai, KenGen responded that the community should try and initiate the project and KenGen would then provide assistance to them.

The above-mentioned issues related to the Maasai communities is further complicated by the fact that these Maasai have settled on private ranches adjacent to the Olkaria Geothermal Plant and Hells Gate National Park. Olkaria records show a letter written in year 2001 from Ngati Farmers Cooperative Society Limited to KenGen asking them not to assist the Maasai community as the land which the Maasai are occupying is private land, belonging to the Cooperative. The Society may take legal action against KenGen if it continues to provide assistance to the Maasai settled on their land. This then makes it difficult for KenGen to get involved in any community development initiatives, such as building clinics or schools. Thus there is an urgent need to resolve the problem of illegal occupancy of private land bt the Maasai.

6.1.2 Kenya Wildlife Services

Hell's Gate National Park was established in 1984, a few years after Olkaria I was commissioned.

In 1994, KenGen and Kenya Wildlife Service (KWS) signed a Memorandum of Understanding (MoU). The MoU provided the basis for mutual cooperation between the two agencies in conducting their respective operations. It described the environmental impacts and mitigation measures required to be undertaken and identified areas requiring collaboration between KenGen and KWS to ensure that no conflicts arise during operations. The chairmanship for MoU meetings was rotational between KenGen and KWS divisional heads depending on the venue of the meeting. The MoU document is always attached to the tender document issued by KenGen for geothermal projects in order to inform the Contractors of the environmental obligations within the Park.

The relationship between KenGen and KWS has, until recently, been amicable. Last year, KWS withdrew the Memorandum on the basis that it had to be reviewed and revised in the light of Olkaria II, and the incoming independent power producer OrPower. The new Park Warden therefore maintains that there is no MoU at the moment. She also implied that KWS had not been informed that a third new unit was being planned.[2] It appears that dialogue

[2] KenGen, however, insists that the present Park Warden's predecessor was aware of the proposed Unit 3, and that the extension had been anticipated as early as 1999.

between KWS and KenGen has somewhat stalled, the reasons for which are not clear to KenGen personnel.

The Wildlife (Conservation and Management) Act of 1985, supported by the Environmental Management and Coordination Act of 1999, allows the Minister to alter park boundaries and declare any areas protected for the purposes of conservation of plant or animal species. This has implications on the operations of both Olkaria power plants as well as the steamfied. Thus it is of paramount importance that the MoU is revised, agreed and signed by both parties.

6.1.3 Naivasha Municipal Council

During the field visit, discussions were held with the acting Environmental Officer of Naivasha Municipal Council. According to him, the Geothermal Project has offered a lot of employment to people in and around Naivasha, and a number of these employees live in Council houses in Naivasha. If the Project expands substantially, it will present a big challenge for the Council in terms of infrastructure provisions. At present the Council needs more funds to improve infrastructure. Many entities, including KenGen and the flower farms, do not pay cess to the council and the cess payed by the flower farmers is very little so it becomes difficult for the council to offer good services with little income.

6.1.4 Lake Naivasha Tourism Group

Comments from a member of Lake Naivasha Tourism Group indicated that the Group felt that KenGen is “doing a good job”. However, due to the Olkaria Geothermal Power Project, and the flower and horticultural farms around Lake Naivasha, there has been a surge of unplanned developments along the roads circling the Lake. The Government has the responsibility to check these unplanned centres, which are environmentally and socially problematic. Some of these settlements have no water supplies or sewerage facilities. Ways must therefore be sought to coordinate such developments.

A member of the LNTG stated that KenGen is a member of the Lake Naivasha Management Committee which is a legally authorized to manage the Lake Naivasha Basin. However, the Lake Naivasha Management Committee were not fully aware of the proposed expansion of Olkaria II to install a new unit. It was hoped that all the necessary studies and planning would be carried out before the new project commences.

6.1.5 Community policy

KenGen does not have a Community Policy to guide them in dealing with community/social development issues, because up until recently they have not seen the need for one. However, after the demonstrations by the Maasai in 2001, KenGen now feels that it is important to develop a Community Policy which will guide them on how to deal with social issues. KenGen’s 5 year business plan mentions that 0.5 % of their annual income will be assigned to community development initiatives. This is a move in the right direction. A committee has been formed to deal with this issue and they are now looking at how the use of the fund can be implemented. It is hoped that the committee will look at various proposals put to them by the Maasai community, and that through continued consultations with the Maasai community and other stakeholders, KenGen will find ways in which they can support these communities.

6.2 Recommendations

In general, the public does not differentiate between Olkaria I and II. Most of the issues of concern cited above relate to the activities and operations of Olkaria I.

From discussions with the Maasai, it is evident that they expect to be given projects, yet they seem to have no sense of ownership with these projects (for example they expect KenGen to give them water without contributing anything). The Maasai therefore need to acquire a sense

of ownership in any projects where they are given assistance. KenGen should avoid becoming the sole provider of public services, which should be the responsibility of the Government. At the same time, it is crucial that KenGen is clear about the limits of the resources they are investing in community development, as well as the distinction between those investments that are part of compensation or mitigation, and those that are “good neigbour” efforts.

Once the issue of land between the Maasai community and the private farms and ranches has been resolved, KenGen should continue with the dialogue with the Maasai communities. However, KenGen must be specific about what they can and are allowed to deliver to the Maasai communities.

It is also important that KenGen works closely with the District and Council Community Development and/or Social Officers, as they already have long established relationship with them and can facilitate discussions. KenGen should not be seen to be working in isolation and should have support from all the Government departments. In this respect, KenGen should revive dialogue with Kenya Wildlife Service, this being one of the major stakeholders in the Olkaria Geothermal Power Project.

KenGen is a member of a number stakeholder committees and associations, and attends meetings where members inform each other of their activities (the Lake Naivasha Riparian Association being one such organisation). It is important that this consultation continues, so that any fears about the operations of the geothermal plant project can be openly discussed.

High level meetings between KenGen and KWS have been held in the past month on the revision of the MoU, and the way forward for both organisations. Additional meetings are also planned. It is hoped that as a result of these meetings, a mutually agreeable solution will be reached as to the operations of KenGen and the management of Hell’s Gate National Park. In the meantime, at Olkaria itself, the Environmental Section (in the absence of a Community Liaison Officer) must make the effort to mend its relationship with KWS and the Park Warden.

As the expectations of the Maasai are very high, continual consultation and education between the Maasai community and KenGen/Olkaria is essential. Discussions with staff at Olkaria, the Maasai communities and other stakeholders, as well as a review of the records at Olkaria suggest a need for KenGen to employ a Community Liaison Officer at Olkaria. The Officer must be able to listen and negotiate on behalf of the company. He/she should be able to hear and consider all the stakeholders’ concerns and suggestions (including the Maasai).

The Audit Report submitted as part of this assignment has made specific recommendations in order to address these issues.

7 ANTICIPATED ENVIRONMENTAL AND SOCIAL IMPACTS AND THEIR MITIGATION

Although the design of the new unit is still at a very early stage, every attempt has been made to present an accurate assessment of anticipated impacts. Mitigation measures have been proposed in this chapter and, while some measures are specific to the new unit, others have been proposed as "best practice" for operations relating to Olkaria as a whole, or as necessary steps to monitor future impacts due to the existing plants, the proposed new unit and/or other developments and activities being undertaken in the Lake Naivasha basin. The recommendations put forward here must be implemented in conjunction with those proposed in the Audit Report submitted separately as part of this assignment.

7.1 Environmental impacts

7.1.1 Hydrology

With regard to the hydrology of the project area, an important issue is the potential impact of the proposed extension on the water resources of Lake Naivasha basin. Any abstraction that results in substantial lowering of the mean lake level will be a cause of concern. Sinclair Knight et al (1994) viewed the amount of lake water drawn by the geothermal project to be a small proportion of the total amount of water abstracted. The report therefore concluded that the power station on its own is unlikely to affect the lake level significantly. Furthermore, indirect abstraction via a possible hydraulic link between the lake and the wells was unlikely to occur.

The increasing rate of abstraction of water from the lake may eventually affect Lake Naivasha's water levels. Although the natural water level of Lake Naivasha is highly dynamic with variations of up to 9 m in the last century, the mean lake level has been estimated at 1,886.9 masl. This corresponds to a lake surface area of approximately 140 km^2. Naturally any abstraction that results in substantial lowering of the mean lake level will be viewed with caution. Unfortunately, the stakeholders have not yet agreed on the sustainable abstraction rate in Lake Naivasha.

The trend in lake level variations is likely to continue in the foreseeable future. It is important to consider that over the expected 30-year life of the proposed power station, there are likely to be periods when the lake level is very low.

Recommended Mitigation:

- KenGen should not rely on the lake as a source of water for the entire life of the project but should develop contingency plans for alternative water sources in the event the lake drops to very low levels.
- There is an urgent need to strategise water abstraction from Lake Naivasha. This must be done by the Lake Naivasha Management Committee which is legally authorised to manage the environment of the Lake Naivasha basin.

7.1.2 Surface water resources

Lake Naivasha, situated 5.3 km to the north of Olkaria II, is an important water resource within and beyond the project area. The most important issue with regard to water resources of Lake Naivasha is the sustainable rate of water abstraction from the lake. The natural water level of Lake Naivasha is highly dynamic, and thus any abstraction that results in substantial lowering of the mean lake level is viewed with caution.

The abstraction of water for the operations of the power station, the cooling towers, drilling of wells and domestic use by KenGen since 1997 averages 1,316,175 m^3/yr. This is only 2% of the total amount of water (65,180,734 m^3/yr) abstracted from the lake (compared with 3.1% in

1990). Figures from 2002 to 2004 show even lower rates of water abstracted by KenGen annually; equivalent to 1.3% of the total water abstracted from Lake Naivasha.

Currently, consumption at both Olkaria I and II is estimated at about 987,130 m^3/yr. The operation of the Unit 3 at Olkaria II will not require any more water to be abstracted for domestic purposes, and the current capacity on site to handle stormwater, foulwater and firewater is sufficient to service the new unit. The cooling tower for the new unit at Olkaria II will require 1,458.6 m^3 of fresh water for its cooling tower at start up. The water will remain in the system for up to three years. This will not increase the water abstraction level by any significant amount and will definitely not affect the hydrology of the lake itself. Moreover, the overall levels of abstraction are quite low and have not resulted in significant lowering of lake level.

The 1994 EIA report concluded that the quality of water in Lake Naivasha would not be affected by the activities of geothermal development. Although the results from monitoring data for important environmental elements in water at given sample showed lead and mercury levels in the water in Lake Naivasha. The source of these pollutants cannot be identified as Olkaria alone, as the horticultural and floricultural industries, as well as other urban activities, also contribute to pollution.

So far there is no evidence to show that Olkaria II Power Station has had any impact on the water resources or the water quality of Lake Naivasha. Thus, the third unit at Olkaria II is unlikely to impact on the water resources or water quality of Lake Naivasha.

Recommended Mitigation:

- Monitoring of precipitation chemistry as well as of chemical parameters of significance should be done as specified in KenGen's Environmental Operational Manual, so that the changes in lake chemistry and precipitation can be monitored.
- Monitoring of significant elements should also cover Olkaria II.
- A more extensive study needs to be done covering all the flower and horticultural farms, as well other industries in the Lake Naivasha Basin, so that point sources of pollution affecting water quality in Lake Naivasha can be established. This should be the responsibility of the Lake Naivasha Management Committee.

7.1.3 Groundwater resources

Concern has been raised on whether geothermal operations are likely to affect the ground water resources of the project area. It should be noted that the Olkaria geothermal wells are very deep approximately 2km. These boreholes access a very deep geothermal aquifer.

It is believed that the groundwater table is not connected to the geothermal reservoirs. Studies are currently being undertaken at Olkaria to monitor the route of the reinjected fluids, through the use of sodium fluorescence tracers. The tracers have been seen in steam from one other production well, but so far in no boreholes in the surrounding area that are used for domestic, agricultural or industrial purposes.

There is no evidence to show that the drilling of geothermal wells, the installation and operation of Olkaria II so far have had an impact on the groundwater resources of Lake Naivasha.

Recommended mitigation:

- A groundwater monitoring programme should be implemented to assess impacts of reinjected fluids on groundwater, which would indicate whether indeed the geothermal reservoirs are isolated from the groundwater table. Samples from selected boreholes within 20 km radius of reinjection wells should be tested for presence of a tracer, as well as parameters such as pH, TDS and silicates.

7.1.4 Soils

Soils in the project area are extremely friable and susceptible to erosion. Soil erosion would be attributed mainly to earthworks and the clearing of vegetation.

During the construction of Olkaria II, areas set aside for the proposed expansion of the plant were prepared, in terms of levelling and filling. Earthworks will comprise a small amount of excavation of the filled area for the laying of foundations and pilings for the cooling tower and turbine hall extensions, and also for pilings for the steamline supports. The total amount of spoil to be removed is expected to be between 2000 to 3000 m^3.

Clearing of the areas for the proposed expansion of the plant itself will not result in serious erosion as these areas are flat, and the surrounding vegetation is sufficiently established. Widening of the steamline corridor, however, is likely to cause some erosion, as the speed of runoff is one of the main contributing factors to erosion and scouring along the steamline routes.

KWS had identified a spoil dump for excess spoil from the construction of Olkaria II. This site can be reused for dumping excess spoil from construction activities for Unit 3.

Monitoring of soil samples at specified locations in and beyond Olkaria show high levels of lead and zinc at most sample locations. While levels for these elements at the wells, Olkaria I and the old X2 campsite may be attributed to geothermal activities, other agricultural and industrial activities in the Lake Basin may also influence zinc concentrations in the soils at the other sample locations. As yet no data is available to show that Olkaria II has contributed to pollution of the soil. As the activities associated with the installation of a third unit at Olkaria do not involve drilling of wells, and all brine discharges and condensate will be reinjected, the proposed extension is not likely to contribute to contamination of the soil.

Recommended Mitigation:

- Earthworks should be controlled during the construction phase, so that land that is not required for the works is left undisturbed.
- Similarly, vegetation should not be unnecessarily disturbed, particularly during installation of the steamlines.
- Excavation activities, organisation and dumping of spoil should be properly managed.
- The X2 Quarry which has recently been rehabilitated, must be landscaped and revegetated after use in order to prevent erosion.
- Tender documents should stipulate that, wherever possible, earthworks should be carried out during the dry season to prevent soil from being washed away by the rain.
- Erosion along the steamline routes can be controlled by introducing check dams, scour checks, catchwater drains and/or berms. Check dams and scour checks need to be installed at specified intervals, depending on the gradient of the slope. All these structures must be well designed, properly constructed and regularly maintained so that runoff does not create gullies.
- Re-vegetation of disturbed areas should be undertaken as soon construction is complete.
- In order to ensure that environmental protection is taken into account during construction, these issues must be specified in the tender documents.

7.1.5 Air quality

At the proposed plant site, dust will result mainly from excavation, and the cement silos. Dust emissions can also be expected at the X2 Quarry site, emanating from excavation activities.

Some emissions may be expected from construction plant and equipment. The main pollutants are sulphur oxides, nitrogen oxides, suspended particulate matter and lead, all of which can have an impact on public health, as well as soils and vegetation. However, the numbers of plant and equipment operating on site will be small, the project area is generally open, and

pollutants will be dispersed by wind. Thus the impact of these emissions is considered to be minor.

During plant operation, dust will not be an issue. However, the process does emit non condensable gases, primarily hydrogen sulphide (H_2S), carbon dioxide (CO_2), sulphur oxides (SO_x), methane (CH_4) and radon. It is estimated that the total volume of non-condensable gases released at the cooling towers will be 50% more than the combined total currently emitted by Units 1 and 2 at Olkaria II.

The findings of the 1994 EIA study, and the subsequent H_2S dispersion study (conducted by Holmes Air Sciences on behalf of Mitsubishi Heavy Industries Ltd in February 2000) forecast that there would be no health risks due to H_2S in the ambient air from Olkaria II, as the plant has superior dispersion (ie the gases are released via the cooling tower). It is likely that the same conclusion in terms of air emissions will be reached with the commissioning of Unit 3.

Data indicates that on the whole H_2S concentrations around the plant at Olkaria II are lower than at Olkaria I. A review of data gathered between April 1997 and June 2004 shows that H_2S levels in areas outside the immediate power plant boundaries (that is at Lakeview and Lakeside Housing Estates and the KWS Gate) were not detectable (see Annex 4). This implies that the cumulative impact of H_2S emissions since the commissioning of Olkaria II on areas outside immediate plant vicinities is negligible.

Currently at Olkaria I and II, only H_2S emissions are being monitored. Thus the impacts of other condensable gases emitted by the process cannot be predicted at this stage.

Recommended Mitigation:

- Proper maintenance of construction plant and equipment (including trucks) in accordance with manufacturer's specifications will reduce emissions of noxious fumes (carbon dioxide, carbon monoxide, nitrogen oxides, sulphur oxides). In addition, drivers of construction vehicles should be instructed not to leave them idling, in order to reduce the emission of exhaust fumes.
- During construction and operation, the speed of construction and other vehicles on site and along the access roads should be limited to reduce dust levels.
- These measures can be achieved by creating awareness among equipment/machinery operators and drivers of construction vehicles.
- Hydrogen sulphide monitoring should continue as stipulated in the Environmental Operational Manual, to include Unit 3. Data should be collected at comparable places within the two sites.
- The cumulative impacts of H_2S emissions should be continuously assessed.
- Non condensable gas emissions (specifically carbon dioxide, methane and radon) should be measured, and then continuously monitored.

7.1.6 Noise and vibration

Construction works are always associated with noise, but this will be temporary. Noise and vibration will result from activities such as earthworks and from construction equipment and vehicles. Noise levels at the proposed plant site due to drilling, mixing of concrete and other construction activities will exceed the ILO threshold limit value (TLV) of 85.0 dB. Actual measurements were not taken during the construction of Olkaria II, so data is not available for comparison.

Noise levels will also exceed the ILO TLV when installing steam pipes, particularly when the piles are being laid. At the X2 Quarry, noise levels will be higher than recommended values during excavation.

During operation, noise levels will probably be within the same range as presently experienced at Olkaria II. However, while noise levels will be acceptable in the office block, switchyard and power plant peripheral areas, noise measurements could exceed the ILO TLV at the utility section (lower deck) of the turbine hall, the upper deck of the turbine hall and the seal pit.

Recommended Mitigation:

- Proper maintenance of construction plant and equipment in accordance with the manufacturers' specifications (including trucks) will reduce noise levels.
- Noise abatement can also be achieved through sensitizing construction workers and drivers, by using signboards and conducting awareness campaigns.
- Movement of heavy vehicles after dark should be prohibited.
- The impacts of noise pollution can be mitigated in the immediate vicinity of the affected area if mufflers and other noise abating equipment is installed, through the provision and enforcing use of personal protective equipment (PPE), and through considerate behaviour.
- Monitoring of noise levels should continue at both Olkaria I and II. In addition, measurements should be taken during and after the construction of Unit 3.
- During operation, all personnel working in the utility section and upper deck of the turbine hall, and the seal pit should wear recommended PPE.

7.1.7 Wastewater

Waste products from the generating process will include brine and steam condensate from the drain pots along the steamlines, and condensate from the cooling towers. Constituents of the brine include fluorides and arsenic of concentrations of 164 mg/l and 0.14 mg/l, respectively (cf. WHO permissible limits of 1.7mg/l and 0.05 mg/l for fluoride and arsenic, respectively). Due to the potential toxicity of the brine, brine from the separators is disposed of by hot reinjection into four deep wells. However, there is no provision for safe disposal of brine and steam condensate released from the drain pots along the steamlines.

The condensate will be highly acidic due to the presence of carbon dioxide and hydrogen sulphide. As with Olkaria II, it will be dosed with soda ash to neutralise it, and then re-injected into deep wells. This method of disposal of brine and condensate eliminates flow of surface waters and the subsequent development of the deep gullies. It also ensures that humans, wild animals and birds are not exposed to the process wastewater.

The 1994 EIA study (Sinclair, Knight et al) concluded that the Lake Naivasha quality would not be affected by the activities of geothermal development. The level of re-injection of brine will be to a reservoir far below lake level and there is little possibility of surface or ground water pollution. So far there is no evidence to show that the installation of Olkaria I and II have had any impact on the water quality of Lake Naivasha. It is therefore unlikely that that the installation of Olkaria II Unit 3 will have any impact on the water quality of the above lake.

The disposal of brine from Olkaria I poses a threat to both wildlife and humans, soil and water resources, in and beyond the boundaries of the Olkaria plant and Hell's Gate National Park. While this is an issue related to operations at Olkaria I, the resultant social implications affect both Olkaria I and II, as well as the proposed new unit, because the public in general does not distinguish between the two plants (see Chapter 6). Immediate action is therefore necessary to ensure that this issue is managed as soon as possible.

Recommended Mitigation:

- Means to contain brine and steam condensate discharges from the steamlines should be developed so that they are not released directly to the ground and on to vegetation.
- All brine discharges must be reinjected.
- Plans are underway at Olkaria I to redirect brine from the separators to a conditioning pond, from where the brine will be reinjected to a deep well. Some physical works have begun on this project, and completion of this sub project should be given priority.

7.1.8 Oil pollution

During construction, sources of oil pollution are likely to be construction plant and equipment (including vehicles), fuel and lubrication oils (either during transportation, delivery or from storage tanks). This could lead also to contamination of the soil and water bodies. Oil wastes

may be a problem where construction vehicles stop and oil is drained (or leaks) from the vehicles onto the ground.

It is not anticipated that an asphalt plant will be required at the X2 Quarry site, hence impacts due to oil products and oil waste at the quarry site are expected to be minimal.

Lubrication and transformer oils will be used during plant operation, as is the current practice with Olkaria II. Oils are currently stored in outdoor yards, while some may soon be kept in indoor storerooms.

Recommended Mitigation:

- Maintenance of construction plant and equipment outside the park, and proper procedures for decanting, storing and handling oil products will minimise the risks of spills.
- Drip trays should be used when draining oil from plant and equipment, and waste oil stored in containers until they can be safely disposed of.
- Oil pollution can be minimised by installing oil interceptors in all the stormwater drains around the new site. Drainage channels constructed for the purposes of construction should be directed into these stormwater drains.
- All the oil and lubricant holding tanks should be contained within bunded areas lined with an epoxy resin coating.
- The areas in the outdoor yards designated for the storage of oils should be covered. In addition, the oils should be kept on sump pallets.
- The floors of any proposed indoor oil/grease stores should be lined with epoxy, the doors isolated (by having a raised verge around the door), and any drains should flow to an interceptor.
- A response plan must be drawn up to address oil spills.

7.1.9 Process chemicals

The process chemicals that are required for the new unit are the same as those used presently for Olkaria II, namely, water treatment chemicals (biocides, soda ash, chlorine, alum), oils and lubricants, and detergents. The chemicals required for Unit 3 operations will be stored in the same stores, and handled and disposed in the same way as for the existing plant.

KenGen has an emergency response plan, but a spill response plan still needs to be prepared.

Recommended Mitigation:

- All chemicals must be stored and handled properly. All personnel handling chemicals should be instructed in their safe use. Procedures and material safety data sheets (MSDS) describing storage and handling of all process chemicals as well as substances hazardous to health should be strictly followed.
- A response plan must be drawn up to address chemical spills.

7.1.10 Construction materials

The recently rehabilitated X2 Quarry will have to be reopened in order to obtain hardstone for building purposes. This quarry has been used by KenGen for many years and has been left open in the past in order to excavate materials for the maintenance of access roads and other purposes. Reopening the quarry site to further excavate it will have some environmental and social impacts, but these would be considered to have low significance provided that proper mitigation measures are incorporated.

There are numerous 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). The Contractors 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.

Recommended Mitigation:

- Excavation must be properly planned, organised and executed.
- All access routes to the X2 Quarry should be planned ahead of construction and described in the tender documents. This will stop several routes being created to the site which would have severe implications on environmental degradation around the excavated area.
- Excavation should be carried out such that drainage is controlled, and water is not allowed to accumulate. Any water that does collect has to be drained and disposed of sensibly, so as not to cause erosion.
- The area to be excavated should be cordoned/fenced off, to keep wildlife and park tourists out.
- Dumping of oil, garbage and spoil in the quarry area must be prohibited.
- Dust levels at the quarry site can be minimised by regularly sprinkling the site with water.
- The site must be landscaped, then reinstated or backfilled with overburden/topsoil.
- The tender documents should specify required standards certification for all materials and appliances.
- Materials not to be used for construction of the new unit 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 paint or any other materials containing lead which may be inhaled, ingested or absorbed;
  - Vermiculite unless it is established as being fibre-free;
  - Any products containing cadmium that are regarded as being injurious substances (refer to the UK Environmental Protection - Controls on Injurious Substances (No.2) Regulations 1993);
  - 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.
- The sources of all construction materials should be certified by the Contractor; for example, hardstone for building should be obtained from bonafide commercial quarries.

7.1.11 Solid waste

Construction waste will be generated while the works are ongoing. This will consist of building materials, concrete, paper and plastic (for example from packaging materials and lagging), timber, scrap metal, etc. Apart from visual impacts, debris can affect water quality.

During construction the Contractors will construct various facilities, which have to be removed and dismantled on completion of the works.

Sludge from the condenser and cooling tower at Olkaria II, including the new unit, will be dried, encased in concrete and buried since it contains toxic non-biodegradable substances. At present it is envisioned that silicate deposits in the steamlines will be buried at the Olkaria dumpsite. This may contaminate the soils and water resources in the park.

Recommended Mitigation:

- Diligence on the part of the Contractors during construction activities will minimise the amount of debris, and also will ensure that debris is disposed of in a sensible manner, at a specified and approved dump.
- The tender documents should specify the proper disposal of waste during construction.
- The tender documents should also ensure that the Contractors leaves the site in a clean and sightly condition on completion of works. The Contractors should be required to restore and landscape all areas to the satisfaction of the Project Manager.
- All solid waste generated during construction and operation should be carefully monitored, collected, stored, and taken out of the park for disposal.
- Waste generated during the operation of the plant must be segregated at source, inventorised and appropriate methods of disposal determined.
- Silicates must be tested for their chemical characteristics and toxicity, after which the most acceptable means of disposal can be determined. It may in the long run be best to encase the silicates in concrete and bury them, as is proposed for the disposal of sludge from the cooling towers and condensers at Olkaria II.

7.1.12 Flora

The flora of the project area comprises seven major vegetation groups including bush land, bushed grassland, shrubbed grassland, grassland, rock outcrops and barren land.

The power generation unit, the cooling towers for the third unit and the switchyard extension will all be constructed in already cleared areas set aside for this development. These areas (apart from the switchyard which is asphalted) have recently been rehabilitated with grasses (*Cynodon dactylon* and *Setaria sphacelata*) and two tree species of *Cordia* and *Acacia*. Development of this area will disturb the plant community, although the area involved is small and has been previously disturbed.

There will also be some disturbance to vegetation in the process of laying down the new steamlines. The steamline from Olkaria I to Olkaria II will also disturb flora along a length of about 1 km. However, it is unlikely that any sensitive floral species will be affected.

The other new steamlines will follow the present corridors thus minimising the impacts on the plant community of the project area. A more subtle impact may occur due to the introduction of exotic species in the cleared areas. Care needs to be taken to ensure that these works do not cause such impacts and that indigenous species are encouraged to re-establish as rapidly as possible.

Indirectly, vegetation could be affected by the action of hot or cold geothermal brine and/or steam condensate either as flowing on the surface or as airborne droplets. Although originally it was felt that vegetation could be affected via the action of gaseous emissions, there is no evidence to support this notion.

One source of concern during construction is the demand for fuelwood by the workforce which may result in the felling of trees. This however can be controlled and mitigated.

It is therefore unlikely that the development of the third unit will have any major negative impacts on the flora of the project area which cannot be mitigated.

Based on lessons learned from the operations of Olkaria I, it would be very interesting to present changes in vegetation patterns since the commissioning of the power plant. However, no vegetation monitoring has been, or is being, carried out. During the field visit, there were no obvious differences in the natural plant species composition of the project area observed. However, some exotic trees including *Eucalyptus saligna* and *Grevillea robusta* have established in the National Park.

On a positive note, discussions with the Olkaria Project environmentalists point to a trend depicting an increase in plant cover since the commissioning of the Olkaria I Geothermal Power Station. They attributed this to an increase in rainfall in the recent past and the reduction of fires, following the sensitisation of the Maasai to stop the practice at least near the National Park. They also attributed the trend partly to the rehabilitation of the project area by planting of trees and grasses and conservation activities leading to the curbing of soil erosion.

Recommended Mitigation:

- Clearing of vegetation and trees should be strictly controlled; it should be limited to what is absolutely necessary and should not be done indiscriminately. Diligence on the part of the Contractor and proper supervision of the workforce is important in this respect.
- All disturbed areas should be re-vegetated with locally occurring grasses, shrubs and trees. Apart from improving aesthetics, this will curb soil erosion in the affected areas.
- Cleared areas should be quickly rehabilitated with appropriate indigenous flora to prevent the growth of opportunistic species.
- All brine and condensate discharges should be deep reinjected in order to avoid potential toxic effects on flora.
- The workforce should be provided with alternatives to fuelwood and charcoal for cooking (eg kerosene cookers), so that the pressure on fuelwood and charcoal will be reduced.
- In order to evaluate the impacts and trends on vegetation within the Olkaria field and Hell's Gate National Park, a detailed study on the vegetation of the Park and its environs will have to be undertaken. This would necessitate sampling in transects, aerial photography or satellite imaging and mapping. Such a study would require specialist input. While KenGen cannot be expected to fund such a study on its own, it could provide support towards it, either through part provision of financial or manpower resources, and through influencing other stakeholders (such as the Kenya Wildlife Service, Lake Naivasha Management Committee, Lake Naivasha Riparian Association, the Lake Naivasha Growers Group) to do the same.

7.1.13 Fauna

The immediate project area lies entirely within Hell's Gate National Park. The Park and its immediate surroundings support about twenty three species of mammals. However, the general impression is that of low numbers of animals and low biodiversity as compared to other national parks. There is free movement between the Park and the adjacent land, although the part of the Park where Olkaria I and II are situated has lower numbers than the rest of the Park.

The environmental assessment study carried out in the project area by Sinclair Knight et al (1994) predicted the loss of habitats, potential toxic effect of brine and death of animals due to road accidents as the major negative impacts of the geothermal development with regard to animal conservation. During the 1994 EIA study conducted for Olkaria II, the fauna survey carried out established baseline data for wildlife in the Hell's Gate National Park and surrounding areas, including animal numbers and density, their migration routes and the avian species of the area. Thereafter, Nakuru Wildlife Forum and Nakuru Wildlife Conservancy carried out subsequent animal counts in Hell's Gate National Park and the surrounding areas. The animal counts showed a declining trend of the wildlife population in Park since 1992, particularly in populations of kongoni, Thompson's gazelle, Grant's gazelle, eland and buffalo (see Section 3.2.9).

This observation raises questions as to whether and how the animal populations have been affected by the location and operations of the power stations, the other development activities (such as flower and horticultural farming, cattle and game ranching, hotels and lodges) and the new urban settlements within the project area, the environs of Hell's Gate and Longonot National Parks, and the area encompassing Lake Navaisha.

The presence and operations of the Olkaria I and II continue to have limited impacts on the animal population in the park. The brine ponds in Olkaria I and II and brine drainage channels in Olkaria I are accessible to animals as sources of water and minerals, thus exposing wildlife to toxic conditions. Indeed warthogs were found grazing in the vicinity of Olkaria II during the field trip and several of the animals were at one time reported to be trapped in some of the brine ponds. In 2000 one of the recently introduced Lammergeyer vultures was found dead in the silencer of the well OW-22; while it can be argued that the silencers were in place long before the birds were introduced to the park, this incident does present a case in point where the geothermal infrastructure can pose a negative impact on wildlife[3].

The development of the third unit at Olkaria II will cause minor disturbances to animals due to increased human activity during its construction and operation phases. Loss of habitat will be minimal because the site earmarked for the expansion is small, and lies within the present operational Olkaria II compound. The area set aside for the extension and subsequent installation of turbines is bare ground with no vegetation nor presence of animals. The area earmarked for the extension of the cooling towers has also suffered disturbance although subsequent rehabilitation including planting of trees and grass has been carried out. Since the area does not contain any wildlife populations (except a few members of insect community), development of this site will not cause any significant impacts on the faunal community.

Recommended Mitigation:

- Fences should be constructed around the brine ponds in order to prevent wildlife drinking geothermal brine.
- All brine discharges and condensate should be disposed of by deep reinjection.
- Drains and steamlines should be located so that they do not form barriers for small animals.
- Movements in the Park of construction traffic, as well as traffic generated by KenGen activities, should be controlled. Speed limits should be enforced and speed bumps introduced to reduce animal deaths from excessive vehicle speeds.
- Cleared areas should be rehabilitated with indigenous vegetation as soon as possible to restore habitats for affected fauna.
- Construction activities should be kept to a minimum to avoid loss of habitat.
- In order to establish the true impact of the geothermal plant and other developments on wildlife populations in Hell's Gate National Park and the surrounding areas, a detailed study will have to be undertaken. As with the vegetation study recommended above, KenGen should solicit support from various stakeholders to fund the study collectively.

7.1.14 Wetlands

The wetlands found in the vicinity of the power stations are associated with the brine ponds that receive drainage from Olkaria I. Brine generated from the Olkaria II is presently disposed through deep well re-injection. The brine that will be generated from the proposed Olkaria II Unit 3 will also be disposed through deep well re-injection as done for the Olkaria II. Thus there will be no interaction between the brine originating in Olkaria II Unit 3 and the wetlands associated with the brine pond Typha dominated wetland near Olkaria I or the papyrus dominated fresh water wetlands around Lake Naivasha.

[3] Several meetings were held between KenGen and Mr Simon Thomsett who was in charge of the project to introduce the Lammergeyers into Hell's Gate National Park. As a result, modifications have been installed in well pad infrastructure in an attempt to prevent such incidents occuring in the future.

7.2 Social impacts

7.2.1 Immigration and settlement

Naivasha town lies 22km to the northeast of the project site and there are fast growing centres around the lake periphery and located relatively close to Olkaria, such as Kasarani (on Moi North Road near Loldia Farm), DCK (near Sulmac and Hell's' Gate National Park Gate), and Karagita (on the Moi South Road). These centres are essentially unplanned and lack basic services such as water supplies, sewerage and solid waste disposal facilities. In addition, they are associated with a number of social problems.

The Naivasha Municipality and the upcoming centres will provide accommodation, goods and other services for the labour force engaged by the project contractors associated with the construction of the new unit at Olkaria II. Due to the earning and spending power of the labour force, there will be temporary input of money earned into the business sector of the surrounding urban centres, which is regarded as a positive impact. However, immigrant labourers are often associated with the propagation of sexually transmitted diseases (including HIV/AIDS), insecurity and violence.

The above urban centres also provide goods and services for all categories of KenGen workers. During operation, however, the new unit may only necessitate employment of one or two operators and/or plant workers, so the impact on the Municipality and urban centres will be negligible.

Recommended Mitigation:

- While KenGen is not directly responsible for the growth of unplanned urban settlement, it should try to influence the Lake Naivasha Management Committee, as well as the Naivasha Municipal Council, to address this issue.

7.2.2 Land use

The project area and its environs support a multiple land use system including ranching, flower farming, tourism, wildlife conservation, human settlement and informal and formal sector activities. In the project area, the land use system was affected substantially by geothermal development (initially Olkaria I, and subsequently Olkaria II), inducing a change from wildlife dispersal area to industrial (power generation) use. The third unit at Olkaria II will not cause further changes to land use in the project area.

There may be indirect and long-term effects on flower farming and tourism, but these require further investigation, and would not be ascribed to Unit 3 alone. The impacts of the project on wildlife, flower farming and tourism have been discussed in Sections 7.1.12 (Flora), 7.1.13 (Fauna), 7.2.4 (Agricultural activities) and 7.2.5 (Tourism).

7.2.3 Employment opportunities

The project is expected to employ in the region of 400 people during construction and 1-2 operators.

There is much anticipation among the local communities that as much as possible local labour be employed on the project, especially to carry out manual tasks that do not require skills. Unskilled positions would include casual labourers, watchmen, etc.

The skilled workforce will most likely be non-locals from other parts of the country, operating the heavy equipment. However, it may be possible to source masons and truck drivers from the local population. The professional and administrative staff will be mainly non-local people.

Most of the skilled labourers will have to be brought in from outside the project area, and this may cause some resentment among the local people.

This temporary employment will lead to increased incomes for those employed. Indirectly, this may enable parents/guardians to pay for scholastic materials and tuition for their children or dependants, thereby positively affecting school attendance at primary and secondary levels in the project area and its environs. However, because employment opportunities will be temporary, it is unlikely that the impacts of increased income will be noticeable or even have permanent benefits. Other common concerns related to increased incomes and temporary employment opportunities are an increase in the level of alcoholism, domestic violence and indiscriminate sexual behaviour.

Recommended Mitigation:

- The Contractor must take care to ensure that the maximum possible number of employees hired are sourced from the settlements within the project area and its immediate area of influence.
- Women must also be given opportunities to participate on the project, and a specific quota (eg. 5-10%) should be reserved for women.

7.2.4 Agricultural activities

The project site is located 1.2 km from the closest flower farm, Oserian. Following concerns expressed about the effects of cooling tower plumes from Olkaria I on flowers grown in the vicinity for commercial purposes, a flower trial study was carried out to this effect with the participation of Oserian Estate and KPC (precursor to KenGen) scientists during the 1994 EIA study. The results of this study revealed that geothermal emissions did not affect the growth of flowers.

Since the conclusion of the flower trials, the flower growers have changed their attitude on the development of the geothermal energy. Indeed, Oserian is now in possession of a well that they currently use for carbon dioxide (CO_2) enrichment in their greenhouses. In addition they reportedly have plans in place to use the well for the generation of 2MW of electricity for their own use.

Although the long term effects of H_2S on the growth of flowers have not been investigated, based on the lessons learnt from the flower trials, it is likely that the proposed third unit at Olkaria II will not have any negative impact on the flower growing and horticultural industries adjacent to the project area.

Recommended Mitigation:

- It is recommended that further research be carried out in order to determine long-term impacts of geothermal emissions and flowers, horticultural produce and the natural flora of the project area.

7.2.5 Tourism

Hell's Gate National Park, within which the Olkaria Geothemal Power Project is located, is a tourist attraction, noted particularly for its scenic beauty and avifauna. The Olkaria geothermal development is a unique feature in the whole of the African Continent and the presence of the Power Station serves as a tourist attraction to the local people and other interested parties (such as schools). However, there is a need to package this product in order to enhance its appeal to the visitors.

Recommended Mitigation:

- KenGen in collaboration with KWS should prepare a high quality explanatory brochure that can be handed to tourists visiting the park. The brochure should stipulate basic park rules and safety precautions that should be adopted by tourist for protection from

harmful or unpleasant experiences associated with the fauna and geothermal activities.

- In addition, the brochure should contain the locations of major attractions in the park and the facilities available to tourists wishing to find out more about the power station.
- KenGen should develop a simple “tourist trail” that could be followed by visitors interested in the geothermal aspect of the Hell’s Gate National Park. The tourist trail could include guided tours of the power stations, the well pads, and other areas of interest.

7.2.6 Trade and commerce

During construction, the workforce will stimulate local businesses at the urban centres along South and North Lake Roads. This will be a positive, but temporary impact.

7.2.7 Archaeological, cultural or historical sites

No sites of archaeological, cultural or historical importance will be affected by the construction of the new unit at Olkaria II.

7.2.8 Disturbance to the public

All construction activities will cause disturbance to the public, whether to KenGen employees, KWS personnel, or persons residing or working along the South Lake Road.

Recommended Mitigation:

- In order to lessen the antagonism that these disturbances may create, it is recommended that the community leaders are notified in advance of possible activities that may cause disturbance. In addition, construction should follow a schedule, and the Contractor must adhere to that schedule, so that the general public can know when to expect such disturbances.
- Warning/informative signs should be erected at the KWS Gate, and at the junction of the Naivasha-Mai Mahiu Road, and at the turn off to Olkaria Geothermal Power Station from along South Lake Road, indicating that 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 further minimise disturbance to settlements and homes in the locality of the work site, construction activities should not be carried out at night.

7.2.9 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 public at large this would be minor. 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.

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 AIDS.

Sanitation and hygiene in the Contractor's/workmen’s camp and on site 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. Public health issues related to the workmen's/Contractor's camp have been dealt with in Section 7.2.11.

The current capacity on site to handle stormwater, foulwater and firewater is sufficient to service the new unit.

One of the major concerns among the Maasai community was induced abortions and skin ailments due to brine discharges into natural water courses which flow beyond Hell's Gate National Park, and are used by the Maasai for watering livestock, washing and other domestic purposes.

Recommended Mitigation:

Mitigation measures for water pollution, air and dust emissions, and noise are described in Sections 7.1.2, 7.1.5 and 7.1.6, respectively, while prevention of contamination by oil is discussed in Section 7.1.8.

Other mitigation measures are:

- STD awareness campaigns should be conducted, and condoms distributed, in the workmen's camp as well as in the urban centres along the North and South Lake Roads.
- To minimise impacts on wildlife, and people residing in the flower farms and estates in the vicinity of the site, no construction activities should be carried out at night.
- During both construction and operation, arrangements should be made for the proper disposal of solid waste and facilities for sanitation should be provided.
- The workforce must be provided with ample potable water at all times.
- During operation, provision should be made for the proper disposal of solid waste.
- The Maasai communities should be sensitised to stop using specified streams that contain brine, until the improvements to reinject all brine discharges have been implemented.
- The incidence of skin ailments and abortions reported by the Maasai inhabiting areas through which brine contaminated water courses flow should be monitored to establish whether this is indeed the cause of their ailments.

7.2.10 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 respective Contractors' supervisors and foremen. As long as proper procedures are followed and personal protective equipment (PPE) is provided and their use enforced, risks of accidents and incidents can be substantially reduced.

During operation, health and safety aspects are expected to be satisfactorily addressed as KenGen has a safety policy, safety is the focus of its Training School, and overall its safety record is good. PPE is provided and used by staff at both Olkaria I and II. Hydrogen sulphide and noise levels are continuously monitored.

Recommended Mitigation:

- All workmen should be provided with suitable protective gear (such as nose masks, ear muffs, helmets, overalls, industrial boots, etc), particularly during quarrying, blasting, drilling, and handling chemicals. This must be stipulated in the tender documents for activities during construction.
- The Conditions of Construction in the tender documents should stipulate health, safety and welfare regulations and work procedures.
- There must be a fully equipped medical centre on site, during and after construction.
- The Project Manager must appoint a Health, Safety and Environment Officer with has first aid training and knowledge of safety regulations, who should always be on site.
- The Contractors are required to must comply with the Codes of Practice provided by KenGen, the Factories Act, the Workmen's Compensation Act, as well as other relevant Ordinances, Regulations and Union Agreements.
- All visitors should be provided with hard hats.
- By law, the Contractor, and KenGen must have workmen's compensation cover.

- Operational procedures for all activities make mention of use of safety equipment. These must be reviewed so that the necessary PPE is made mandatory for high risk activities.
- KenGen should revise the existing "*Employee Guide to Accident Prevention*" to reflect its current operations and safety procedures.

7.2.11 Construction camps

Several types of environmental and social impacts can result due the presence of the workforce. These revolve around the availability of housing and living conditions, sanitation and wastewater, solid waste disposal, competition with local populations for water and fuelwood, the spread of sexually transmitted diseases and HIV/AIDS, among others.

At this point it is not certain whether a labour camp will be constructed or whether the workforce will have to seek private accommodation in the urban centres along the South Lake and North Lake Roads or in Naivasha. To minimise the impact of the workmen's camp, the preferred solution would be for the latter. However, this may not suit the Contractor in terms of logistics.

Contractors often drill boreholes for their camp supplies. From available information, groundwater potential in the project area is good. Should the Contractor decide to sink a borehole, he is required to conduct an EIA (in accordance with EMCA 1999 and the Water Act of 2002), and ensure that the right procedures for obtaining abstraction permits is followed.

It is likely that the Contractors will erect pit latrines on the site for their workforce. Communal bathrooms/lavatories leading to soakaway pits are another option, but would be slightly more expensive.

Recommended Mitigation:

- Care should be taken not to stress the supply of potable water, at the expense of the local population. In this connection, the Contractor must consult with the Municipal Council to identify acceptable potable water sources so that there is no conflict with the local people.
- The workforce should be discouraged from buying charcoal. Use of gas or kerosene should be made mandatory in the camp. A central canteen at the workmen's camp should be set up to serve the entire workforce within the camp. This would be more economical in terms of use of fuel as well as other resources. In addition, a central canteen would contribute towards the general health in the camp as kitchen wastes can be disposed of in an organised manner, while hygiene can be monitored.
- The Contractors should be not be allowed to set up separate eating shacks on site for their staff and workers, as this proved to be environmentally undesirable during the construction phase of Olkaria II, when several issues regarding the disposal of wastewater and solid waste, as well as the availability of water, arose.
- On site, an arrangement should be made to use the existing canteen to provide the workforce with meals as required. Ideally, food should be cooked off site (outside the park) and brought in only to be served.
- Solid wastes should be disposed of in a sensible manner. All waste, both during and after construction, should be taken out of the National Park. Waste should be segregated into metals, paper, plastics and organic waste, so that it can be sold, reused, buried or burned as appropriate. Wastes that do not fall into these categories should be taken to an approved council dump.
- Pit latrines for the workforce on site must be carefully located and designed depending on the height of the water table in the area of the proposed camp. Ideally, the drop should be between 2.5-3.5 metres (8-12 feet), but where the water table is high, a composting style double shallow pit design is more suitable. The location of pit latrines in the camp should preferably be downhill of potable water sources, or 30 m from any surface water body, and protected from runoff.

- The workmen's camp should not be located at an isolated point where it would attract periphery businesses, and provide a nucleus for the growth of an unplanned settlement.
- STD awareness campaigns should be conducted, and condoms distributed, in the workmen's camp.

7.2.12 General 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.

During operation, ruptures and leaks may occur at any time due to malfunctioning valves, corrosion of the pipes or tank surfaces, earth movements, etc. While procedures for fire precautions and emergencies do exist, these were drawn up as Kenya Power and Lighting Company procedures.

Recommended Mitigation:

- The tender documents should ensure that the Contractors take precautions against fire.
- Fire and emergency response plans must be drawn up as applicable to KenGen's current operations at Olkaria. The emergency response plans must give details of containment and clean up methods.
- Regular inspection and maintenance of the entire plant is essential.
- In the event of a leak or spill, clean up should be carried out immediately, the affected areas restored/rehabilitated, and clean up materials disposed of in a specified manner.

7.2.13 Visual intrusion

The main visual impacts would have occurred during earthworks for the foundation of the new unit. The earthworks for the foundation of the new unit were done during the construction of the existing plant.

Visual impacts will result due to the reopening of the X2 Quarry. However, these will be confined to the X2 Quarry, and will not be visible from the parts of the park that are frequented by tourists.

During operation, there would be little impact. Emissions will be visible from the additional cooling towers. Rather than eight plumes, twelve will be seen, but these will be colourless or white if the scrubbers are functioning properly.

Visually, therefore, the new unit will have minimal impact.

Recommended Mitigation:

The rehabilitation of the X2 Quarry has been discussed in Section 7.1.10 above. Other mitigation measures are as follows:

- Once earthworks have been done, restoration of the worked area which is not to be built on should be carried out immediately, by backfilling, landscaping and planting of grass or shrubs.
- Mitigation can be achieved through clearing construction debris, keeping dust levels down and rehabilitating/ landscaping the X2 Quarry site.
- Planting of endemic species at the X2 Quarry site would also serve to mitigate visual impacts. KenGen has a tree nursery has already planted some 4000 saplings on site from which plants can be sourced.
- In addition, the site should be landscaped by planting endemic tree, shrub and grass species around power units and administrative buildings, and along the boundary fence.

7.3 Summary of environmental and social impacts

The impacts due to or affecting certain components during construction and operation are presented below in tabular form for ease of reference in Table 7-1. Impacts can be positive or negative, direct or indirect. The magnitude of each impact is described in terms of being significant, minor or negligible, temporary or permanent, long-term or short-term, specific (localised) or widespread, reversible or irreversible.

These qualities are indicated in the assessment table as follows:

Key	Type of Impact	Key	Type of Impact
++	major positive impact	**+**	minor positive impact
--	major negative impact	**-**	minor negative impact
0	negligible/zero impact	NC	no change
sp	specific/localised	w	widespread
r	reversible	ir	irreversible
S	short term	L	long term
t	temporary	p	permanent
c	continuous	?	uncertain
Y	mitigation of negative impacts/ enhancement of positive ones IS possible	N	mitigation of negative impacts/ enhancement of positive ones is NOT possible

Table 7-1 Summary of Environmental and Social Impacts

Impacts on or due to	Construction		Operation		Remarks
	Type of impact	Mitigation	Type of impact	Mitigation	
Hydrology.	NC		NC		The original hydrological regime would have already been altered when the existing plant was first constructed. No substantial earthworks are expected to be undertaken, which could hinder the natural drainage. All access roads have been constructed and provision for stormwater drainage has been made at the existing site.
Soil.	-- L sp	Y	-	Y	Erosion may occur along steamlines, particularly at steep sections. Erosion may continue to occur after construction. Incorporating appropriate soil conservation measures during construction would mitigate impacts during operation.
			-- L ir	Y	Contamination of soil may occur from brine and condensate discharges during operation.
Pollution:					Air, dust, noise pollution will increase as a result of construction activities. Oil pollution will result from spills and leaks from construction plant and machinery. This could impact on water quality, as would sediment loading resulting from earthworks. After construction, dust emissions are likely to reduce, but air pollution and noise will still occur. Risk of contamination by oil products will still be there. Brine and steam condensate may enter into water courses. Water quality (including contamination by oil) will need to be monitored.
air/dust;	-- t ir	Y	- ir	Y	
noise;	-- t ir	Y	- ir	Y	
oil wastes;	-- L ir	Y	-- L ir	Y	
water quality.	- t ir	Y	-- L ir	Y	

Impacts on or due to	Construction		Operation		Remarks
	Type of impact	Mitigation	Type of impact	Mitigation	
Water sources.	-- w L	Y	- S	Y	Water required for construction purposes as well as for the Contractor's/workmen's camps may compete with local supplies. Planning the construction schedule and proper management of water use will help to mitigate this. During operation, water will be required for the cooling towers.
Process chemicals.	0		-- L sp/w	Y	Some process chemicals to be used are classified as hazardous. Proper storage and handling is required.
Construction materials.	?	Y	0		The sources of construction materials are yet to be established. The Project Manager must specify use of environmentally friendly materials.
X2 Quarry.	- sp L r	Y	-- L r	Y	Soil erosion will be the major negative impact resulting from quarrying activities, but these are anticipated to be limited in scale. Other impacts include dust emissions, hazards to wildlife. These impacts could also apply after construction if the quarry is not rehabilitated.
Solid waste.	-- sp/w	Y	-- L sp/w	Y	Construction waste is unsightly and can cause pollution of water courses and litter the national park. Solid waste will also be generated during and operation. Proper disposal of wastes is necessary.
Vegetation/ flora.	- -- L w ir	Y	0		Clearing of vegetation will be necessary for laydown areas and the Contractor's offices, and along the new steamline routes. This vegetation has recently been planted for the purposes of landscaping at Olkaria II, so does not have any special conservation value. Nonetheless, uncontrolled clearing of vegetation by the Contractor should not be permitted. The demand for fuelwood by the workforce may result in felling of trees, thereby having significant long term impacts. The workforce must be provided with alternative fuel sources.
Wildlife/fauna.	- t	Y	NC	Y	There will be minor disturbance to animals/bird life, due to the clearance of vegetation, noise/dust pollution and construction activities. This will probably revert to the present situation after construction.
Wetlands.	0		0		Impacts on wetlands will be negligible, both during and after construction, as all brine discharges from the new unit will be reinjected into deep wells.
Forests.	0		0		No forests will be impacted upon by the construction of the new unit.
Settlement.	- t sp	Y	+ -- L	Y	There will be a temporary influx of people into the project area due to construction workers. This may stimulate the economy, thereby encouraging higher urbanization in centres along the South and North Lake Roads.
Land use.	NC		NC		Land use changed from wildlife dispersal area to industrial use when Olkaria I and II were constructed. The new unit is an extension of the existing one, on land that is designated for its construction within the existing Olkaria II plant site.

Impacts on or due to	Construction		Operation		Remarks
	Type of impact	Mitigation	Type of impact	Mitigation	
Employment opportunities.	++ t -	Y	0		The project will provide temporary employment for some of the local people. Skilled labourers will have to be brought in from outside the project area. This may cause some resentment among the local people. Discussions will need to be held with local leaders and chiefs during recruitment of labour. Women must also be given opportunities to work on the project.
Agricultural activities.	0		0		Impacts due to construction activities will be minor. After construction, agricultural activities, including the flower farms, will not be affected.
Trade and commerce.	+ t sp		NC		During construction, the workforce will stimulate local businesses at the urban centres along South and North Lake Roads. After construction, the situation is likely to revert to the present.
Tourism.	- t sp	Y	+ L		During construction, tourists are unlikely to visit the Olkaria area. After construction there is potential to conduct site tours of the power station.
Fisheries.	0		0		No impacts are anticipated on fisheries.
Sites of archaeological,cultural, historic or traditional significance.	0		0		No sites of archaeologicial, cultural, atraditional or historic significance, will be affected during construction or operation.
Disturbance to the public	- t	Y	- L	Y	During construction there will be temporary disturbance to people working and residing along South Lake Road due to noise, dust, construction activity, etc. This can be partly mitigated through diligence on the part of the Contractor. After construction, noise levels and air emissions will continue, and will need to be monitored.
Public health and occupational safety	-- t ir -- L ir	Y Y	 - ir -- L ir	 Y Y	During construction, temporary increases in dust, noise and air pollution levels could impact on employees' and workers' health. During operation, there will be an increase in levels of pollutants (especially H_2S), but their impact will have to be determined through monitoring. The workforce may also propagate STDs in the settlements along South and North Lake Roads, the effects of which will carry over to the operation stage. STD awareness drives should be initiated in the workmen's camps and in centres along the roads.
Construction camps	+ sh -- L ir	 Y	0		Short term benefits are expected from increased business at the small urban settlements along the lakeshore due to the workforce. The demand for water, fuelwood in these centres will

Impacts on or due to	Construction		Operation		Remarks
	Type of impact	Mitigation	Type of impact	Mitigation	
					increase, possibly having long term effects. The issues of sanitation and solid waste disposal arise. Selection of appropriate sites for the workmen's camps is important.
Visual intrusion	- t sp	Y	0		During construction, visual intrusion will be attributed to earthworks and construction traffic, although these would be confined mainly to the X2 Quarry and the expansion site. Mitigation can be achieved through controlling traffic, sensitizing the workforce, clearing debris after construction and rehabilitating/ landscaping the X2 Quarry and worked areas on the site. After construction the situation will be similar to the present.

The analysis of impacts indicates that there are no impacts that would arise from the installation of a third unit at Olkaria of significant magnitude that cannot be mitigated.

8 ENVIRONMENTAL MANAGEMENT PLAN

In this chapter, an environmental and social management plan has been prepared to cover all the phases of the project life: planning, design, construction, defects liability, operation and maintenance.

Table 8-1 presents the environmental and social management plan. It describes how each of the main mitigation measures proposed in Chapter 7 should be implemented, how frequently, and who should be responsible during and after construction. Chapter 9 discusses environmental and social monitoring, which is an integral part of environmental and social management. Consequently, monitoring indicators and means of monitoring have also been included in Table 8-1 below. Reference should also be made to Table 9-1 and 9-2.

Mitigation measures that can be included in the tender documents have been *italicised* in Table 8-1 for ease of reference. These measures should therefore be reflected in the Conditions of Contract and Bills of Quantities. It is imperative that Project Report is made available to the contractor during the tendering process so that he 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 Resident Engineer or Project Manager. In his schedule of works, the contractor must include all proposed mitigation measures, and the Project Manager 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 and implementation of all the proposed mitigation measures during construction and the defects liability period will lie with the Project Manager and the contractors, respectively. After the defects liability period, responsibility for the maintenance of Unit 3 (as with the Olkaria II station) will rest with the Olkaria II Station Manager, while monitoring activities will be undertaken by the Olkaria Environmental Section.

Table 8-1 also presents an estimate of the costs of environmental management and mitigation. As the design of the proposed third unit is still in its conceptual stage, it is not possible to allocate specific mitigation costs at this point. In general, mitigation costs for such projects amount to roughly 5% of the total project cost. However, 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 quarry rehabilitation and for “making good” will be part of the construction costs to be determined by the Contractors.

Some activities, such as monitoring of emissions and noise, are already being carried out at Olkaria, and thus they will not entail additional costs. These have been indicated as “internal costs” in the table below.

The total cost that would be incurred by KenGen for incorporating the recommended mitigation measures, and for environmental and social and monitoring, is estimated at KSh 12,220,000 (US$ 152,750) for the first year of implementation of the environmental management plan.

Table 8-1 Environmental Management Plan

Environmental/ Social Impact	Proposed Mitigation and Aspects for Monitoring	Responsibility for intervention and 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	Estimated Cost for 1st year of EMP (KShs)
Hydrology.	- Develop contingency plans for alternative water sources. - Initiate water abstraction strategy.	n/a	Olkaria Environmental Section.	(o) Plans prepared, strategy drawn up.	(o) Continuous after plans and strategy have been produced.	- To be determined - Internal
Soils.	- *Control earthworks.* - *Control clearing of vegetation, and revegetate as required.* - *Manage excavation activities, and disposal of spoil.* - *Rehabilitate X2 Quarry.* - *Undertake earthworks during dry season.*	Project Manager; Project HS&E Officer; Contractor.	Olkaria Environmental Section.	(c) Inspection	(c) Continuous	(c) Construction cost.
	- *Control erosion along the steamline routes.*	Project Manager; Project HS&E Officer; Contractor.	Olkaria Environmental Section.	(o) Inspection	(c) (o) Once a month	(c) Construction cost. (o) Internal.
	- Monitor significant elements.	Olkaria Environmental Section.	Olkaria Environmental Section.	(c) (o) Sampling	(c) (o) Quarterly	(o) Internal.
Surface water.	- Monitor water quality. - Monitor precipitation chemistry. - Monitor significant elements.	Olkaria Environmental Section.	Olkaria Environmental Section.	(c) (o) Sampling	(c) (o) Quarterly	(o) Internal.
	- Conduct study to establish point sources of pollution affecting water quality in Lake Naivasha.	Olkaria Environmental Section.	Olkaria Environmental Section.	(c) (o) Independent study.	(c) (o) Once in 5 years.	2,000,000 per study
Groundwater.	- Implement groundwater monitoring programme.	Olkaria Environmental Section.	Olkaria Environmental Section.	(c) (o) Sampling.	(c) (o) Quarterly	500,000 per year
Air quality.	- *Maintain construction plant and equipment.* - *Control speed of construction and other vehicles on site.* - *Sensitise equipment/machinery operators and drivers of construction vehicles.*	Project Manager and Contractor.	n/a	(c) inspection / observation	(c) Daily/random	(c) Construction cost.
	- H_2S monitoring to include Unit 3. - Assess cumulative impacts of H_2S emissions. - Measure and monitor NCGs.	Olkaria Environmental Section.	Olkaria Environmental Section.	(c) (o) Sampling.	(c) (o) 3 times / week. (c) (o) Once / week for cumulative measurements and NCGs.	(o) Internal.

Environmental/ Social Impact	Proposed Mitigation and Aspects for Monitoring	Responsibility for intervention and 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	Estimated Cost for 1st year of EMP (KShs)
Noise.	- *Maintain construction plant and equipment.* - *Sensitise construction workers and drivers using appropriate signage.* - *Control movement of heavy vehicles after dark.*	Project Manager and Contractor.	n/a	(c) Inspection / observation	(c) Daily/random	(c) Construction cost.
	- *Provide and enforce use of PPE.*	Project Manager; Contractor.	Section Heads/ Geo Safety Coordinator.	(o) observation	(o) random	(c) Construction cost. (o) Internal.
	- Continue noise level monitoring.	Olkaria Environmental Section.	Olkaria Environmental Section.	(c) (o) Sampling.	(c) (o) Once / week.	(o) Internal.
Wastewater.	- Contain brine and steam condensate discharges from drain pots. - Reinject all brine discharges.	Design Consultant; Project Manager; Contractor.	Generation Manager.	(c) (o) Inspection	(c) (o) daily	To be determined during design. (c) Construction cost.
Oil pollution.	- *Maintain construction plant and equipment outside the park.* - *Prepare procedures for proper storage and handling of oil products.*	Design Consultant; Project Manager; and Contractor.	n/a	(c) Inspection	(c) Continuously	(c) Construction cost.
	- Install oil interceptors in all the stormwater drains around the new site. - Bund oil and lubricant holding tanks. - Cover outdoor storage yards. - Line oil store floors with epoxy, isolate doors and any drains should flow to an interceptor.	Design Consultant; Project Manager; and Contractor.	n/a	(c) Inspection.	(c) On completion of construction.	To be determined during design. (c) Construction cost.
	- Deploy drip trays while maintaining power plant equipment. - Maintain oil interceptors.	n/a	Olkaria II Station Manager. Civil Superintendent.	(o) Routine maintenance	(o) As stipulated in procedures.	(o) Internal.
	- *Draw up emergency response plan for oil spills.*	Contractor.	Geo Safety Coordinator.	(c) (o) Plan available.	(c) (o) Continuous.	(o) Internal.
Process chemicals.	- Procedures and MSDS for handling all process chemicals should be strictly followed.	n/a	Olkaria II Station Manager. Civil Superintendent.	(o) Inspection.	(o) Continuous.	(o) Internal.
	- Draw up emergency response plan for chemical spills.	n/a	Geo Safety Coordinator.	(c) (o) Plan available.	(o) Continuous.	(o) Internal.

Environmental/ Social Impact	Proposed Mitigation and Aspects for Monitoring	Responsibility for intervention and 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	Estimated Cost for 1st year of EMP (KShs)
Construction materials.	- *Properly plan excavation activities.* - *Control access and routes to X2 Quarry.* - *Control drainage at X2 Quarry.* - *Fence off area to be excavated at Quarry.* - *Prohibit dumping of oil, garbage and spoil in the quarry area.* - *Sprinkle site with water to reduce dust.* - *Specify required standards for all materials and appliances.* - *Specify materials not to be used for construction.* - *Verify sources of all construction materials.*	Project Manager; Project HS&E Officer; Contractor.	n/a	(c) Meetings, inspections.	(c) Continuous.	(c) Construction cost.
	- *Landscape/revegetate excavated area.*	Project Manager; Project HS&E Officer; Contractor.	Olkaria Environmental Section.	(c) (o) Inspection.	(c) (o) Monthly.	(c) Construction cost. (c) Construction cost.
Solid waste.	- *Specify proper disposal of construction wastes including oil, solid wastes, and debris .* - *Contractor should leave the site in a clean and sightly condition on completion of works.* - *Monitor, segregate, collect, store and dispose of all solid waste generated out of the park*.	Project Manager; Project HS&E Officer; Contractor.	n/a	(c) Inspection. (c) Certificate of completion.	(c) Weekly. (c) On completion of works.	(c) Construction cost.
	- Segregate, inventorise and recommend disposal methods for waste generated during plant operation. - Test silicates for their chemical characteristics and toxicity to determine disposal means. -	Olkaria Environmental Section.	Olkaria Environmental Section.	(c) (o) Sampling, observation.	(c) (o) Weekly.	(c) Construction cost. 20,000

Environmental/ Social Impact	Proposed Mitigation and Aspects for Monitoring	Responsibility for intervention and 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	Estimated Cost for 1st year of EMP (KShs)
Vegetation / flora.	- Reinject all brine and condensate discharges. - *Control clearing of vegetation and trees.* - *Rehabilitate and revegetate all disturbed areas with endemic plant species.* - *Provide workforce with alternatives to fuelwood and charcoal.*	Project Manager; Project HS&E Officer; Contractor.	n/a	(c) Inspection	(c) Daily	(c) Construction cost.
	- Conduct study on the vegetation patterns in the Park and its environs.	Olkaria Environmental Section.	Olkaria Environmental Section.	(c) (o) Independent study.	(c) (o) once in 3 years.	2,000,000
Wildlife / fauna.	- Reinject all brine discharges and condensate. - Locate drains and steamlines so as not to obstruct small animals. - *Control movements of construction traffic in the Park.* - *Rehabilitate cleared areas with endemic vegetation.* - *Control construction activities to limit habitat loss.*	Design Consultant. Project Manager; Project HS&E Officer; Contractor.	n/a	(c) Inspection.	(c) Continuous.	(c) Construction cost.
	- Construct and maintain fence around brine ponds (from Olkaria I discharges).	n/a	Olkaria I Station Manager.	(o) Inspection.	(o) Regularly.	Part of ongoing works on Olkaria I.
	- Conduct study on wildlife populations in Hell's Gate National Park and the surrounding areas.	Olkaria Environmental Section.	Olkaria Environmental Section.	(c) (o) Independent study.	(c) (o) Annually.	1,000,000.

Table 8-2 Social Management Plan

Environmental/ Social Impact	Proposed Mitigation and Aspects for Monitoring	Responsibility for intervention and 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	Estimated Cost for 1st year of EMP (KShs)
Immigration and settlement.	- Address unplanned settlement with Municipal Council.	Naivasha Municipal Council, with assistance from KenGen.	Naivasha Municipal Council, with assistance from KenGen.	(c) (o) Meetings, barazas.	(c) (o) Continuous.	(o) Internal.
Employment opportunities.	- *During construction, ensure employment of local people.* - *Recruit women during construction.*	Contractor	n/a	(o) Certificate of employment.	(o) Quarterly.	(c) Construction cost.

Environmental/ Social Impact	Proposed Mitigation and Aspects for Monitoring	Responsibility for intervention and 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	Estimated Cost for 1st year of EMP (KShs)
Agricultural activities.	- Conduct further study to determine long-term impacts of geothermal emissions and flowers, horticultural produce and the natural flora.	Olkaria Environmental Section.	Olkaria Environmental Section.	(c) (o) Independent study.	(c) (o) Once in 5 years.	2,000,000
Tourism	- Prepare brochure. - Develop "tourist trail".	n/a	Administrative Section.	(c) Brochures available.	(o) Continuous.	200,000
Disturbance to the public	- *Minimise pollution as above* - *Notify community leaders of possible disturbances during construction.*	Project Manager; Project HS&E Officer; Contractor.	n/a	(c) Inspection.	(c) Daily.	(c) Construction cost.
	- *Erect warning/informative signs.*	Project Manager; Project HS&E Officer; Contractor.	n/a	(c) Inspection.	(c) When erected.	(c) Construction cost.
	- *Prohibit construction activities at night.*	Project Manager; Project HS&E Officer; Contractor.	n/a	(c) Inspection.	(c) Daily.	(c) Construction cost.
Construction camps.	- *Manage water use in camps.* - *Conduct STD awareness campaign in camps.* - *Provide alternatives to charcoal and firewood.* - Establish central canteen at the workmen's camp. - *Prevent Contractors from setting separate eating shacks on site.* - Arrange to use existing canteen facilities on site. - *Provide proper disposal of solid waste.* - *Provide proper sanitation facilities on site.* - Locate workmen's camp at existing urban centres.	Project Manager; Project HS&E Officer; Contractor.	n/a	(c) Inspection.	(c) Daily.	(c) Construction cost.

Environmental/ Social Impact	Proposed Mitigation and Aspects for Monitoring	Responsibility for intervention and 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	Estimated Cost for 1st year of EMP (KShs)
Public health.	- *Reduce dust levels.* - *Reduce noise levels.* - *Conduct STD awareness campaigns in urban settlements.* - *Prohibit construction activities at night.* - *Proved proper facilities for solid waste and sanitation.* - *Provide workforce with potable water.*	Project Manager; Project HS&E Officer; Contractor.	n/a	(c) Inspection.	(c) Daily.	(c) Construction cost. 1,000,000
	- Monitor water pollution, air and dust emissions, and noise.	Olkaria Environmental Section.	Olkaria Environmental Section.	(c) (o) Sampling.	(c) (o) Continuous, as specified in procedures.	(o) Internal.
	- Sensitise Maasai communities to stop using brine contaminated streams, until measures to redirect brine are completed.	Olkaria Environmental Section.	Olkaria Environmental Section.	(c) (o) Meetings, barazas.	(c) (o) Continuous.	(o) Internal.
	- Monitor impact of HIV/AIDS.	Project HS&E Officer.	Olkaria Environmental Section; Sister in charge, Mvuke Clinic.	(c) (o) Inspection of records.	(c) (o) Once a year.	250,000
	- Monitor the incidence of skin ailments and abortions reported by the Maasai.	n/a	Olkaria Environmental Section. Ministry of Health.	(o) Independent study	(o) Once a year.	500,000
Occupational health and safety.	- *Provide and ensure use of PPE.* - *Stipulate health, safety and welfare regulations and work procedures.* - *Ensure Contractors comply with the Codes of Practice, laws, ordinances, regulations and union agreements.*	Project Manager; Project HS&E Officer; Contractor.	Geo Safety Coordinator.	(c) (o) Inspection. .	(c) (o) Daily, random. .	(c) Construction cost. (o) Internal.
	- Appoint Health, Safety and Environment Officer.	Project Manager.	n/a	(c) Appointment letter.	(c) Once.	(c) Construction cost.
	- Establish fully equipped medical centre on site.	Project Manager.	Chief Manager; Geo Safety Coordinator.	(c) (o) Centre established.	(c) (o) Once.	Salaries: 750,000 Equipment: 2,000,000
	- KenGen to review/revise health and safety operational procedures for all activities make mention of use of safety equipment. - KenGen to "*Employee Guide to Accident Prevention*".	n/a	Geo Safety Coordinator.	(o) Revised procedures available.	(o) Once.	(o) Internal.

Environmental/ Social Impact	Proposed Mitigation and Aspects for Monitoring	Responsibility for intervention and 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	Estimated Cost for 1st year of EMP (KShs)
General risks and hazards.	- *Draw up fire and emergency response plans.*	Project HS&E Officer; Contractor.	Geo Safety Coordinator.	(c) (o) Plans displayed.	(c) (o) Continuous.	(c) Construction cost. (o) Internal.
	- Inspect and properly maintain entire power plant and associated infrastructure.	n/a	Olkaria II Station Manager; Civil Superintendent.	(o) Inspection.	(o) Daily.	(o) Internal.
Visual intrusion	- *Restore/rehabilitate/revegate all worked areas, including X2 Quarry.* - *Control clearing of vegetation.* - *Proper disposal of construction debris.* - *Reduce dust levels.*	Project Manager and Contractor	Olkaria Environmental Section.	(c) (o) Inspection	(c) (o) Daily / random	(c) Construction cost. (o) Internal.

9 ENVIRONMENTAL MONITORING

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 discussed in the previous chapter. 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 EMP/SMP.

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.

Environmental monitoring has been undertaken at Olkaria for about a decade. The following aspects are monitored by the Environmental Section:

- Water quality testing, for pH, temperature, electrical conductivity, TDS, Cl, F, B, H_2S, DO, turbidity, TSS, As, Pb, Li, Hg, CO_3^{2-} and HCO_3^-, Cd, Cu, Cr, Fe, Mg, Mn, K, Na, SO_4^{2-} and Zn;
- Air quality monitoring (H_2S);
- Meteorological data;
- Noise measurements;
- Parameters for precipitation chemistry (ie. pH, TDS, conductivity, chlorine and sulphates);
- Chemical elements of environmental significance in water, soil and vegetation around designated locations, including pH, temperature, As, Ba, B, Cd, Cu, F, Hg, Pb, Li and Zn.

Monitoring data is summarised in Annex 4. In practice, and apart from air quality, noise and meteorological data, monitoring has been carried out for Olkaria I only. Reference should be made to the Audit Report submitted as part of this assignment, which analyses monitoring data and makes recommendations for the same.

In this report, monitoring focuses on activities pertinent to the proposed third unit at Olkaria II. The types of parameters that can be monitored may include mitigation measures or design features, or actual impacts. In some cases, such as soil conservation interventions, monitoring is fairly straightforward and can be done as part of routine maintenance. However, other parameters, particularly those related to socio-economic and ecological issues can only be effectively assessed over a period of 3-5 years.

The monitoring plan in Table 9-1 below presents the activities that should be monitored during the course of this project. 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.

Table 9-1 Environmental Monitoring Plan

Project Impacts and Aspects	Activity	Performance Indicator	Baseline data	Responsibility for monitoring during design, construction and defects liability period	Responsibility for, monitoring after defects liability period	Monitoring means (d) = design (c) = construction (o) = operation	Recommended frequency of monitoring
Soil erosion.	- Monitor efficiency of erosion control measures.	Number of silted check dams along steamlines. Number and size of gulleys in along steamlines.	Zero siltation. Zero erosion.	Project Manager; Project HS&E Officer; Contractor.	Olkaria Environmental Section.	(c) Inspection. (o) Inspection.	(c) Continuous. (o) Continuous.
	- Elements of significance.	pH, temperature, As, Ba, B, Cd, Cu, F, Hg, Pb, Li and Zn.	Permissible WB and WHO limits.	Olkaria Environmental Section.	Olkaria Environmental Section	(c) Sampling. (o) Sampling.	(c) (o) Quarterly.
Water pollution.	- Monitor water quality.	Measurements for: pH, temperature, electrical conductivity, TDS, Cl, F, B, H2S, DO, turbidity, TSS, As, Pb, Li, Hg, CO_3^{2-} and HCO^{3-}, Cd, Cu, Cr, Fe, Mg, Mn, K, Na, SO_4^{2-} and Zn.	Permissible WB and WHO limits.	Olkaria Environmental Section.	Olkaria Environmental Section.	(c) Sampling. (o) Sampling.	(c) (o) monthly.
	- Precipitation chemistry.	Measurements for: pH, TDS, conductivity, chlorine and sulphates	Permissible WB and WHO limits.	Olkaria Environmental Section.	Olkaria Environmental Section.	(c) Sampling. (o) Sampling.	(c) (o) Quarterly.
	- Elements of significance.	pH, temperature, As, Ba, B, Cd, Cu, F, Hg, Pb, Li and Zn.	Permissible WB and WHO limits.	Olkaria Environmental Section.	Olkaria Environmental Section.	(c) Sampling. (o) Sampling.	(c) (o) Quarterly.
	- Surface water pollution study for the Lake Basin covering all activities surrounding the Lake Naivasha.	Measurements for: pH, temperature, electrical conductivity, TDS, Cl, F, B, H2S, DO, turbidity, TSS, As, Pb, Li, Hg, CO_3^{2-} and HCO^{3-}, Cd, Cu, Cr, Fe, Mg, Mn, K, Na, SO_4^{2-} and Zn.	Permissible WB and WHO limits.	-	Lake Naivasha Management Committee in conjunction with prominent stakeholders.	Survey and sampling.	Every 5 years.
	- Monitor groundwater pollution.	Measurements for pH, TDS, SiO_2	Permissible WB and WHO limits.	-	Olkaria Environmental Section	Sampling.	Quarterly.

Project Impacts and Aspects	Activity	Performance Indicator	Baseline data	Responsibility for monitoring during design, construction and defects liability period	Responsibility for, monitoring after defects liability period	Monitoring means (d) = design (c) = construction (o) = operation	Recommended frequency of monitoring
Air Quality.	- Monitor H_2S emissions.	Measurements on site for: H_2S.	Permissible WB and WHO limits.	Olkaria Environmental Section.	Olkaria Environmental Section.	(c) Sampling. (o) Sampling.	(c) (o) 3 times/week.
	- Monitor cumulative levels of H_2S.	Measurements off site for: H_2S.	Permissible WB and WHO limits.	Olkaria Environmental Section.	Olkaria Environmental Section.	(c) Sampling. (o) Sampling.	(c) (o) Once a week.
	- Monitor other NCG emissions.	Measurements for: CO_2, CH_4, SO_2, radon.	Permissible WB and WHO limits.	Olkaria Environmental Section.	Olkaria Environmental Section.	(c) Sampling. (o) Sampling.	(c) (o) Once a week on site and off site.
Noise.	- Monitor noise levels.	Measurements for: ambient and occupational noise.	Permissible WB and WHO limits.	Olkaria Environmental Section	Olkaria Environmental Section.	(c) Sampling. (o) Sampling.	(c) (o) weekly.
X2 Quarry.	- Rehabilitate gravel sites.	Established vegetation.	Zero vegetation.	Project Manager Contractor; Project HS&E Officer.	Olkaria Environmental Section.	(c) Inspection. (o) Inspection.	(c) Once a month. (o) Once a month.
Flora.	- Vegetation within the Olkaria field and Hell's Gate National Park.	Number of newly dominant plant species. Number of alien species. Distribution of newly dominant plant species.	Number and type of species currently dominant. No alien species. Distribution of dominant species.	-	Olkaria Environmental Section.	(o) Independent study: aerial surveys, satellite imagery, ground surveys.	(o) Once in 3 years.
	- Monitor impacts of H_2S on flower and horticultural activities	Incidence of discoloration of petals, vegetables. Changes in growth rate.	Normal petal and vegetable colours. Normal growth rate.	-	Olkaria Environmental Section/ LNGG / Flower and horticultural farms	(o) Independent study.	(o) Once in 5 years.
Fauna.	- Monitor wildlife populations.	New number and type of species currently dominant New distribution of various species Changes in movement / migration patterns of various species.	Number and type of species present. Current distribution of various species. Movement / migration patterns of various species.	-	Olkaria Environmental Section.	(o) Independent study: animal counts.	(o) annually.

Project Impacts and Aspects	Activity	Performance Indicator	Baseline data	Responsibility for monitoring during design, construction and defects liability period	Responsibility for, monitoring after defects liability period	Monitoring means (d) = design (c) = construction (o) = operation	Recommended frequency of monitoring
Solid Waste.	- Construction waste.	Amount of waste dumped at authorised sites.	Zero construction waste dumped at unauthorised sites.	Project Manager Contractor; Project HS&E Officer.	-	(o) Inspection	(o) Once a week
	- Monitor solid waste on site.	Measure volume of waste. Identify types of waste produced. Identify wastes that can be reduced, recycled, or reused.	Current volumes of waste. Current types of waste. Current waste recycled, reused or returned.	Olkaria Environmental Section.	Olkaria Environmental Section.	(c) Sampling. (o) Sampling.	(c) (o) weekly.

Table 9-2 Social Monitoring Plan

Project Impacts and Aspects	Activity	Performance Indicator	Baseline data	Responsibility for monitoring during design, construction and defects liability period	Responsibility for, monitoring after defects liability period	Monitoring means (d) = design (c) = construction (o) = operation	Recommended frequency of monitoring
Public Health and Occupational Safety.	- Use of PPE.	No. of workforce not wearing PPE.	Assume all wear PPE.	Project Manager and Contractor.	Olkaria Environmental Section	(c) Inspection.	(c) Continuously.
	- Monitor impact on public health with regard to STDs (HIV/AIDS).	Reported cases per month.	Baseline study.	-	Olkaria Environmental Section / Ministry of Health	(o) Independent study.	(o) Once a year.
	- Monitor impacts of brine discharges on health status of Maasai communities.	No. of Maasai from ranches downstream of brine flow visiting health facilities with skin ailments. No. of reported abortions of Maasai from ranches downstream of brine flow.	Current incidence of various skin infections. Current abortion rate for local communities.	-	Olkaria Environmental Section / Ministry of Health	(o) Independent study.	(o) Once a year.
Road Safety.	- Impact on wild animals in park.	No. of kills	Zero kills.	Project Manager and Contractor.	Olkaria Environmental Section, Geo Safety Coordinator.	(c) (o) Accident records.	Continuous.

Project Impacts and Aspects	Activity	Performance Indicator	Baseline data	Responsibility for monitoring during design, construction and defects liability period	Responsibility for, monitoring after defects liability period	Monitoring means (d) = design (c) = construction (o) = operation	Recommended frequency of monitoring
Employment.	- Recruit local people	No. of local people employed	Zero local employment.	Contractor; Project Manager.	-	(o) Certificate of employment.	(o) Quarterly.
	- At least 5-10% of employees should be women	No. of women employed	Zero women employed.	Contractor; Project Manager.	-	(o) Certificate of employment.	(o) Quarterly.
Land use.	- Monitor changes in land use	Area covered by settlement. Area of arable land Area of pasture. Area of degraded land. Area of shrub/bushland. Area of social land.	Baseline study.	-	Lake Naivasha Management Committee / District Agriculture Office / District Physical Planning Dept	(o) Independent study	(o) Once in 5 years.

10 CONCLUSIONS AND RECOMMENDATIONS

10.1 Conclusions

Currently geothermal energy contributes to about 10% of the energy to the National Grid. The proposed project has the potential to generate an extra 35 MW at Olkaria, equivalent to about 3% of the total installed capacity within the country (CBS, *Economic Survey 2003*). This has great economic significance to the country, given the increasing demand for electrical power.

The World Bank and the United States Environmental Protection Agency regard geothermal energy as "clean energy" for the following reasons:

- Emissions associated with generating electricity from geothermal technologies are negligible because no fuels are combusted. Geothermal facilities have significantly lower carbon dioxide emissions than fossil fuels.
- Geothermal power plants usually re-inject brine (spent geothermal fluids), eliminating impacts of pollution of surface and ground water resources.
- Geothermal technologies do not produce a substantial amount of solid waste while creating electricity.
- Geothermal power plants typically require the use of less land than fossil fuel power plants.
- Geothermal plants can co-exist successfully with other land uses.

Furthermore, geothermal energy is considered to be renewable because the reservoirs are continuously being replenished. It is also sustainable these sources will replenish naturally into the future and faster than they can be used.

Nevertheless, there will be some adverse impacts resulting from the construction and operation of the third unit at Olkaria II, but all of these can be mitigated. Overall, the negative impacts are outweighed by the more obvious advantages geothermal power production has over fossil fuel power plants.

The new unit is essentially an extension of the present Olkaria II. It will consist of a new cooling tower block, extension of the turbine hall, expansion of the switchyard and additional steamlines. Provision for expansion has been made at the existing site to accommodate the first three components.

Hydrogen sulphide monitoring data indicate no significant change in cumulative H_2S levels in areas outside the immediate Olkaria II plant boundary due to the operations of the power plant. H_2S emissions from Olkaria II are also considerably lower than at Olkaria I due to the superior dispersion through its cooling towers. The new unit will result in a 50% increase in air emissions at Olkaria II. Although cumulative levels of H_2S after the commissioning of Unit 3 are expected to be acceptable, this can only be confirmed through continual monitoring.

Although long term effects of hydrogen sulphide on the growth of flower have not been investigated, based on the lessons learned from the flower trials, it is unlikely that the development of the third unit will have any negative impacts on the flower growing industry adjacent to the project area.

Noise levels will exceed recommended levels during construction of the new unit, and also in some sections of the plant during operation. The former will be temporary, while the latter can be mitigated.

Dust emissions will occur during construction, and there is a risk of oil pollution resulting from both construction and operational activities. These aspects can be controlled.

There is no evidence to show that the drilling of geothermal wells, the installation and operation of Olkaria II so far have had significant impacts on the water resources or quality of

Lake Naivasha. The installation of a third unit at Olkaria II will not necessitate any significant water abstraction from the Lake, nor is it likely to affect the Lake's hydrology or water quality.

Installation of the steamlines will cause minor disturbances to animals due to clearance of vegetation and increased human activity during the construction phase. The area earmarked for the third unit within the Olkaria II compound does not contain any wildlife populations (except a few members of insect community). Consequently, development of the site will not cause any significant impacts on the faunal community.

However, the brine and steam condensate released from the drain pots into natural watercourses will have high concentrations of mineral, fluorides and arsenic. This can pose a threat to wild animals who may drink the brine.

Vegetation will have to be cleared at the proposed site, as well as along the new steamline routes. In addition, the recently rehabilitated X2 Quarry may have to be reopened for the winning of construction materials. However, these are minor impacts, and can be mitigated.

The proposed project will not affect the wetlands in the project area, as all brine and condensate that will be generated from Olkaria II Unit 3 will be disposed through deep well re-injection (as currently done for the Olkaria II). There will be no interaction between the brine originating in Olkaria II Unit 3 and the wetlands associated with the *Typha* dominated brine ponds/wetland near Olkaria I, nor with the papyrus dominated fresh water wetlands around Lake Naivasha.

Construction activities will encourage an influx of people into the project area, comprising the workforce as well as people seeking employment. A number of environmental and social impacts can result due the presence of the workforce. These revolve around the availability of housing and living conditions, sanitation and wastewater, solid waste disposal, competition with local populations for water and fuelwood, the spread of sexually transmitted diseases and HIV/AIDS, all of which have implications on public health.

Other issues which will arise during construction and operation, but can be mitigated, are associated with disturbance to the public, visual intrusion, general risks and hazards, handling and storage of construction and process materials, solid and construction waste.

Construction has been going on at the Olkaria II site since the year 2000. As such, environmental and social impacts caused by activities associated with the construction of Unit 3 will be of a lesser scale than that experienced over the past four years.

In conclusion, provided the recommended mitigation and environmental management measures are effectively implemented during the construction and operation phases of the proposed new unit, the anticipated environmental and social impacts for the most part will have low significance.

10.2 Recommendations

Recommendations for the prevention and mitigation of adverse impacts are as follows:

- Earthworks and excavation activities must be controlled and planned.
- All access and routes to the X2 Quarry must be controlled.
- Drainage at X2 Quarry must be controlled
- Clearing of vegetation and trees must be controlled; all disturbed areas should be revegetated with endemic species.
- X2 Quarry must be rehabilitated.
- Dumping of oil, garbage and spoil in the quarry area must be prohibited.
- The quarry site should be sprinkled with water to reduce dust levels.
- Erosion control measures must be installed along steamlines.

- Construction plant and equipment must be properly maintained.
- Idling of vehicles and plant should not be allowed.
- The movement and speed of construction and other vehicles should be controlled, especially during the night.
- Equipment/machinery operators, construction workers and drivers of construction vehicles must be sensitized on public health issues and STD awareness through campaigns.
- PPE must be provided and its use ensured.
- All brine and condensate discharges must be reinjected.
- Oil products and process chemicals must be properly handled and stored; spill response plans must be drawn up, as well as plans for disposal of clean up materials.
- Interceptors must be installed in stormwater drains potentially carrying oil.
- Standards for all materials and appliances must be specified, and bonafide sources of materials ensured.
- All solid waste generated should be segregated and monitored and disposed of in a responsible manner.
- Silicates should be tested to determine most acceptable means of disposal.
- Alternatives must be provided to the workforce for fuelwood and charcoal for cooking.
- Fences should be constructed around the brine ponds.
- Contractors should dispose of construction waste properly, leaving the site in a clean and sightly condition on completion of the works.
- Contractors must employ local people as far as is possible, and women should be recruited during construction works.
- Community leaders must be notified of possible activities that may cause disturbance.
- Warning/informative signs must be erected.
- Water pollution, air, dust and noise emissions must be monitored and mitigated.
- STD awareness campaigns must be conducted.
- Facilities must be provided for the proper disposal of solid and sanitary waste during and after construction.
- The workforce must be provided with potable water.
- The Maasai communities must be sensitised with regard to brine contaminated streams.
- Health, safety and welfare regulations and work procedures must be stipulated to the contractors.
- A fully equipped medical centre must be established on site.
- The Project Manager must appoint a Health, Safety and Environment Officer.
- The Contractors must comply with the Codes of Practice and legal ordinances and regulations.
- KenGen's operational safety procedures must be reviewed.
- The existing "*Employee Guide to Accident Prevention*" must be revised.
- Contractors should be prevented from setting up eating shacks on site.
- Workmen's camp should be located in existing towns or urban settlements.
- Stress on local water supplies by construction camps and activities should be avoided.
- The contractors must take precautions against fire.
- Fire and emergency response plans must be drawn up for the construction and operation stages.
- The entire plant must be regularly inspected and properly maintained.

The Environmental Section at Olkaria carries out monitoring activities for the entire geothermal development, which should continue as stipulated in their Environmental Operational Procedures, and must also cover Unit 3. These include monitoring of the following:

- Precipitation chemistry;
- Significant environmental elements;
- Meteorology;
- Noise levels;
- Hydrogen sulphide.

In addition, the Environmental Section should monitor the following:

- Non-condensable gases;
- Groundwater contamination.

A number of independent studies have been proposed to provide baseline information which will prove valuable in later years to assess the impact of the two geothermal power plants on the area of influence. These studies would aim to establish:

- Point sources of pollution affecting water quality in Lake Naivasha;
- Vegetation patterns of Hell's Gate National Park;
- Long-term impacts of geothermal emissions on flowers, horticultural produce and the natural flora;
- Wildlife populations in Hell's Gate National Park and the surrounding areas;
- Incidence of skin ailments and abortions reported by the Maasai;
- Changes in land use around the Lake Naivasha Basin.

The tender documents for the construction Olkaria II Unit 3 should stipulate many of the mitigation measures proposed here. The KPCL *Employee Guide to Accident Prevention* also addresses a number of critical issues. These documents must be adhered to during construction and operation, respectively. In addition, all mitigation measures must be included in the Engineering Drawings, Specifications and Bills of Quantities.

Diligence on the part of the Contractor and proper supervision during construction and the initial operation period is crucial for mitigating impacts.

During operation, maintenance is a key factor in protecting the environment.

The estimated project cost for Extension of Olkaria II Third Unit is US$ 50 million.

ANNEX 1

LIST OF REFERENCES

Clarke, M C G, Woodhall, D G, Allen, D and Darling, G; Geological, Volcanological and Hydrologeological Controls on the Occurrence of Geothermal Activity in the area surrounding Lake Naivasha, Kenya; Ministry of Energy, Kenya; 1990.

Gibb (Eastern Africa) Ltd; EHS Audits of Utilities in the Electric Power Sub-Sector, Geothermal Power Plants; Final Report; Electricity Regulatory Board; July 2003.

Giitwa, T W; Environment Sub-Section Safety and Loss Control Audit Report; Kenya Electricity Generating Company Ltd, Ol Karia Geothermal Project; April 2003.

Holmes Air Sciences; Air Quality Impact Assessment, Ol Karia 2 Geothermal Power Project Hydrogen Sulphide Dispersion Study Using Revised Emissions; Mitsubishi Heavy Industries Ltd/Nagasaki Ship Yard and Machinery Works; February 2000.

Kenya Electricity Generating Company Ltd; Olkaria II Geothermal Project Environmental Operational Manual; July 1999.

Kenya Electricity Generating Company Ltd; Olkaria II Geothermal Project Scientific Laboratories Safety and Loss Control Audit Report Physical Conditions Guide and Follow Up Recommendation; 27th June 2000.

Kenya Electricity Generating Company Ltd, KWS, Orpower 4 Inc. and KPLC; Environmental Management in Respect of Hell's Gate and Longonot National Parks; 2000.

Kenya Electricity Generating Company Ltd; Olkaria II Geothermal Power Project: Environmental Reports (June and December, 2003).

Kenya Electricity Generating Company Ltd; First Quarter Internal Environmental Audit (Draft Report), Olkaria Geothermal Power Project; 2003

Kenya Electricity Generating Company Ltd; Industrial Accidents; Olkaria Geothermal Power Project; undated.

Kenya Electricity Generating Company Ltd; Olkaria II Geothermal Project Social and Environmental Complaints (file)

Kenya Power Company Ltd; Ol Karia Geothermal Project Employee Guide to Accident Prevention; Abko Holdings (1977) Ltd; undated.

Kenya Power Company Ltd & Kenya Wildlife Service; Agreement on Geothermal Development in Hell's Gate and Longonot National Parks; 1994.

Kollikho, P, and B Kubo; Olkaria Geothermal Gaseous Emissions and its effect to the Environment – A Flower Trial Case Study; Ol Karia Geothermal Project; undated.

Kubo, B, P Kollikho and J Were; Olkaria II Geothermal Project Environmental Report for the Second BOC Meeting; KenGen; October 1999.

Proklima; ODS Phase Out in Kenya – A Handbook; Deutcshe Gesellschaft fur Technische Zusammenarbeit (GTZ) GmbH; undated.

Republic of Kenya; 1999 Population and Housing Census, Volume I: Population Distribution by Administrative Areas and Urban Centres; Central Bureau of Statistics; January 2001.

Republic of Kenya; Nakuru District Development Plan 2002-2008; Ministry of Finance and Planning.

Republic of Kenya; Economic Survey; Central Bureau of Statistics/Ministry of Planning and National Development; 2003.

Rural Focus Ltd; Lake Naivasha Water Resource Management Programme, 2001 Water Status Report; Lake Naivasha Growers Group, 2002.

Sayeed; Economy versus Environment: How a system with RS and GIS can assist in Decisions for Water Resouce Management; (Quoted in Rural Focus, 2001).

Sinclair Knight in association with ESA Pty Ltd and RPS International Ltd; Environmental Assessment of the North East Ol Karia Power Development Project, Executive Summary; The Kenya Power Company Ltd; September 1993.

Sinclair Knight in association with ESA Pty Ltd and RPS International Ltd; Environmental Assessment of the North East Ol Karia Power Development Project, Final Report; The Kenya Power Company Ltd; March 1994.

Sombroek, W G, Braun, H M H and Pour, B J A. van der; Exploratory Soil Map and Agro-climatic Zone Map of Kenya; Exploratory Soil Survey Report No. E1, Kenya Soil Survey, 1982.

Thompson, A O, and Dodson, R G; Geology of Naivasha Area; Republic of Kenya; 1958.

Wambugu, J M; Chemical Changes of Drilling Return Fluids for Well OW 902 in Ol Karia Domes Geothermal Prospect Area; Kenya Electric Power Generating Company Ltd; April 1999.

Were, J O; Environmental Assessment of Exploration Drilling of Well OW 901 in Ol Karia Domes Field; Kenya Electric Power Generating Company Ltd, Ol Karia Geothermal Project; November 1998.

Were, J; Review of Environmental Performance Audits; Ol Karia Geothermal Project; 2002.

World Bank; Environmental Assessment Sourcebook, Volume I Policies, Procedures and Cross Sectoral Issues; World Bank Technical Paper No. 139; 1991.

World Bank; Environmental Assessment Sourcebook, Volume II Sectoral Guidelines; World Bank Technical Paper No. 140; 1991.

World Bank; Environmental Assessment Sourcebook, Volume III Guidelines for Environmental Assessment of Energy and Industrial Projects; World Bank Technical Paper No. 154; 1991.

World Bank; Elimination of Ozone Depleting Substances; Environmental Assessment Sourcebook Update No. 12; March 1996.

World Bank; Pollution Prevention and Abatement Handbook 1998 – Toward Cleaner Production; in collaboration with the United Nations Environment Programme and the United Nations Industrial Development Organisation; April 1999.

World Bank; Greening Industry: New Roles for Communities, Markets and Governments; World Bank Policy Research Report; 2000.

Websites:

www.who.int/environmental_information/Noise
www.who.int/environmental_information/Air
www.worldbank.org/hmtl/fpd/energy/geothermal
www.prototypecarbonfund.org
www.USEPA/EPA - Clean Energy from Renewable Sources.htm

ANNEX 2

LIST OF PERSONS CONSULTED DURING THE PREPARATION OF THE ENVIRONMENTAL PROJECT REPORT

James K Wahogo	Corporate Planning and Strategy Manager, KenGen HQ, Nairobi
Martin Mwangi	Chief Manager, KenGen Olkaria Geothermal Plants I and II
S K Maina	Generation Manager, KenGen Olkaria Geothermal Plants I and II
Silas Simiyu	Geothermal Development Manager, KenGen Olkaria Geothermal Plants I and II
Beatrice Kipn'gok	Human Resources Manager, KenGen Olkaria Geothermal Plants I and II
Z W Muna	Chief Geothermal Scientist, KenGen Olkaria Geothermal Plants I and II
Peter Ouma	Chief Engineer - Reservoir, KenGen Olkaria Geothermal Plants I and II
Isaac Osiemo	Supplies Officer, KenGen Olkaria Geothermal Plants I and II
Peter Aloo	Olkaria II Station Manager
F N Ndumbi	Steamfield Engineer, Olkaria II
Moses Nthiga	Resident Engineer, Olkaria II
Edward Kimosop	Senior Geo Safety Coordinator
Fred Onderi	Training Coordinator, Geothermal Training Centre
Paul Mutua	Electrical Engineer, Olkaria II
Tom Rajogi	Civil Superintendent, Olkaria II
H Mungai	IT Technician, Olkaria II
Y M Sheik	Instrumentation Technician, Olkaria II
Z Mulinge	Asst Protective Services Officer
Kwambai Clety	Maintenance Engineer, Olkaria I
Mr Abutika	Stores i/c, Rig Stores, KenGen Olkaria Geothermal Plants I and II
Mr Murito	General Stores, Olkaria I
Isaac Kwambe	Stores, Olkaria II
Jennifer Gache	Mechanical Engineer, Strategic Planning Dept, KenGen HQ, Nairobi.
Pacifica Ogola-Ochieng	Environmental Scientist, KenGen HQ, Nairobi
Benjamin Kubo	Environmental Scientist, KenGen Ol Karia
Pius Kollikho	Environmental Scientist, KenGen Ol Karia
Joshua Were	Environmental Scientist, KenGen Ol Karia
Johnson Ndege	Plant Engineer, KenGen Ol Karia
Sarah Higgins	Lake Naivasha Riparian Association
Catherine Wekesa	Park Warden, KWS Hells Gate National Park
Michael Mwangi	Senior Sergeant, KWS Hells Gate National Park
Peter Nyamumbo	Pubic Health Officer (MoH), Naivasha
Mukasi Benard	Social Development Officer (Social Services) Naivasha
Komo Stephen	Inspector of Schools, Ministry of Education, Naivasha
Patrick Kinyanjui	Division Extension worker, Ministry of Agriculture, Naivasha
Mr. Simon Mwai	Manager Kedong Farm
Patrick Sarry	Head Teacher, Mvuke Primary School
Mark Kariuki	Lake Naivasha Tourism Group (The Belle Inn)
John K. Kamau	DO, Naivasha
Mr. Daniel Nderitu	Acting Environmental Officer, Naivasha Municipal Council
Rose Odhiambo -	Sister In-charge of Mvuke Clinic (Kengen)

1. View of Olkaria II Geothermal Power Station. Areas earmarked for expansion of the turbine hall, cooling towers & switch yard on the left of the photo.

2. Area allocated to house the new turbine for Unit 3 (adjacent to the existing turbine hall on the left of the photo).

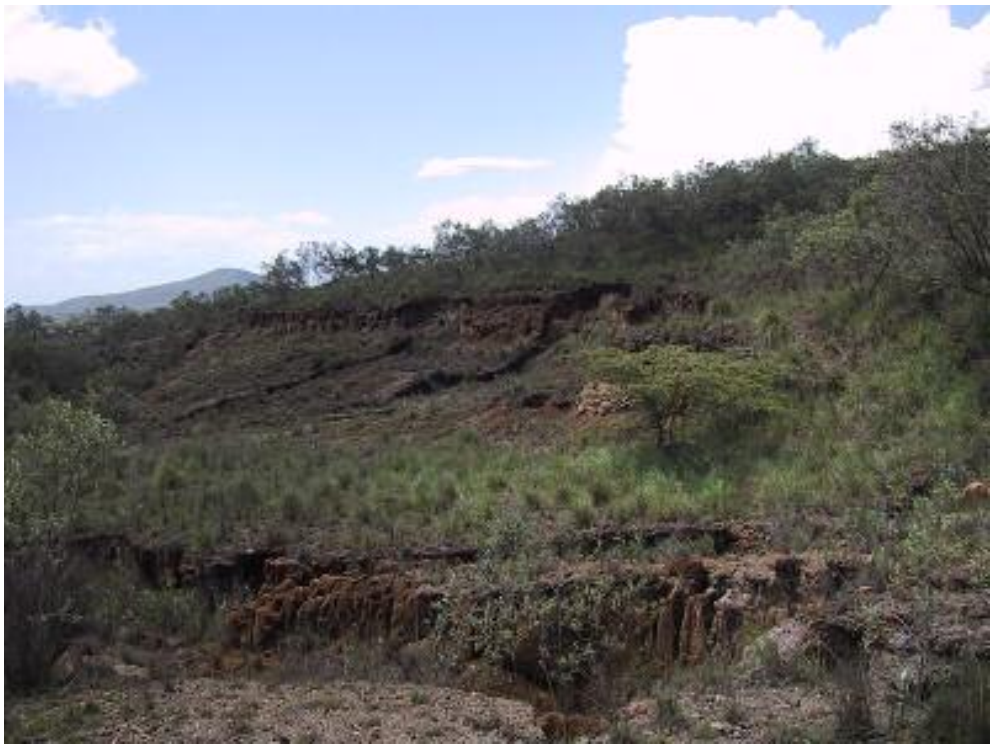
3. Area allocated for the construction of a new cooling tower block next to the existing cooling tower block.

4. The recently rehabilitated X2 Quarry. A small section of the quarry may have to be reopened for acquiring construction materials.

5. KenGen's tree nursery grows a variety of plant species.

6. Oserian flower farm, viewed from the main access road to the western steamfield in Hell's Gate National Park.

7. Warthogs seen in the Olkaria area



8. Soils in the project area are highly prone to erosion.

9. Brine discharge from Olkaria I Power Station into a wetland nearby.

10. Brine discharge flowing along a natural watercourse.

Table 3a Noise emission levels based on mean and range in 2001

No.	Stations	January	February	March	April	May	June	July	August	September	October	November	December
1	Olkaria I Station	nd	nd	75(70-82)	74(73-76)	nd	nd	82(75-89)	70.3(68-74)	75.5(69-81)	71.7(69-79)	72.7(69-79)	77.8(73-93)
2	Admin. Block	nd	nd	55(49-59)	55.3(52-61)	nd	nd	68(55-81)	55.3(53-59)	58.5(55-62)	56.4(55-60)	54.6(52-55)	56.2(50-63)
3	MV & Rig Workshops	nd	nd	36.5(35-38)	32.7(30-35)	nd	nd	35(35-35)	43.3(35-53)	38.5(35-40)	39.9(34-45)	43.2(35-47)	40.2(34-53)
4	Stores	nd	nd	49.3(41-55)	46(43-48)	nd	nd	51.5(45-58)	47(41-54)	50.3(43-55)	47.7(44-50)	47(42-54)	51.4(49-53)
5	Scientific Lab	nd	nd	46.5(40-51)	45.7(45-47)	nd	nd	52.5(44-61)	45(42-49)	47.8(40-60)	50.9(47-55)	49.5(42-56)	49.4(46-52)
6	Well OW-10	nd	nd	47.5(43-51)	50.3(48-53)	nd	nd	52.5(43-62)	45.3(45-46)	45.8(42-49)	49.3(42-54)	51.7(48-55)	41.8(38-47)
7	Well OW-22	nd	nd	39.7(35-42)	40.3(35-44)	nd	nd	nd	nd	nd	nd	36.5(34-42)	nd
8	X-2 Camp	nd	nd	32(30-34)	30(30-30)	nd	nd	38.5(37-40)	34(30-38)	34.3(31-38)	37.3(34-40)	39(34-48)	28.8(25-35)
9	KWS Olkaria Gate	nd	nd	33.5(32-35)	36(35-38)	nd	nd	35(35-35)	34(28-39)	35.8(35-38)	37.7(35-40)	37(33-41)	30(30-40)
10	Lakeside Estate	nd	nd	32(32-32)	34(30-38)	nd	nd	34.5(31-38)	36(34-38)	36.3(34-38)	36(35-38)	32.3(33-38)	39(34-48)
11	Lakeview Estate	nd	nd	30(30-30)	31.5(28-35)	nd	nd	33.5(29-38)	34.7(32-37)	36.3(34-38)	38.3(37-41)	36(33-37)	32.5(32-34)

nd: not determined
(34-38): Noise emission range-Min & Max
79.4 : Mean monthly Noise emission level

Observed noise levels in dB(A) : 2002-04 at Olkaria I

Sites	MV-Rig W/Shop	Olkaria I	Admin. Block	OW-10	OW-22	KWS Gate	L-View	L-Side	Stores	X-2 camp	Scientific Lab
Date	Noise Levels in dB(A)										
01/02/02	35	74	53	42		43	34	32	47	23	45
01/09/02	34	75	52	37		34	37	28	49	33	48
18/1/02	37	74	44	39		28	28	25	51	30	46
Min	34	74	44	37		28	28	28	47	23	45
Max	37	75	53	42		43	37	32	51	33	48
Avg	35.33333333	74.33333	49.66666667	39.333		35	33	28.333	49	28.666667	46.33333333
13/2/2002	44	75	55	41	32		35	33	58		52
19/02/2002	43	72	55	40		35	30	34	47	32	45
Min	43	72	55	40	32	35	30	33	47	32	45
Max	44	75	55	41	32	35	35	34	58	32	52
Avg	43.5	73.5	55	40.5	32	35	32.5	33.5	52.5	32	48.5
03/04/02	42	72	55	39		33	37	39	52	35	49
03/08/02	45	72	55	43		34	38	37	40	35	38
Min	42	72	55	39		33	37	37	40	35	38
Max	45	72	55	43		34	38	39	52	35	49
Avg	43.5	72	55	41		33.5	37.5	38	46	35	43.5
15/4/2002	38	73	55	44		35	33	35	43	34	42
17/04/2002	35	72	55	40		33	35	38	45	30	42
22/04/2002	35	72	55	46		37	34	35	45	35	47
Min	35	72	55	40		33	33	35	43	30	42
Max	38	73	55	46		37	35	38	45	35	47
Avg	36	72.33333	55	43.333		35	34	36	44.3333	33	43.66666667
05/09/02	35	73	58	45		32	20	20	55	30	53
Min	35	73	58	45		32	20	20	55	30	53
Max	35	73	58	45		32	20	20	55	30	53
Avg	35	73	58	45		32	20	20	55	30	53
06/03/02	38	72	58						47		45
06/06/02	45	73	58	48					45		43
06/10/02	40	72	58	42	43	38			45	40	42
19/6/02	40	74	68	47	38	36	37	34	46	35	47
21/6/02	32	74	58	43	43	38	37	35	47	32	46
26/6/02	36	72	55	41	38		35	38	46	36	44
Min	32	72	55	41	38	36	35	34	45	32	42
Max	45	74	68	48	43	38	37	38	47	40	47
Avg	38.5	72.83333	59.16666667	44.2	40.5	37.333333	36.3333	35.667	46	35.75	44.5
07/01/02	38	72	58	49	36	52	35	36	45	35	47
07/10/02	42	72	55	48	38	35	38	34	40	37	39
17/7/02	34	73	53	75		37			53	34	43
19/7/02	42	72	55	55	43	38	35	34	45	34	42
Min	34	72	53	48	36	35	35	34	40	34	42
Max	42	73	58	75	43	52	38	36	53	37	47
Avg	39	72.25	55.25	56.75	39	40.5	36	34.667	45.75	35	42.75
08/12/02	38	72	54	49	45	34	37	38	51	38	48
14/8/02	42	74	58	44	38	37	38	35	49	34	44
22/8/02	38	72	55	49	47	37	35	38	45	34	41
29/8/02	38	69	51		43				45		43
Min	38	69	51	44	38	34	35	35	45	34	41
Max	42	74	58	49	47	37	38	38	51	38	48
Avg	39	71.75	54.5	47.333	43.25	36	36.6667	37	47.5	35.333333	44
09/02/02	38	69	51	40	33	35	37	33	55	34	44
09/06/02	42	73	55	40	33	34	37	36	45	35	43
26/9/02	38	72	55	52	52	36	35	37	45	38	43
Min	38	69	51	40	33	34	35	33	45	34	43
Max	42	73	55	52	52	36	37	37	55	38	44
Avg	39.33333333	71.33333	53.66666667	44	39.333	35	36.3333	35.333	48.3333	35.666667	43.33333333
10/01/02	34	72	49	58	38	37	38	36	45	34	43
16/10/02	39	69	57	40	35	34	35	40	45	35	47
29/10/02	38	72	62	40	35	37	38	35	40	36	42
Min	34	69	49	40	35	34	35	35	40	34	42
Max	39	72	62	58	38	37	38	40	45	36	47
Avg	37	71	56	46	36	36	37	37	43.3333	35	44

11/04/02					38						
11/06/02	38	72	58	48	38	39	38	37	45	35	46
Min	38	72	58	48	38	39	38	37	45	35	46
Max	38	72	58	48	38	39	38	37	45	35	46
Avg	38	72	58	48	38	39	38	37	45	35	46
12/01/02											
Min											
Max											
Avg											
14/1/2003	53	74	50	48	38				63		54
29/1/2003	35	72	56	45	39	38	37	39	44	36	43
Min	35	72	50	45	38	38	37	39	44	36	43
Max	53	74	56	48	39	38	37	39	63	36	54
Avg	44	73	53	46.5	38.5	38	37	39	53.5	36	48.5
02/06/03	44	70	55	47	39	37	37	38	45	34	47
02/11/03	51	87	76	48	53	38	37	36	65	34	60
Min	44	70	55	47	39	37	37	36	45	34	47
Max	51	87	76	48	53	38	37	38	65	34	60
Avg	47.5	78.5	65.5	47.5	46	37.5	37	37	55	34	53.5
20/3/03	38	75	51	47	40	37	37	38	46	37	39
Min	38	75	51	47	40	37	37	38	46	37	39
Max	38	75	51	47	40	37	37	38	46	37	39
Avg	38	75	51	47	40	37	37	38	46	37	39
04/07/03	37	77	47	43	38	30			47	28	36
Min	37	77	47	43	38	30			47	28	36
Max	37	77	47	43	38	30			47	28	36
Avg	37	77	47	43	38	30			47	28	36
28/5/03	42	74	51	39		40			47	34	42
Min	42	74	51	39		40			47	34	42
Max	42	74	51	39		40			47	34	42
Avg	42	74	51	39		40			47	34	42
06/04/03			52	44	38				35		40
16/6/03	38	72	42	43	34	54		32	50	30	42
18/6/03	32	66	46	39	36	41			42	34	42
24/6/03	37	74	50	42	40	25			47	30	39
Min	32	66	42	39	34	25		32	35	30	39
Max	38	74	52	44	40	54		32	50	34	42
Avg	35.66666667	70.66667	47.5	42	37	40		32	43.5	31.333333	40.75
07/04/03	33	74	58	42	35	40				45	
07/08/03	44	52	68	44	32	56	38	34	70	34	43
10/703	43	73	56	43	38				48		40
15/7/03	50	67	55	55	32	41			47	34	40
17/7/03	28	63	49								
Min	28	52	49	42	32	40	38	34	47	34	40
Max	50	74	68	55	38	56	38	34	70	45	43
Avg	39.6	65.8	57.2	46	34.25	45.666667	38	34	55	37.666667	41
18/8/03	25	73	44	44	50	28			38	30	37
20/8/03	41	74	58	50	48	36	37	38	52	34	54
26/8/03	39	74	55	38	39	36	37	38	40	35	42
Min	25	73	44	38	39	28	37	38	38	34	37
Max	41	74	58	50	50	36	37	38	52	35	54
Avg	35	73.66667	52.33333333	44	45.667	33.333333	37	38	43.3333	33	44.33333333
09/01/03	42	73	55	43	38	38	37	36	35	36	40
09/09/03	44	74	48	48	34	35	38	37	75	36	40
16/9/03		74	51	34	43	45	38	37	41	36	43
19/9/03	35	70	51	45	36	37	36	37	38	34	41
25/9/03	37	74	55	43	39	36	36	37	39	35	42
Min	38	69	48	34	34	35	36	36	35	34	40
Max	42	73	55	48	43	45	38	37	75	36	43
Avg	39.5	73	52	42.6	38	38.2	37	36.8	45.6	35.4	41.2
10/03/03	35	68	56	40	38	38	39	35	38	35	35
10/07/03	49	70	49	49	38	37	35	36	45	36	47
10/09/03	35	70	58	47	40	37	38	37	41	34	38
14/10/03	39	71	58	42	38	37	36	35	38	34	39
23/10/03	42	74	54	42	38	37	37	36	45	34	44
29/10/03	39	74	52	40	44	38			44	33	44
Min	35	68	49	40	38	37	35	35	38	33	35
Max	49	74	58	49	44	38	39	37	45	36	47
Avg	39.83333333	71.16667	54.5	43.333	39.333	37.333333	37	35.8	41.8333	34.333333	41.16666667

11/07/03	40	73	50	43	32	25			52	29	51
Min	40	73	50	43	32	25			52	29	51
Max	40	73	50	43	32	25			52	29	51
Avg	40	73	50	43	32	25			52	29	51
12/09/03	38	81	59	44	40				49		44
Min	38	81	59	44	40				49		44
Max	38	81	59	44	40				49		44
Avg	38	81	59	44	40				49		44
01/02/04	43	73	53	34	44	40			51	36	48
13/1/04		78	58	39	36	35			53	34	45
15/1/04	36	77	53	54	39	35			52	28	53
22/1/04	40	77	57	37	39	25			53	28	47
29/1/04	45	79	62	58	42	38	36	37	47	36	45
Min	36	73	53	34	36	25	36	37	47	28	45
Max	45	79	62	58	44	40	36	37	53	36	48
Avg	41	76.8	56.6	44.4	40	34.6	36	37	51.2	32.4	47.6
02/05/04	43	76	54	41					50		49
02/12/04	51	78	56	38		39			58		54
Min	43	76	54	38		39			50		49
Max	51	78	56	41		39			58		54
Avg	47	77	55	39.5		39			54		51.5
03/02/04	45	69	55	39	40	36	37	38	42	37	45
03/05/04	35	72	58	45	47	37	36	38	50		55
03/11/04	43	72	54	50	43	38	36	37	42		48
18/3/04	35	76	52	46	43	25	38	37	44		48
24/3/04	41	76	65	50	43	38	37	38	43		42
30/3/04	35	79	61	44	43	38	37	36	46		45
Min	35	69	52	39	40	25	36	37	42	37	42
Max	45	79	65	50	47	38	37	38	50	37	55
Avg	39	74	57.5	45.667	43.167	35.333333	36.8333	37.333	44.5	37	47.16666667

MeanRange of Elements in Soil 1993 - 2002

mg/l

	As	Ba	B	Cd	Cu	F	Pb	Li	Hg	Zn
OW-2		0.00 - 1.00			0.00 - 0.15		0.00 - 0.80	0.05 - 0.61		1.80 - 4.25
OW-10		0.10 - 1.10		0.00 - 0.02	0.00 - 0.3		0.00 - 0.70	0.10 - 0.44	100.7	2.10 - 3.97
OW-13	45.25	0.20 - 0.40			0.00 - 0.5		0.00 - 4.30	0.00 - 0.77		2.10 - 3.1
OW-16			0.30 - 1.70	0.00 - 0.10	0.10 - 0.5		0.00 - 1.80	0.10 - 0.84	106.5	2.20 - 8.1
OW-22		0.00 - 0.80			0.09 - 0.30		0.00 - 2.30	0.04 - 1.37		3.09 - 5.18
OW-26		0.00 - 1.80			0.00 - 0.9		0.00 - 3.30	0.10 - 0.99		2.40 - 9.50
OW-27/31/33								0.53 - 0.84		
OW-29/30							0.00 - 0.20	0.10 - 0.58		1.80 - 2.41
OW-32				0.00 - 0.01			0.00 - 0.30	0.07 - 0.44		1.65 - 2.30
IP-1		0.10 - 2.05			0.09 - 0.30		0.00 - 0.80	0.05 - 0.35		2.31 - 4.71
IP-2		0.40 - 0.95		0.00 - 0.01	0.08 - 0.12		0.00- 0.80	0.10 - 0.78	79.28	0.51 - 4.25
IP-3			0.60 - 2.30		0.00 - 0.18		0.00- 0.65	0.00 - 0.63	121.4	1.79 - 3.33
Site		0.00 - 0.40		0.00 - 0.01	0.00 - 0.10		0.00 - 0.40	0.09 - 0.45		2.40 - 2.80
OW-702/716										
OW-707										
OW-711										
OW-714		0.20 - 0.30			0.00 - 0.63			0.10 - 0.20		2.00 - 2.54
OW-721					0.06 - 0.10	0.4		0.09 - 0.10		1.60 - 4.30
OW-722/728										
OW-725										
X2 Camp		0.09 - 0.50		0.00 - 0.49	0.06 - 0.50	0	0.00 - 1.50	0.02 - 0.23	0.5	2.43 - 7.01
LSE		0.1 0- 0.40		0.00 - 0.02	0.10 - 0.19		0.41 - 0.60	0.09 - 0.10		1.50 - 5.00
LVE		0.40 - 0.80			0.10 - 0.20		0.50 - 0.60	0.10 - 0.20		2.90 - 4.90
Lake Nvsa		0.80 - 1.20			0.10 - 0.20		0.10 - 0.50	0.00 - 0.10		2.30 - 2.40
Nvsa Town				0.00 - 0.02	0.01 - 0.60		0.06 - 1.90	0.10 - 0.11		3.80 - 4.43
WB g/lines	0.1			0.1	0.5	20	0.1		0.01	2
Nat g/lines	0.002	2		0.05	0.05	2	0.1		0.005	0.5

Mean Range of Elements in Vegetation 1993-2002

mg/l

	As	Ba	B	Cd	Cu	F	Pb	Li	Hg	Zn
OW-2		0.60 - 1.75			0.31 - 3.35		0.00 - 1.25	0.00 - 0.41		2.70 - 10.35
OW-10		0.0 - 0.6		0.00 - 0.01	0.08 - 0.20		0.00 - 0.30	0.00 - 0.30		1.41 - 3.80
OW-13	26.01	0.10 - 0.30		0.00 - 0.02	0.09 - 0.20		0.00 - 0.14	0.00 - 0.38	28.88	1.40 - 2.22
OW-16		0.00 - 0.35		0.00 - 0.02	0.08 - 0.30		0.00 - 0.25	0.00 - 0.07		1.00 - 5.60
OW-22		0.10 - 0.80			0.20 - 0.35		0.00 - 0.5	0.00 - 1.37		0.30 - 9.00
OW-26		0.00 - 0.40	5.4	0.00 - 0.02	0.00 - 0.3		0.10 - 0.20	0.00 - 0.38		2.58 - 4.00
OW-27/31/33										
OW-29/30								0.25 - 0.35		
OW-32			7.9				0.00 - 0.10	0.04 - 0.44		0.93 - 2.30
IP-1		0.30 - 1.20	7.5		0.10 - 0.25		0.00 - 0.20	0.06 - 0.10		0.78 - 2.21
IP-2		0.55 - 0.80			0.20 - 0.54			0.02 - 0.70		0.54 - 4.35
IP-3		0.00 - 0.30	6.6	0.00 - 0.02	0.06 - 0.24		0.00 - 0.30	0.04 - 0.63		0.6 - 3.17
Site		0.00 - 0.10		0.00 - 0.03	0.00 - 0.3			0.00 - 0.45		1.00 - 2.78
OW-702/716										
OW-707										
OW-711			2.3				0.00 - 0.10	0.01 - 0.04		1.46 - 9.39
OW-714		0.03 - 0.30	4.98	0.00 - 0.03	0.10 - 0.26		0.13 - 0.20	0.00 - 0.12		1.43 - 6.62
OW-721		0.20 - 0.90	2.6	0.00 - 0.03	0.26 - 0.50		0.00 - 0.90	0.02 - 0.10		1.21 - 4.70
OW-722/728										
OW-725										
X2 Camp		0.00 - 7.15		0.00 - 0.04	0.00 - 0.2		0.00 - 0.32	0.00 - 0.40		0.90 - 7.01
LSE		0.00 - 0.10			0.12 - 0.50		0.20 - 0.63	0.00 - 0.03		0.70 - 2.05
LVE		0.00 - 9.25		0.00 - 0.04	0.00 - 0.30		0.00 - 0.30	0.00 - 0.15		1.10 - 3.50
Lake Nvsa	5.13	0.00 - 0.80	6.28		0.00 - 0.12		0.10 - 0.30	0.00 - 0.02	13.4	0.70 - 5.20
Nvsa Town	0.6	0.20 - 0.30	4.2	0.00 - 0.04	0.00 - 0.30	0	0.10 - 0.30	0.00 - 0.09	0	1.30 - 5.02
WB g/lines	0.1			0.1	0.5	20	0.1		0.01	2
Nat g/lines	0.002	2		0.05	0.05	2	0.1		0.005	0.5

Mean Range of Elements in Water 1993-2002

mg/l

	As	Ba	B	Cd	Cu	F	Pb	Li	Hg	Zn
OW-2		0.00 - 0.10	5.09 - 6.74		0.00 - 0.02	30.00 - 107.00	0.00 - 0.10	0.00 - 2.68	0.00 - 11.28	0.00 - 1.58
OW-10	53.09 - 1580.00	0.00 - 0.10	3.48 - 10.93	0.00 - 0.12	0.00 - 0.43	5.06 - 120.00	0.00 - 3.00	0.00 - 4.31	0.00 - 9.44	0.00 - 1.74
OW-13		0.00 - 0.30	1.10 - 2.64		0.00 - 0.29	25.00 - 125.80	0.00 - 0.10	0.13 - 0.63		0.00 - 1.18
OW-16		0.00 - 0.30	0.35 - 4.73		0.00 - 0.10	16.00 - 87.50	0.00 - 0.10	0.16 - 2.96		0.00 - 3.20
OW-22		0.00 - 0.30	0.45 - 3.36		0.00 - 0.30	56.20 - 171.00	0.00 - 0.30	0.00 - 1.21		0.00 - 0.21
OW-26		0.00 - 0.30	1.6 - 2.74	0.00 - 0.01		56.00 - 112.00	0.00 - 0.10	0.20 - 2.20		
OW-27/31/33										
OW-29/30			4.09 - 4.95	0.00 - 0.002		50.40 - 94.00	0.00 - 0.10	0.60 - 3.28		0.00 - 0.28
OW-32			5.37 - 8.18			55.00 - 87.50				
IP-1	8.33 - 29.44	0.00 - 0.20	1.00 - 3.92	0.00 - 0.08	0.00 - 0.01	0.25 - 61.80		0.00 - 2.89	0.00 - 11.18	0.01 - 0.23
IP-2		0.00 - 0.30	1.87 - 2.67		0.00 - 0.13	22.30 - 62.34	0.00 - 0.60	0.00 - 1.51	27.15 - 75.16	0.00 - 2.93
IP-3		0.00 - 0.20	1.40 - 5.40	0.00 -0.009	0.00 - 0.09	47.00 - 89.00	0.00 - 0.30	0.00 - 2.35		0.06 - 2.21
Site		0.00 - 0.53	0.00 - 0.15	0.00 - 0.03	0.00 - 0.19	1.83 - 8.14	0.00 - 0.13	0.00 - 0.05		0.00 - 1.33
OW-702/716										
OW-707										
OW-711										
OW-714					0.00 - 0.02		0.00 - 0.23	1.00 - 1.13		0.00 - 0.55
OW-721										
OW-722/728										
OW-725				0.00 - 0.01			0.00 - 0.24			
X2 Camp	0.00 - 9.70	0.00 - 0.20	0.00 - 0.22		0.00 - 0.02	1.73 - 9.20	0.00 - 0.13	0.00 - 0.99		0.00 - 5.01
LSE		0.00 -0.30	0.00 - 1.71		0.00 - 0.02	1.80 - 9.30	0.00 - 0.13	0-0.01		0.00 - 2.48
LVE		0.00 - 0.07	0.00 - 0.93	0.00 - 0.02	0.00 - 0.04	1.85 - 9.00	0.00 - 0.1	0.00 - 0.01		0.00 - 0.87
Lake Nvsa	0.00 - 0.09		0.00 - 0.12	0.00 - 0.02	0.00 - 0.05	0.00 - 13.63	0.00 - 0.2	0.00 - 0.02	0.00 - 2.00	0.00 - 0.51
Nvsa Town										
WB g/lines	0.1			0.1	0.5	20	0.1		0.01	2
Nat g/lines	0.002	2		0.05	0.05	2	0.1		0.005	0.5

Maximum, Minimum and average H2S concentrations at Olkaria I

Date	Site	MV-Rig w/shop	Power station	Admin. Block	Seal pit	OW-10	OW-22	KWSGate	L-View	L-Side	Stores	X-2 camp	Geophy lab
	Min	0	1.4			1.2							
Apr-97	Max	0	2.3			1.2							
	Ave	0	1.85			1.2							
	Min	0	0.1	0		0		0	0	0			
May-97	Max	0	1.3	0.4		0		0	0	0	0.3		
	Ave	0	0.5556	0.075		0		0	0	0	0.3		
	Min	0	0	0		0		0	0	0			
Jun-97	Max	0	1.9	0.4		1.3		0	0	0			
	Ave	0	0.6333	0.025		0.2421		0	0	0			
	Min	0	0	0		0		0	0	0			
Jul-97	Max	0.2	2.6	0.3		0.6		0	0	0			
	Ave	0.00588	0.3114	0.0333		0.0639		0	0	0			
	Min	0	0	0		0		0	0	0			
Aug-97	Max	0	1	0		0.9		0	0	0			
	Ave	0	0.1973	0		0.0771		0	0	0			
	Min	0	0	0		0		0	0	0			
Sep-97	Max	0.2	1.5	0		0.7		0	0	0			
	Ave	0.01053	0.1647	0		0.1		0	0	0			
	Min	0	0	0	0	0		0	0	0			
Oct-97	Max	0.1	0.9	0.3	1.1	0.2		0	0	0			
	Ave	0.01111	0.25	0.025	0.2455	0.0273		0	0	0			
	Min	0	0	0	0	0							
Nov-97	Max	0.2	1.9	0.4	0.9	1							
	Ave	0.0125	0.5471	0.0267	0.1294	0.1688							
	Min	0	0	0	0	0					0		
Dec-97	Max	0	1.6	0.8	0.1	0.2					0		
	Ave	0	0.3714	0.1071	0.0071	0.0286					0		
	Min	0	0	0	0	0		0	0	0			
Jan-98	Max	0.4	0.7	0.9	0	0		0	0	0			
	Ave		0.1636	0.0909	0	0		0	0	0			
	Min	0	0	0	0	0		0	0	0			
Feb-98	Max	0	1.9	0.5	0	0		0	0	0			
	Ave	0	0.5545	0.0818	0	0		0	0	0			
	Min												
Mar-98	Max												
	Ave												
	Min												
Apr-98	Max												
	Ave												
	Min												
May-98	Max												
	Ave												
	Min	0	0	0	0	0		0	0	0			
Jun-98	Max	0	1.5	0	0.2	0.3		0	0	0			
	Ave	0	0.18	0	0.0222	0.0333		0	0	0			
	Min	0	0	0	0	0	0	0	0	0			
Jul-98	Max	0.1	1.3	0.1	2.5	0.2	0.2	0	0	0			
	Ave	0.00833	0.4063	0.0063	0.1938	0.0429	0.0727	0	0	0			
	Min	0	0	0	0	0	0		0.1	0			
Aug-98	Max	0.8	0.8	0.6	1	0.5	1		0.1	0			
	Ave	0.12308	0.2286	0.0846	0.2625	0.1733	0.1176		0.1	0			
	Min	0	0	0	0	0	0	0					
Sep-98	Max	0.1	1.1	0.1	2.4	0.8	0.3	0.1					
	Ave	0.03571	0.2933	0.0267	0.2467	0.1933	0.0929	0.05					
	Min	0	0.1	0.1	0	0	0	0	0				
Oct-98	Max	0.2	4.4	0.2	1	0.7	0.6	0.2	0				
	Ave	0.06154	1.5077	0.1154	0.2429	0.2643	0.1538	0.083333	0				

	Min	0	0	0	0	0	0	0	0	0			
Nov-98	Max	0.2	2.4	0.2	0.3	0.3	0.2	0	0	0			
	Ave	0.0625	0.3778	0.0333	0.06	0.0545	0.0333	0	0	0			
	Min	0	0.2	0	0	0	0	0	0	0	0.1		
Dec-98	Max	0.4	1.2	0.6	0	0.1	0.1	0	0	0	0.1		
	Ave	0.1	0.55	0.15	0	0.0125	0.0125	0	0	0	0.1		
	Min	0	0	0	0	0	0				0.1		
Jan-99	Max	0.2	3.9	1.3	0.1	0.1	0.1				0.2		
	Ave	0.03333	1.475	0.275	0.025	0.0125	0.025				0.1667		
	Min	0	0	0	0	0	0	0	0	0	0		
Feb-99	Max	0	2.9	1	0	0.2	0.2	0	0	0	0.3		
	Ave	0	0.5833	0.2273	0	0.02	0.05	0	0	0	0.1333		
	Min	0	0	0	0	0	0	0	0	0	0.1		
Mar-99	Max	0	2.3	0.4	1.4	0.1	0	0.2	0	0	0.8		
	Ave	0	0.7333	0.0833	0.225	0.0222	0	0.04	0	0	0.45		
	Min	0	0	0	0	0	0	0	0	0			
Apr-99	Max	0	2.5	0	1.2	0.7	0	0	0	0			
	Ave	0	0.9889	0	0.28	0.2	0	0	0	0			
	Min	0	0	0	0	0	0	0	0	0			
May-99	Max	0	1.8	0.1	2.8	0.3	0	0	0	0			
	Ave	0	0.6	0.0077	0.4692	0.0615	0	0	0	0			
	Min	0	0	0	0	0	0	0	0	0	0	0	
Jun-99	Max	0	2.6	0.2	1.2	0.3	0	0	0	0	0	0	
	Ave	0	0.92	0.0222	0.2545	0.06	0	0	0	0	0	0	
	Min	0	0	0	0	0	0	0	0	0	0	0	0
Jul-99	Max	0	0.8	0	0.2	0	0	0	0	0	0	0	0
	Ave	0	0.8	0	0.2	0	0	0	0	0	0	0	0
	Min	0	0	0	0	0	0	0	0	0	0	0	0
Aug-99	Max	0.1	1.9	0.1	1.2	0.8	0	0	0	0	0	0	1.3
	Ave	0.00588	0.2833	0.0105	0.15	0.14	0	0	0	0	0	0	0.18889
	Min	0	0	0	0	0	0	0	0	0	0	0	0
Sep-99	Max	0	0.9	0	2	0.6	0.1	0.1	0	0	0.1	0	0
	Ave	0	0.275	0	0.4167	0.1417	0.0333	0.016667	0	0	0.0111	0	0
	Min	0	0	0	0	0	0	0	0	0	0	0	0
Oct-99	Max	0	2.1	0	1.3	0.6	0.2	0	0	0	0	0	0.3
	Ave	0	0.3692	0	0.3455	0.1385	0.0462	0	0	0	0	0	0.03
	Min	0	0	0	0	0	0	0	0	0	0	0	0
Nov-99	Max	0.1	0.6	0.1	0.1	0.1	0	0	0	0	1.2	0	0.1
	Ave	0.01667	0.1143	0.0143	0.02	0.0333	0	0	0	0	0.34	0	0.04
	Min	0	0.4	0	0	0	0	0	0	0	0	0	0
Dec-99	Max	0.1	2	1.5	0.1	0.1	0	0	0	0	0.1	0	1.4
	Ave	0.02	1.05	0.35	0.02	0.02	0	0	0	0	0.0143	0	0.47143
	Min	0	0	0	0	0	0	0	0	0	0		0
Jan-00	Max	0	2.4	1.2	0	0	0	0	0	0	0.9		1.3
	Ave	0	0.9429	0.3	0	0	0	0	0	0	0.2429		0.55714
	Min	0	0	0	0	0	0	0	0	0	0		0
Feb-00	Max	0	0.5	0.5	0	0	0	0	0	0	2.2		0.4
	Ave	0	0.3167	0.0833	0	0	0	0	0	0	0.4667		0.06667
	Min												
Mar-00	Max												
	Ave												
	Min	0	0	0	0	0	0	0	0	0	0	0	0
Apr-00	Max	0	1.4	0	0	0.4	0	0	0	0	0	0	0
	Ave	0	0.8	0	0	0.1	0	0	0	0	0	0	0
	Min	0	0	0	0	0	0	0	0	0	0	0	0
May-00	Max	0	0	0	0	0	0	0	0	0	0	0	0
	Ave	0	0	0	0	0	0	0	0	0	0	0	0
	Min	0	0	0	0	0					0	0	0
Jun-00	Max	0	1.2	0	0.6	0.2					0	0	0
	Ave	0	0.24	0	0.12	0.1					0	0	0

	Min	0	0	0	0	0	0	0			0	0	0
Jul-00	Max	0.1	0.3	0	0.6	0.4	0	0			0	0	0
	Ave	0.01667	0.12	0	0.1	0.0833	0	0			0	0	0
	Min	0	0	0	0	0	0	0			0	0	0
Aug-00	Max	0	0.8	0	1.7	0.3	0.1	0			0	0	0
	Ave	0	0.2833	0	0.3833	0.1667	0.0333	0			0	0	0
	Min	0	0	0	0	0	0	0	0	0	0	0	0
Sep-00	Max	0	0.5	0.1	1.9	0.2	0.1	0	0	0	0	0	0
	Ave	0	0.125	0.0143	0.425	0.075	0.0875	0	0	0	0	0	0
	Min	0	0	0	0	0	0	0			0	0	0
Oct-00	Max	0	0.4	0.1	0.7	0.3	0.2	0			0.1	0	0.1
	Ave	0	0.2	0.0143	0.1	0.0833	0.0571	0			0.0143	0	0.01429
	Min	0	0	0	0	0	0				0	0	0
Nov-00	Max	0.2	1.3	0.2	0	0	0				1.3	0	1.6
	Ave	0.03333	0.3667	0.0333	0	0	0				0.2167	0	0.5
	Min	0	0	0	0	0	0	0	0	0	0	0	0
Dec-00	Max	0.2	1.2	0.8	0.2	0.3	0.5	0	0	0	0.2	0	0.5
	Ave	0.06667	0.4167	0.15	0.04	0.0667	0.1167	0	0	0	0.0667	0	0.16667
	Min												
Jan-01	Max												
	Ave												
	Min												
Feb-01	Max												
	Ave												
	Min												
Mar-01	Max												
	Ave												
	Min												
Apr-01	Max												
	Ave												
	Min												
May-01	Max												
	Ave												
	Min	0	0.1	0	0	0	0	0	0	0	0	0	0
Jun-01	Max	0.1	0.5	0	0.1	0.4	0	0	0	0	0	0	0
	Ave	0.025	0.3	0	0.05	0.125	0	0	0	0	0	0	0
	Min												
Jul-01	Max												
	Ave												
	Min	0	0	0	0	0	0	0	0	0	0	0	0
Aug-01	Max	0	0.5	0	0	0.3	0	0	0	0	0	0	0
	Ave	0	0.15	0	0	0.175	0	0	0	0	0	0	0
	Min	0	0	0	0	0		0	0	0	0	0	0
Sep-01	Max	0	0	0	0.6	0.1		0	0	0	0	0	0
	Ave	0	0	0	0.2	0.0333		0	0	0	0	0	0
	Min	0	0	0	0	0		0	0	0	0	0	0
Oct-01	Max	0	0.4	0.2	1	0.2		0	0	0	0	0	0.1
	Ave	0	0.1143	0.0286	0.26	0.0429		0	0	0	0	0	0.01429
	Min	0	0	0	0	0	0	0	0	0	0	0	0
Nov-01	Max	0	0.6	0	0	0.4	0	0	0	0	0	0	0
	Ave	0	0.1571	0	0	0.0857	0	0	0	0	0	0	0
	Min	0	0	0	0	0		0			0		0
Dec-01	Max	0.1	1.4	0.5	0.3	0		0			1.3		1.3
	Ave	0.04	0.38	0.26	0.06	0		0			0.425		0.425

OLKARIA II HYDROGEN SULPHIDE DATA

Date	Site	Time	H_2S concentrations (ppm)
19-Jun-02	OW 707	10.40 am	0.3
	OW-M1	10.50 am	0.3
27-Jun-02	OW-727	9.26 am	0.0
	OW-701	9.40 am	1.2
	OW-M1	9.55 am	0.0
	OW-715	10.08 am	0.0
	OW-707	10.23 am	0.6
	OW-708	10.38 am	0.0
	H-Young Office	10.56 am	0.0
	Consultant's office	11.01 am	0.0
	KWS Olkaria Gate	10.52 am	0.0
28-Jun-02	OW-727	10.54 am	0.0
	OW-701	11.08 am	1.2
	OW-M1	12.08 pm	0.0
	OW-715	12.22 pm	0.0
	OW-707	11.50 am	0.2
	OW-708	11.21 am	0.0
	H-Young Office	11.47 am	
	Consultant's office	12.35 pm	0.0
	KWS Olkaria Gate	11.38 am	0.0
01-Jul-02	OW-727	1043 am	0.0
	OW-701	10.28 am	1.7
	OW-M1	9.40 am	0.1
	OW-715	9.52 am	0.0
	OW-707	10.15 am	0.2
	OW-708	9.20 am	0.0
	H-Young Office	9.35 am	0.0
	Consultant's office	10.10 am	0.0
	KWS Olkaria Gate	9.17 am	0.0
03-Jul-02	OW-727	11.44 am	0.1
	OW-701	9.25 am	1.5
	OW-M1	10.40 am	0.0
	OW-715	10.56 am	0.0
	OW-707	11.15 am	0.4
	OW-708	10.15 am	0.0
	H-Young Office	10.37 am	0.0
	Consultant's office	11.10 am	0.0
	KWS Olkaria Gate	10.10 am	0.0
10-Jul-02	OW-727		
	OW-701	9.25 am	1.5
	OW-M1	9.41 am	0.0
	OW-715	10.00 am	0.0
	OW-707	10.15 am	0.1
	OW-708	10.40 am	0.0
	H-Young Office	10.35 am	0.0
	Consultant's office	10.30 am	0.0
	KWS Olkaria Gate	10.55 am	0.0

11-Jul-02	OW-727	3.55 pm	0.0
	OW-701	3.40 pm	1.2
	OW-M1	2.48 pm	0.0
	OW-715	3.05 pm	0.0
	OW-707	3.24 pm	0.3
	OW-708	2.31 pm	0.0
	H-Young Office	2.45 pm	0.0
	Consultant's office	3.18 pm	0.0
	KWS Olkaria Gate	2.27 pm	0.0
17-Jul-02	OW-727	10.00am	0.0
	OW-701	10.15am	3.3
	OW-M1	10.33am	0.0
	OW-715	10.50am	0.0
	OW-707	11.10am	0.2
	OW-708	11.25 am	0.0
	H-Young Office	11.40am	0.0
	Consultant's office	11.06 am	0.0
	KWS Olkaria Gate	11.46 am	0.0
18-Jul-02	OW-727	11.05am	0.0
	OW-701	10.50am	0.0
	OW-M1	9.48am	0.0
	OW-715	10.10am	0.0
	OW-707	10.30am	1.7
	OW-708	9.20am	0.0
	KWS Olkaria Gate	9.35am	0.0
	H-Young Office	9.40am	0.0
	Consultant's office	9.22am	0.0
29-Jul-02	KWS Olkaria Gate	2.35pm	0.1
	OW-708	2.43pm	0.0
	OW-707	3.10pm	1.2
	OW-M1	3.28pm	0.0
	OW-715	3.45pm	0.0
	Consultant's office	4.00pm	0.0
	H-Young Office	4.03pm	0.0
	OW-701	4.11pm	1.0
	OW-727	4.28pm	0.0
01-Aug-02	KWS Olkaria Gate	11.20am	0.0
	OW-708	9.15am	0.0
	OW-707	9.35am	0.0
	OW-M1	10.02am	0.0
	OW-715	10.19am	0.0
	Consultant's office	9.50am	0.0
	H-Young Office	10.34am	0.0
	OW-701	10.45am	0.3
	OW-727	11.05am	0.0
06-Aug-02	KWS Olkaria Gate	10.20am	0.0
	OW-708	10.05am	0.0
	OW-707	11.26am	0.1
	OW-M1	10.35am	0.0
	OW-715	10.56am	0.0
	Consultant's office	11.12am	0.0
	H-Young Office	10.25am	0.0
	OW-701	11.40am	0.7
	OW-727	12.00pm	0.0

08-Aug-02	KWS Olkaria Gate	9.35am	0.0
	OW-708	9.29am	0.0
	OW-707	10.30am	0.2
	OW-M1	9.53am	0.0
	OW-715	10.10am	0.0
	Consultant's office	10.22am	0.0
	H-Young Office	9.41am	0.0
	OW-701	10.48am	1.4
	OW-727	11.08am	0.0
	OW-R3	11.30AM	14.8
13-Aug-02	KWS Olkaria Gate	11.49am	0.0
	OW-708	11.35am	0.0
	OW-707	11.09am	0.7
	OW-M1	10.48am	0.0
	OW-715	10.27am	0.0
	Consultant's office	11.21am	0.0
	H-Young Office	11.24am	0.0
	OW-701	9.45am	0.6
	OW-727	10.08am	0.0
	OW-R1	12.00pm	15.1
15-Aug-02	KWS Olkaria Gate	11.35am	0.0
	OW-708	9.15am	0.0
	OW-707	10.20am	0.3
	OW-M1	9.36am	0.0
	OW-715	9.56am	0.0
	Consultant's office	10.12am	0.0
	H-Young Office	9.28am	0.0
	OW-701	10.39am	3.1
	OW-727	10.58am	0.1
	OW-R1	11.18am	15.5
19-Aug-02	KWS Olkaria Gate	11.42am	0.0
	OW-708	9.25am	0.0
	OW-707	10.41am	0.3
	OW-M1	9.49am	0.0
	OW-715	10.12am	0.0
	Consultant's office	10.29am	0.0
	H-Young Office	9.39am	0.0
	OW-701	11.03am	3.0
	OW-727	11.25am	0.0
	OW-R1	11.55am	17.8
23-Aug-02	KWS Olkaria Gate	4.35pm	0.0
	OW-708	4.22pm	0.0
	OW-707	3.43pm	0.4
	OW-M1	2.53pm	0.0
	OW-715	3.15pm	0.0
	Consultant's office	3.30pm	0.0
	H-Young Office	4.00pm	0.0
	OW-701	2.35pm	4.2
	OW-727	2.15pm	0.0

28-Aug-02	KWS Olkaria Gate	10.52am	0.0
	OW-708	10.35am	0.0
	OW-707	12.00pm	0.2
	OW-M1	11.12am	0.0
	OW-715	11.34am	0.0
	Consultant's office	11.49am	0.0
	H-Young Office	10.59am	0.0
	OW-701	12.22pm	7.9
	OW-R1	12.41PM	11.9
04-Sep-02	KWS Olkaria Gate	9.50am	0.0
	OW-708	9.35am	0.0
	OW-707	11.04am	0.4
	OW-M1	10.15am	0.0
	OW-715	10.37am	0.0
	Consultant's office	10.52am	0.0
	H-Young Office	10.05am	0.0
	OW-701	11.20am	2.0
	OW-727	11.45AM	0.0
12-Sep-02	OW-R1	2.25PM	10.2
	KWS Olkaria Gate	4.50PM	0.0
	OW-708	5.00PM	0.0
	OW-707	4.25PM	0.3
	OW-M1	3.35PM	0.0
	OW-715	3.55PM	0.0
	Consultant's office	4.11PM	0.0
	H-Young Office	4.40PM	0.0
	OW-701	3.10PM	2.9
	OW-727	2.45PM	0.0
16-Sep-02	KWS Olkaria Gate	10.56am	0.0
	OW-708	11.06am	0.0
	OW-707	10.32am	0.8
	OW-M1	9.53am	0.0
	OW-715	10.11am	0.0
	Consultant's office	10.23am	0.0
	H-Young Office	10.50am	0.0
	OW-701	9.36am	
	OW-727	9.15am	0.0
25-Sep-02	KWS Olkaria Gate	10.50am	0.0
	OW-708	10.35am	0.0
	OW-707	12.03pm	1.2
	OW-M1	11.11am	0.0
	OW-715	11.31am	0.0
	Consultant's office	11.50am	0.0
	H-Young Office	10.59am	0.0
	OW-701	12.25pm	4.3
	OW-727	12.46pm	0.0
16-Oct-02	KWS Olkaria Gate	12.00pm	0.0
	OW-708	11.45am	0.0
	OW-707	11.15am	0.1
	OW-M1	10.25am	0.0
	OW-715	10.45am	0.0
	Consultant's office	11.30am	0.0
	H-Young Office	11.35am	0.0
	OW-701	10.05am	1.7
	OW-727	9.45am	0.0

06-Nov-02	KWS Olkaria Gate	10.15am	0.0
	OW-708	10.20am	0.0
	OW-707	11.20am	0.1
	OW-M1	10.40am	0.0
	OW-715	11.00am	0.0
	Consultant's office	10.30am	0.0
	H-Young Office	10.25am	0.0
	OW-701	11.40am	0.0
	OW-727	12.00pm	0.0
19-Nov-02	KWS Olkaria Gate	9.25am	0.0
	OW-708	9.10am	0.0
	OW-707	10.30am	0.8
	OW-M1	9.40am	0.0
	OW-715	10.05am	0.0
	Consultant's office	10.20am	0.0
	H-Young Office	9.30am	0.0
	OW-701	10.50am	1.7
	OW-727	11.10am	0.0
26-Aug-03	OLKARIA-II		
	Office	9.25am	0.0
	Cooling tower	9.30am	0.0
	P/Station	9.35am	0.0
	Sealpit	9.41am	0.0
12-Sep-03	Office	8.50am	0.1
	Cooling tower	9.16am	0.0
	P/Station	9.00am	0.1
	Sealpit	9.10am	0.0
	Office	11.46am	0.1
	Cooling tower	11.35am	0.0
	P/Station	11.41am	0.0
	Sealpit	11.30am	0.0
15-Sep-03	KWS Olkaria Gate	9.25am	0.0
	Cooling tower	9.30am	0.0
	Sealpit	9.35am	0.0
	P/Station	9.40am	0.0
	Office	9.46am	0.1
	Cooling tower	11.45am	0.0
	Sealpit	11.51am	0.0
	P/Station	11.56am	0.0
	Office	12.02am	0.1
18-Sep-03	Cooling tower	8.35am	0.0
	Sealpit	8.40am	0.1
	P/Station	8.45am	0.1
	Office	8.25am	0.0
	Cooling tower	11.14am	0.3
	Sealpit	11.25am	0.1
	P/Station	11.30am	0.1
	Office	11.35am	0.3
	KWS Olkaria Gate	11.40am	0.0
22-Sep-03	KWS Olkaria Gate	10.27am	0.3
	Sealpit	10.33am	0.2
	P/Station	10.38am	0.0
	Office	10.44am	0.3
	Cooling tower	10.20am	0.2

01-Oct	KWS Olkaria Gate	1.30am	0.1
	Cooling tower	1.38am	0.1
	Sealpit	1.44am	0.0
	Office	1.50am	0.1
03-Oct-03	KWS Olkaria Gate	8.30am	0.1
	Cooling tower	10.05am	0.0
	Sealpit	10.10am	0.0
	Office	10.15am	0.0
07-Oct-03	KWS Olkaria Gate	8.45am	0.0
	Cooling tower	11.05am	0.1
	Sealpit	11.10am	0.0
	Office	11.14am	0.1
10/09/03	Cooling tower	11.15am	0.3
	Sealpit	8.20am	0.0
	Office	8.25am	0.0
	KWS Olkaria Gate	10.35am	0.0
31/10/2003	Cooling tower	2.30pm	0.0
	Sealpit	2.35pm	0.0
	P/Station	2.40pm	0.0
	Office	2.45pm	0.0
15/10/2003	Cooling tower	10.00am	0.1
	Sealpit	10.10am	0.0
	P/Station	10.15am	0.1
	Office	10.20am	0.1
23/10/2003	Cooling tower	12.10pm	0.3
	Office	12.15pm	0.9
	Sealpit	12.20pm	0.3
	P/Station	12.25pm	0.1
28/10/2003	Cooling tower	9.30am	0.0
	Office	9.45am	0.0
	P/Station	9.50am	0.0
	Sealpit 1	9.55am	0.0
	Sealpit 11	10.00am	0.0
30/10/2003	Office	9.05am	0.0
	P/Station	9.15am	0.0
	Sealpit 1	9.20am	0.0
	Sealpit 11	9.25am	0.0
	Cooling tower	9.30am	0.0
	KWS Olkaria Gate	9.35am	0.0
11/07/03	KWS Olkaria Gate	8.15am	0.0
	Office	8.20am	0.0
	P/Station	8.26am	0.2
	Sealpit 1	8.31am	0.0
	Sealpit 11	8.37am	0.0
	Cooling tower	8.41am	0.1
27/11/2003	Cooling tower	12.05pm	0.0
	Sealpit 1	12.10pm	0.0
	Office	12.15pm	0.0
	P/Station	12.25pm	0.0
	KWS Olkaria Gate	12.30pm	0.0
12/03/03	Cooling tower	2.10pm	0.1
	Sealpit 1	2.15pm	0.0
	P/Station	2.25pm	0.0
	Office	2.30pm	0.0
	KWS Olkaria Gate	2.28pm,	0.0
29/12/2003	Office	8.20am	0.1
	Cooling tower	8.25am	0.0
	Sealpit 1	8.30am	0.0
	P/Station	8.35AM	0.0

2004			
13/1/2004	P/Station		0.0
	Sealpit 1		0.0
	Cooling tower		1.0
	Sealpit 11		0.0
	P/Station		0.1
15/1/2004	Office	2.15pm	0.0
	P/Station	2.35pm	0.0
	Sealpit 1	2.29pm	0.0
	Cooling tower	2.23pm	0.0
22/1/2004	Cooling tower	9.06am	0.0
	P/Station	9.26am	0.0
	Office	9.33am	0.0
	Sealpit 1	9.10am	0.0
	Sealpit 11	9.15am	0.0
03/03/04	Cooling tower	10.00am	0.0
	Office	10.15am	0.0
	Sealpit 1	10.20am	0.0
	Sealpit 11	10.25am	0.0
03/04/04	Office	8.45am	0.4
	Sealpit 1	9.05am	0.0
	Sealpit 11	9.00am	0.7
	P/Station	9.15am	0.3
	Cooling tower	9.10am	0.7
03/10/04	Office	2.00pm	0.0
	Cooling tower	2.05pm	0.0
	Sealpit 1	2.10pm	0.0
	Sealpit 11	2.15pm	0.0
	P/Station	2.20pm	0.0
18/3/2004	Cooling tower	2.40pm	0.0
	Office	2.30pm	0.0
	P/Station	2.35pm	0.0
	Sealpit 1	2.45pm	0.0
	Sealpit 11	2.50pm	0.0
24/3/2004	Cooling tower	9.20AM	0.2
	Office	9.25am	0.1
	p/Station	9.30am	0.0
	Sealpit 1	9.35am	0.0
	Sealpit 11	9.40am	0.1
04/07/04	Cooling tower	8.30am	0.0
	Sealpit 1	8.35am	0.0
	Sealpit 11	8.40am	0.0
	Office	8.45am	0.0
21/4/2004	Cooling tower	9.10am	0.0
	Sealpit 1	9.15am	0.0
	Sealpit 11	9.15am	0.0
	Office	9.22am	0.0
	P/Station	9.27am	0.0
28/4/2004	Cooling tower	8.05am	0.0
	Sealpit 1	8.10am	0.0
	Sealoit 11	8.15am	0.0
	Office	8.20am	0.0
	P/Station	8.25am	0.0

ANNEX 5

FLORA OF THE PROJECT AREA

ACANTHACEA
Moechma debile (Forssk.) Nees
Justicia sp 'A' of U.K.W.F.
Hypoestes arisata (Vahl) Roem. & Schult.
Thunbergia verticillaris Sims
Hypoestes veticillaris (Linn.f.)
Roem, & Schult
Dyschoriste radicans Nees

ADIANTACEA
Pellaea calomelanos (Swartz) Link
P. quadripinnata (Forssk.) Prantl
P. adiantoides (Wild.) J. Sm
P. viridis (Forssk.) Prantl
Actiniopteris radiate (Swartz) Link

AGAVACEAE
Sansevieria ehrenbergii Bak.
S. intermedia N.E. Br.

AIZOACEA
*Hypertelis bowkeriana S*ond.
Delosperma nakurense (Engl.) Herre
Sesuvium sp.

AMARANTHACEAE
Aerva lanata (L.) Juss.
Cythula cylindrical Moq.
Amarathus hybridus L.
Achyranthes aspera L. va. Pubescens (Moq.)
C.C. Townsend
Gomphrena celosioides Mart.

ANACARDIACEAE
Rhus natalensis Krausss
Rhus vulgaris Miekle

APOCYNACEAE
Carrisa edulis (Forssk.(Vahl
Acokanthera schimperi (DC.) Benth
Schefflera volkensii (Harms) Harms
Cussonia spicata
C. arboea

ASCLEPAIDACEA
Sarcistenna vunubake (L.) R. Br.

GLEICHENIACEAE
Dicranopteris linearis (Burm.f.)

ASPLENIACEAE
Asplenium aethiopicum *(Burm. f.)*
Becherer

BORAGINACEA
Asplenium steudneri *Vatke ssp*
Bullatum Verdc.

CEASALPINIACEAE
Cassia didymobotrya Fres.
C. grantii Oliv.
C. mimosoides L.

CAPPARACEAE
Capparis tomentosa L.
Maerua sp.
Cleome monophylla L.

CAMPANULACEAE
Wahlenbergia abyssinica (A. Rich.) Thulin
W. virgata Engl.

CARYOPHYLLACEAE
Pollichia campestris *Ait*
Silene burchellii DC

CARYPHYLLACEAE
Pollichia campestris Ait.
Silene burchellii DC.

CHENOPODIACEAE
Chenopodium opulifolium Koch. & Ziz.
C carinatum R. Br.
C. pumilio R. Br.

COMMELINACEAE
Commelina benghalensis L.
C. imberbis Hassk.
C. africana L.
C. purpurea Rendle
Aneilema sp.

COMPOSITAE
Tarchonanthus camphorates L.
Psiadia punctulata (DC.) Vatcke
Tagetes minuta L.
Bidens pilosa L.
Osteospermum vaillantii (Decne) T. Norl.
Aspilia mossambicensis (Oliv.) Wild
Bothriocline fusca (S. Moore) M. Gilbert
Notonia hildebrandtii Vatcke
Felicia abyssinica A. Rich. (Thunb.) Nees
F. municata
Carduus nyassanus (S. Moore) R.E. Fries
Helichrysum cymosum
H. globesum Sch. Bip.
H. glumaceum DC.
H. odoratissimum (L.) Less.
Bidens ruepellii (Sch. Bip.) Sherff
Galinsoga parviflora Cav.

G. ciliata (Rafn.) Blake
Artemisia afra Willd.
Conyza newii Oliv. & Hiern
Crassocephalum mannii (hook. f.) Milne-Redh.
C. crepidioides (Benth.) S. Moore
Pluchea bequaertii Robyns
Vernonia lasiopus O. Hoffmn.
Hirpicium diffusum (O. Hoffm.) Roess.-
Gutenbergia cordifolia Oliver
Senecio handensis S. Moore (syn. S. petitianus)

CRASSULACEAE
Crassula coleae Bak.
C.alba Forssk.
C. pentandra (Edgerworth) Schonl.-
C. alsinoides (Hook. f.) Engl.
C. volkensii Engl.
Cotyledon barbeyi Schweinf.
Kalanchoe densiflora Rolfe
K. glaucescens Britten
K. lanceolata (Forssk.) Pers.-
Umbilicus botryoides A. Rich

CRUCIFERAE
Rorippa cryptantha (A. Rich.) Rob. et Boutique)
R. micrantha (Roth) Jonsell
Farsetia undulicarpa Jonsell
F. stenoptera Hochst. *ssp. stenoptera*
Crambe abysssinica R.E. Fries

CUCURBITACEAE
Cucumis sp.
Kedrostis foetidissima (Jacq.) Cogn.
Zehneria scabra (Lin. f.) Sond.

CUPPRESSACEAE
Juniperus procera Endl.

CYPERACEAE
Fimbristylis exilis (H.B.K.) Roem. & Schult.
F. hispidula (Vahl) Kunth
Bulbostylis coleotricha (A. Rich.) C.B. Cl.
Mariscus amauropus (Stendel) Curf.
Cyperus obtusiflorus Vahl
C. rigidifolius Steudel
C. laevigatus
C. immensus C.B. Cl.

DAVALLACEAE
Oleandra distincta Kunze

EBENACEAE
Euclea divinorum Hiern

ERICACEAE
Agauria salicifolia (Lam.) Oliv.
Erica arborea L.

EUPHORBIACEAE

Euphorbia inaequilatera Sond.
E. kibwezensis
Ricinus communis L.
Phyllanthus rotundifolius Willd.

FLACOURTIACEAE
Dovyalis abyssinica (A. Rich.) Warb.

GERANIACEAE
Geranium aculeolatum Oliv.
G. ocellatum Cambess.
Monsonia Angustifolia A. Rich.
Pelargonium allchemilloides (L.) Ait.

GLEICHENIACEAE
Gleichenia linearis (Burm.) C.B. Cl.
Dicranopteris linearis (Burm. f.) Underw.-

GRAMINEAE
Rhynchelytrum repens (Willd.) C.E. Hubbard
Setaria pumila (Poir.) Roem. & Schult.
Panicum maximum Jacq.
Sporobolus fimbriatus (Trin.) Dur. & Sch.
Eragrostis cilianesis (All.) F.T. Hubboard
Brachiaria leersioides (Hochst.) Stapf
Pennisetum squamulatum Fresen
P. Procerum (Stapf) W.D. Clayton
P. clandestinum Chiov.
Cynodon dactylon (L.) Pers.
C. nlemfuensis Vanderyst var. nlemfuensis
C. plectostachyus (K. Schum.) Pilg.
Chloris gayana Kunth
Harpachne schimperi A. Rich.
Hyparrhenia hirta (L.) stapf
H. papillipes (A. rich.) Stapf.
Themeda triandra Forssk.
Tragus berteronianus Schult.
Digitaria abyssinica (A. Rich.) Stapf-
Aristida keniensis Henr.
A. congesta Roem. & Schult.
A. adoenisis Hochst.
A. mutabilis Trin. & Rupr.
Cymbopogon nardus (L.) Rendle
Sporobolus africanus (Poir.) Robyns & Tourney
S. macranthelus Chiov.
Setaria sphacelata (Schummach.) Moss var. aurea
(a. Br.) W.D. Clayton
Eragrostis racemosa (Thunb.) Steud.
E. tenuifolia (A. Rich.) Steud.
E. tenuifolia (A. Rich.) Steud.
E. olivacea K. Schum.
E. braunii Schweinf.
Dactyloctenium aegyptium (L.) Wild.
Paspalum scrobiculatum L.
Microchloa kunthii Desv.
Heteropogon contortus (L.) Roem. & Schult.

HYPERICACEAE
Hypericum revolutum Vahl

IRIDACEAE
Aristea angolensis Bak.
Gladiolus newii Baker ssp. newii

LABIATAE
Tetradenia riparia (Hochst.) Codd
Becum obovatum (E. Mey.) N.E. Br.
Ocimum suave Willd.
Leucas glabrata (Vahl) R. Br.
L. pratensis Vatke
L. neuflizeana Courb.-
Plectranthus marrubioides R.H. Willemse
P. zatarhendi (Forssk.) E.A. Bruce
P. caninus Roth
P. pubescens Bak.
Leontis mollissima Guerke
L. nepetifolia R. Br.
Satureja biflora (D. Don) Benth.
Iboza multiflora (Benth.) E.A. Bruce
Fuerstia africana T.C.E.Fr.

LILIACEAE
Asparagus buchananii Bak.
A. africanus Lam.
Bulbine abyssinica R. Rich.
Kniphofia thomsonii Bak.
Aloe kedongensis Reynl.
A. myriacantha (Harv.) R. & S.
A. secundiflora Engl.
Gloriosa superba L.

LINACEAE
Linum volkensii Engl.

LOBELIACEAE
Lobelia holstii Engl.

LOGANIACEAE
Buddleia polystachya Fresen.

LORANTHACEAE
Englerina heckmanniana (Engl.) Balle
Odontella fischeri Engl.
Tapinanthus zizyphifolius (Engl.) Danser

LYCOPODIACEAE
Lycopodium cernuum L.

MALVACEAE
Abutilon mauritianum (Jacq.) Medic.
A. longiscupe Hochst.
Hibiscus fuscus Garcke
H. flavifolius Ulbr.
H. aponeurus Sprague & Hutch.
Sida tenuicarpa Vollensen
S. cuneifolia Roxb.
S. rhombifolia L.
S. schimperiana A. Rich.-
S. ovata Forssk.

Pavonia patens (Andr.) Chiov.

MELASTOMATACEAE
Dissotis irvingiana Hook. var. alperstis (Taub.) A.R. Fernandes
Forma alpestris
D. senegambiensis (Guill. & Perr.) Tiana var. *senegambiensis*
S. senegambiensis (Guill. & Perr) Triana var. *alpestris* (Taub.) A. & R. Fernandes

MELIACEAE
Ekebergia capensis Sparrm.

MIMOSACEAE
Acacia seyal Del. var. seyal
A. gerrardii Benth. var. gerrardii
A. drepanolobium Sjostedt
A. xanthophloea Benth.

MORACEAE
Ficus ingens Miq.
F. pretoriae B. Davy
F. thonningii Guerke

MYRICACEAE
Myrica salicifolia A. Rich.

MYRSINACEAE
Myrsine africana L.

OLEACEAE
Olea europaea L. ssp. *africana* (Mill.) S.P. Green

OPHIOGLOSACEAE
Ophioglossum rubellum A. Br.

ORCHIDACEAE
Angraecum humile Summer
Ansellia gigantean Reichb. f. var. nilotica
Cyrtorchis arcuata (Lindl.) Schltr.
Pleroglossaspis ruwenzoriensis Rolfe

OXALIDACEAE
Oxalis obliquifolia A. Rich.

PAPIOLIONACEAE
Crotalaria sp. aff. C. *chrysochlora* Harms
C. dewildermaniana Wilczek
C. deserticola Bak. f.
C. agatiflora Schweinf. ssp. engleri (Taub.) *Polhil*
C. spinosa Benth.
C. incana L. ssp. purpurescens (Lam.) Milne-Redh.
C. agatiflora Schweinf. ssp. agatiflora
C. chrysochlora Harms
Indigofera tanganyikensis Bak. f. var.

strigulosior Gillett
I. ambelacensis Schweinf.
I. masaiensis Gillett
I. bogdanii Gillett
I. arrecta A. Rich.
Zornia pratensis Milne-Redh.
Z. setosa Bak. f. ssp. *obovata* (Bak.f.)
J. Leon & Milne-Redh.
Argyrolobium rupestre (E. Mey.) Walp.
Lotus becquetii Boutique
L. goetzii Harms
Macrotyloma axillare (E. Mey.) Verdc.
Tephrosia emeroides A. Rich.
T. linearis (Willd.) Pers.

PITTOSPORACEAE
Pittosporum viridiflorum Sims

PHYTOLACCACEAE
Phytolacca dodecandra L'Herit.
P. octandra L.

POLYPODIACEAE
Pleopetis macrocarpa (Willd.) Kaulf.

POLYGALACEAE
Polygala abyssinica R. Br.
P. amboniensis Gurke
P. sphenopterea Fresen.

POLYGONACEAE
Rumex usambarensis (Damer) Dammer
Polygonum senegalense Meisn.
Oxygonum sinuatum (Meisn.) Dammer

PROTEACEAE
Protea gaguedi J.F. Gmel.

RHAMNACEAE
Scutia myrtina (Burm. f.) Kurz.

RUBIACEAE
Galium aparinoides Forssk.
G. spurium L.
Kohautia caespitose Schnizl. var.
amaniensis (K. Krause) Brem.
Pentas zanzibarica (KI.) Vatke
P. parvifolia Hiern
Oldenlandia corymbosa L.
O. scopulorum Bullock
O. wiedemannii K. Schum.
Rubia cordifloia L.
Pentanisia ouranogyne S. Moore
canthium phyllanthoideum Baill.
RUTACEAE
Teclea simplicifolia (Engl.) Verdoon

SANTALACEAE
Osyris abyssinica A. Rich.

SAPINDACEAE
Allophylus abyssinicus (Hochst.) Radlk.
Dodonea angustifolia L.f.
D. viscose L. Jacq.

SCROPHULARIACEAE
Alectra sessiliflora (Vahl.) Kunth
var. senegalensis (Benth.) Hepper
Misopates orontium (L.) Rafin
Cycnium volkensii Engl.
C. tubulosum (L.f.) Engl. ssp.
montanum (N.E.Br.) O.J. Hansen
(*syn. Rhamphicarpa Montana*)
Striga linearifolia (Schum. & Thonn.) *Hepper*
Hebenstretia dentate L.
Pseudosopubia hildebranditii (Vatke) Engl.
Striga asiatica (L.) Kuntze
Cycniopsis obtusifolia Skan
Craterostigma pumilum Hochst.

TILIACEAE
Grewia similis K. Schum.

TYPHACEAE
Typha latifolia L.
T. domingensis Pers.

ULMACEAE
Trema guineensis (Schm. & Thonn.) Ficalho

SOLANACEAE
Solanum incanum L.
S. mauense Bitter
S. nigrum L.
Cestrum aurantiacum Lindl.
Datura stramonium L.
Nicotiana glauca R. Grah.
Withania somnifera (L.) Dunal

UMBELLIFERAE
Ferula communis L.
Heteromorpha trifoliolata (Wendl.) Eckl,. & Zeyh

VERBENACEAE
Clerodendrum myricoides Vatke
Lippia ukambensis Vatke
L. javanica (Burm.f.) Spreng
Lantana camara L.

VISCACEAE
Viscum tuberculatum A. Rich.

VITACEAE
Cyphostemma nierense (Th. Fr. jr.) Desc.

ZYGOPHYLLACEAE
Tribulus terrestris L.

Source: Sinclair Knight et al. 1992.

ANNEX 6

MAMMALS OF HELL'S GATE NATIONAL PARK

Aardvark	*(Orycteropus afer)*
Buffalo	*(Syncerus caffer)*
Dik-dik	*(Rhynchotragus Kirkii)*
Eland	*(Taurotragus oryx)*
Giraffe	*(Giraffa cemelopardalis)*
Grants gazelle	*(Gazella grantii)*
Hare	*(Lepus spp.)*
Hedgehog	*(Erinaceus albiventris)*
Impala	*(Apyceros melampus)*
Jackal	*(Canis spp.)*
Klipspringer	*(Oreotragus oreotragus)*
Kongoni	*(Alcephalus buselaphus coki)*
Leopard	*(Panthera pardus)*
Lion	*(Panthera leo)*
Mole rat	*(Tachyorectes plendens)*
Olive baboon	*(Papio anubis)*
Rat-like rodents	
Reedbuck	*(Rendunca redunca)*
Rock hyrax	*(Heterophyrax brucei)*
Spring hare	*(Pedetes capensis)*
Squirrel	*(Finisciurus spp.)*
Steinbuck	*(Rhaphicerus campestris*
Thompsons gazelle	*(Gazella thomsonii)*
Warthog	*(Phacochoerus aethiopicus)*
Waterbuck	*(Kobus defessa)*
Zebra	*(Equus burchelli)*

Source: Sinclair Knight et al. 1992.

ANNEX 7

BIRDS OF HELL'S GATE NATIONAL PARK

Abyssinian Scimitarbill	*(Phoeniculus minor)*
African Fish Eagle	*(Haliaeetus vocifer)*
African Hawk Eagle	*(Hieraaetus spilogaster)*
African Hobby	*(Falco cuvieri)*
African Hoopoe	*Upupa epops*
African Pied Wagtail	*(Moticilla aguimp)*
African Rock Martin	*(Hirundo fuligula)*
Anteater Chat	*(Myrmecocichla aethiops)*
Auger Buzzard	*(Buteo rufofuscus)*
Batleur	*(Terathopius ecaudatus)*
Bearded Woodpecker	*(Thripias namaquus)*
Black-backed puffback	*(Dryoscopus cubla)*
Black-breasted Apalis	*(Apalis flavida)*
Black-headed Oriole	*(Oriolus larvatus)*
Black-lored Babbler	*(Turdoides melanops)*
Blue-eared Glossy Starling	*(Lamprotornis chalybaeus)*
Brimstone Canary	*(Serinus sulphuratus)*
Bronze Sunbird	*(Nectarinia kilimensis)*
Brown Woodland Warbler	*(Phylloscopus umbrovirens)*
Brown-headed Tchagra	*(Tchagra Australia)*
Buff-bellied Warbler	*(Phylloclais pulchella)*
Chin-spot Flycatcher	*(Batis molitor)*
Cinnamon-breasted Rock Bunting	*(Emberiza tahapisi)*
Cocqui Francolin	*(Francolinus coqui)*
Common Sandpiper	*(Tringa hypoleucos)*
Common Waxbill	*(Estrilda astrild)*
Crimson-rumped Waxbill	*(Estrilda rhodopyga)*
Crombec	*(Sylvietta brachyrura)*
Crowned Plover	*(Vanelus coronatus)*
Didric Cuckoo	*(Chrysococcyx caprius)*
Diongo	*(Dicurus adsimilis)*
Dusky Flycatcher	*(Alsenax adustus)*
Egyptian Vulture	*(Neophron percnopterus)*
European Swallow	*(Hirundo rustica)*
Fiscal Shrike	*(Lanius collaris)*
Fox Kestrel	*(Falco alopex)*
Golden-breasted Bunting	*(Emeriza flaviventris)*
Gold-tailed Woodpecker	*(Campethera cailliautii)*
Grey Flycatcher	*(Bradornis microrhynchus)*
Grey Wagtail	*(Motacilla Clara)*
Grey-backed Camaroptera	*(Camaroptera brevicaudata)*
Grey-backed Fiscal Shrike	*(Lanius excubitorius*
Grey-headed Sparrow	*(Passer griseus)*
Grey-rumped Swallow	*(Hirundo griseopyga)*
Harrier Hawk	*(Polybariodes radiatus)*
Helmeted Guinea Fowl	*(Numida melaegris)*
Hildebrandt's Francolin	*(Francolinus hildebranti)*
Horus Swift	*(Apus hours)*
Hunter's Sunbird	*(Nectarinia hunteri)*
Klaas's Cuckoo	*(Chrysococcyx klaas)*
Kori Bustard	*(Ardeotis kori)*
Lammergeyer	*(Gypaetus barbatus)*
Lanner	*(Falco biarmicus)*
Laughing Dove	*(Streptopelia senegalensis)*
Little Swift	*(Apus affinis)*

Long-crested Eagle	*(Lophaetus occipitalis)*
Mottled Swift	*(Apus aequatorialis)*
Nightjar sp.	*(Caprimulgus sp.)*
Nubian Vulture	*(Torgos tracheliotus)*
Nyanza Swift	*(Apus niansae)*
Ostrich	*(Struthio cemlus)*
Peregrine	*(Falco peregrinus)*
Pin-tailed Whydah	*(Vidua macroura)*
Plain-backed pipit	*(Anthus leucophrys)*
Purple Grenadier	*(Uraeginthus ianthinogaster)*
Rattling Cisticola	*(Cisticola chiniana)*
Red-billed Oxpecker	*(Buphagus erythrorhynchus)*
Red-chested Cuckoo	*(Cuculus solitarius)*
Red-eyed Dove	*(Streptopelia semitorquata)*
Red-faced Apalis	*(Apalis rufifrons)*
Red-rumped Swallow	*(Hirundo daurica)*
Redwing Bush Lark	*(Mirafra hypermetra)*
Redwing Starling	*(onychognathus morio)*
Richard's Pipit	*(Anthus novaeseelandiae)*
Richenow's Weaver	(ploceus baglafeht)
Ring-necked Dove	*(Streptopelia capicola)*
Robin Chat	*(Cossypha caffra)*
Rufous Sparrow	*(Passer motitensis)*
Rufus-naped Lark	*(Mirafra africana)*
Rupell's Vulture	*(Gyps ruppellii)*
Scaly Francolin	*(Francolinus Squamatus)*
Scarlet-chested Sunbird	*(Necterinia senegalensis)*
Schalow's Wheatear	*(Oenanthe lugubris)*
Secretary Bird	*(Saggitarius serpentarius)*
Speckled Mousebird	*Colius Striatus*
Speckled Pigeon	*(Columba guinea)*
Spotted Eagle Owl	*(Bubo africanus)*
Stone Chat	*(Saxicola torquata)*
Superb Starling	*(spreo superbus)*
Tawny Eagle	*(Aquila rapax)*
Tawny-flanked Prinia	*(Prinia sublava)*
Temminck's Courser	*(Cursorius temminckii)*
Tropical Boubou	*(Laniarius ferruineus)*
Variable Sunbird	*(Necterinia venusta)*
Verreaux's Eagle	*(Aquila verrauxii*
Vitteline Masked Weaver	(ploceus velatus)
Whalberg's Eagle	*(Aquila wahlbergi)*
White Pelican	*(Pelicanus onocratalus)*
White-backed Vulture	*(Gyps bengalensis)*
White-browed Coucal	*(Centropus superciliosus)*
White-browed Robin Chat	*(Coccypha heuglini)*
White-eyed Slaty Flycatcher	*(Dioptornis fischeri)*
White-fronted Bee Eater	*(Merops bullockoides)*
Willow Warbler	(Phylloscopus trochilus)
Wood Warbler	*(Phylloscopus sibilatrix)*
Yellow Bishop	*(Euplectes capensis)*
Yellow-rumped Seed Eater	*(Serinus atrogularis)*
Yellow-vented Bulbul	*(Pycnonotus barbatus)*

Source: Sinclair Knight et al. 1992.

ANNEX 8

LIST OF LAWS RELEVANT TO THE PROJECT

Act / Bill	Relevant Part or Section	Provisions
Environmental Management & Coordination Act (1999)	Part II General Principles Section 3	- provides for compensation for any victim of pollution and the cost of any beneficial losses therefrom - provides for any person to compel the company to restore a degraded environment to its immediate condition prior to damage
	Part V Protection and Conservation of the Environment Section 42, 56	- provides for standards for the management of lakeshores - protects the interests of communities within or around a lakeshore or wetland - requires NEMA to issue guidelines and programmes to minimise damage to the ozone layer
	Part VI Environmental Impact Assessment	- for any project falling within the Second Schedule, the Act requires a proponent to apply for an EIA License by submitting a project report
	Part VII Environmental Audit and Monitoring Section 68	- requires accurate records to be kept and annual audit reports to be submitted - environmental inspectors may enter premises to assess conformance and for monitoring purposes
	Part VIII Environmental Quality Standards Sections 71, 72, 73, 74, 75, 78, 79, 80, 86, 87, 88, 89, 91, 92, 93, 101, 104, 105, 107	- requires NEMA to set standards for emissions, ambient and occupational air quality and protocols for monitoring. - makes it an offence to pollute. - gives powers to NEMA to inspect facilities for air pollution. - requires applications to be submitted for emission licences within 12 months of the Act coming into operation - requires NEMA to set standards for use of water for industrial purposes, discharge of effluents and protocols for monitoring. - makes it an offence to pollute any aquatic environment. - requires industries to supply plant information on discharge effluents. - requires industries to discharge effluents only into existing sewerage systems. - requires an effluent discharge licence for the discharge of any effluents directly into the environment. - applications to be submitted for discharge licences within 12 months of the Act coming into operation - requires NEMA to issue guidelines and prescribe measures for management of materials that are dangerous to human health and the environment, prescribe standards for waste, their classification and analysis and advise on standards for waste disposal. - prohibits the disposal / discharge of waste which could cause pollution or pose a risk to human health - requires that persons transporting waste from a site require a licence.

Act / Bill	Relevant Part or Section	Provisions
		- requires any person who owns or operates a waste disposal site to apply for a licence. - requires NEMA to issue guidelines for the management of hazardous waste - requires activities generating hazardous waste to obtain a licence - prohibits the discharge of hazardous substances, chemicals and maeriasl or oil into the environment - regulates the storage and handling of toxic and hazardous waste, chemicals and materials - the transportation of hazardous waste requires a permit - requires NEMA to set standards for noise level and noise emissions for construction sites, plant and machinery - makes it an offence to emit noise in excess of the prescribed standards. - requires NEMA to prepare standards for ionising and other radiation - allows inspectors to enter, inspect and examine any premises where ionisation radiation is used/stored. - requires NEMA to set standards for the control of noxious smell.
	Part X Inspection, Analysis and Records Sections 117, 118, 121,122	- environmental inspectors to monitor compliance, use of environmental resources, conduct audits. - inspectors may require facilities to obtain analysis certificates at their discretion.
Geothermal Resources Act (1982)		- Controls the exploitation and use of geothermal resources - Requires licence to be issued for use of geothermal resources
	Part II – Exploitation of Geothermal Resources	- Requires every bore to be closely supervised, maintained in a safe condition and finally left in a condition of lasting safety
	Part III – Safety and Accidents	- Licensee is responsible for loss, damage or injury resulting from works or operations. - A bore may be closed if it is a source of danger to persons or property or is a nuisance - A bore may be closed for the protection of the environment, including groundwater against contamination
Geothermal Resources Regulations (1990)	Part II – Application for Authority and Licence	- geothermal license does not authorise applicant to exercise rights in a national park.
	Part III – Drilling	- requires protection of human and wildlife resources from unacceptable noise levels - operations must be conducted to minimise erosion and disturbances to natural drainage - requires protection of quality of surface waters, air and other natural resources, including wildlife, soil, vegetation, natural history, scenic and recreational resources, during operations. - requires licensee to conduct all operations so as to afford protection of fish, wildlife and natural habitats
Electric Power Act (1998)	Part II – Licensing	- Regulates the generation and supply of electricity - Requires electric power producers to be licensed

Act / Bill	Relevant Part or Section	Provisions
Public Health Act (rev. 1986) Cap 242	Part IX Sanitation and Housing Section 115, 116, 17, 118, 121, 126	- makes it an offence to emit smoke in such quantity or manner as to be offensive or injurious or dangerous to health - makes it an offence to emit any smell that is offensive, injurious or dangerous to health, and thereby causes a nuisance - nuisances liable to be injurious or dangerous to health are unlawful. - Penalties shall be accrued for those failing to remove the nuisance. - can confer powers to local authorities to inspect buildings, factories and trade premises
	Part XI – Public Water Supplies, Sections 129, 130	- the local authority is responsible for the prevention of any pollution to any water supplies used for human and domestic consumption.
	Seventh Schedule – Rules under Section 126, Drainage and Latrine rules	- the local authority is responsible for the passing and rejection of building plans including the supervision of drainage structures.
Factories Act (rev. 1972) Cap 514	Part III Registration of Factories Section 8	- requires registration of existing factories
	Part III – Health, Safety and Welfare – Special Provisions and Rules Section 53, 55	- suitable provisions to be made for protective clothing. - Minister may modify or limit the hours of exposure
	Part IV – Health – General Provisions Section 13, 15, 17	- refers to the removal of waste from floors, benches of workrooms, staircases and passages - suitable provisions to be made for securing and maintaining the circulation of fresh air in each work room
	Part V – Safety – General Provisions Sections 21, 22, 23, 27, 39, 41	- requires that all moving parts be fenced off, unless it is in such a position or of such construction to be safe to all employees - requires that every fixed vessel, structure, sump or pit containing dangerous chemicals where the edge is less than three feet above the adjoining ground shall be covered or fenced to prevent any person falling into that vessel, structure, etc - requires all stocks of inflammable substances to be kept in a fire-resisting store or in a safe place outside any occupied building - specifies operating requirements for air compressors - has standards for air emissions
Local Government Act (rev. 1998) Cap 265	Part X – Certain Powers, Duties, Provisions relating to Municipalities etc. Section 163, 176	- makes it an offence to emit smoke, fumes, chemicals, gases, dust, and smells that may be a source of danger, discomfort, or annoyance. - gives the municipal council the authority to regulate sewerage and drainage. - Persons intending to carry out sewage or drainage works must give notice to the local authority
	Part XI Certain Powers, Duties, Provisions relating to Municipalities	- empowers local authorities to grant a licence to carry out business, trade or occupation - empowers local authorities to grant licences to carry out business, trade or occupation

Act / Bill	Relevant Part or Section	Provisions
Physical Planning Act (1996) Cap 286	Part V – Control of Development, Sections 29, 30, 31, 32, 36	- the local authority can prohibit/control development of buildings, approve development applications and grant development permission - Individuals shall be liable to a fine or imprisonment if they break the law - empowers local authorities to request existing facilities to conduct environmental assessments
Building Code (1997)	Part I – Introductory, By-laws 3, 4, 5, 6, 16	- prior to erection of buildings an application, submission of plans and payment of fees are to be made to the municipal/county council
	By-law 143, 171, 180, 181, 183, 196, 197, 198, 202, 251	- a sufficient supply of water is required for the building - Sub-soil, surface/storm or rainwater is to be kept separate from sewage water or wastewater - Provisions are to be made for conveying rainwater from the building to a public drain - All drains shall be properly ventilated and all ventilating and waste pipes are to comply with the by-laws. - Suitable storage measures are to be set out for liquid waste
Building Code (1997) Local Government Regulations (1963)	Schedule Part III Miscellaneous Section 31	- contains requirements relating to certificates for occupation of premises
Trade Licensing Act Cap 497		- requires a licence for carrying out of business related activities
Penal Code (rev. 1985) Cap 63	Chapter XVII Nuisances and Offences against Health and Convenience Section 175, 191,192	- makes it an offence to cause common nuisance - makes it an offence to foul water so as to make it less fit for the purpose it is ordinarily used - makes it an offence to pollute the atmosphere so as to make it noxious to the health of general public
The Water Act (2002)	-	- makes provision for the conservation, control, apportionment, use of water. - Regulates the management of water supply and sewerage services
	Part III – Water Resources Management Section 25	- requires permit to be obtained for use of water from a water resource
	Part IV – Water Supply and Sewerage Section 56	- letter of appointment required from the Ministry of Water appointing a water undertaker to supply water to more than 20 households - Undertaker is required to give notice to the public for the supply of water
	Part VI – General and Supplemental Section 94	- makes it an offence to pollute any water resource
Wildlife (Conservation and Management) Act (rev. 1985) Cap 376	Part III – National Parks, National Reserves and Local Sanctuaries, Sections 8, 13,19, 33	The minister may: - The minister may: o Alter the boundaries of a park. o Declare any area within the Olkaria field a local sanctuary for wildlife - It is an offence to cut, injure or set fire to vegetation in a park; damage objects of scientific interest; or knowingly introduce domestic animals or vegetation into a national park. - any person causing suffering to a protected or game animal shall be liable to a fine or imprisonment

Act / Bill	Relevant Part or Section	Provisions
Lakes and Rivers Act (rev. 1983) Cap 409	Part IV – General, 11(*e*), 12	- provides for the protection of bird and animal life on or in a lake or river.
The Petroleum Bill (2002)	Part III – Licensing Section 8	- requires a licence for anyone who stores or transports petroleum
The Petroleum Bill (2002)	Part V – Safety and Environmental Standards Section 28	- notwithstanding the provisions of the Act, own use petroleum facilities shall be subject to any other written law relating to environment, health and safety
Food, Drugs and Chemical Substances Act (rev. 1992) Cap 254	Part II E Chemical Substances Section 24	- makes it an offence to dispose of any chemical substance likely to cause contamination of water as to be injurious or dangerous to human health
Food, Drugs and Chemical Substances Act (rev. 1992) Cap 254	Part III Administration and Enforcement Section 30	- allows an authorised officer to inspect that chemicals are stored on site in a proper manner
Use of Poisonous Substances Act (rev. 1983) Cap 247	Sections, 3, 4, 6, 8	- imposes restrictions and conditions on the use of poisonous substances - requires persons concerned with disposal, transportation, storage or use of poisonous substances to be registered or licensed - requires observance of precautions against poisoning - provides for limitations of periods of exposure to risk of poisoning - Samples may be taken from any part of the site for testing of poisonous substances.
Radiation Protection Act (1985) Cap 243	Part III – Control and Use of Radiation Sources Section 8	- requires persons possessing or using any irradiating device to be licenced.
Radiation Protection Act (1985) Cap 243	Part IV – Licensing Provisions	- the holder of the licence must ensure that exposure to ionising radiation resulting from operation, storage, transport or disposal of an irradiating device must be kept as low as practicable below prescribed limits
The Exchequer and Audit (Procurement) Regulations (2001)	Part IX – Disposal of Stores and Equipment	- provides for Accounting Officer to convene a Board of Survey to recommend best methods of disposal - Requires disposal of obsolete and surplus items as follows: i. transfer to another public entity ii. sale by public transfer iii. sale by public auction iv. destruction, dumping or burying
Public Procurement and Disposal Bill (2003)	Part X – Disposal of Stores and Equipment Sections 130, 131, 132, 133, 134	- applies to disposal of stores and equipment of a public entity that are unserviceable, obsolete or surplus - requires public entities and its employees to comply with procedures and regulations which are part of this Act - the public entity must establish a disposal committee in accordance with the regulations to recommend best methods of disposal - methods of disposal of stores/equipment may include: i. transfer to another public entity ii. sale by public transfer iii. sale by public auction iv. destruction, dumping or burying

Act / Bill	Relevant Part or Section	Provisions
Scrap Metal Act (rev. 1972) Cap 503	Sections 2(*3*), 3	- A licence is required for dealing in scrap metal
Workmen's Compensation Act (rev. 1988) Cap 236	Part II – Compensation for Injury	- provides for compensation of workmen in the case of death or incapacity resulting from accidents

The Kenya Power & Lighting Co. Ltd.

Occupational Safety & Health Policy

The safety and health of employees is of paramount importance to the Kenya Power & Lighting Co. Ltd. The organization's responsibility is to provide safe working conditions and to train employees on safe working procedures. The employees' responsibility is to follow safe procedures in all on the job activities

All levels of supervision and management are accountable for ensuring a healthy working environment with safe work procedures, proper equipment and training programmes. All employees will be accountable for learning and following proper procedures at all times. These accountabilities are fundamental components of evaluating performance at all levels.

The company has invested a good deal of effort and money in developing safety programmes and procedures which meet or exceed both regulatory standards and standards of other companies in our industry. If any employee, at any time, has suggestions for improvement of our safety programmes and procedures, I urge you to bring them forward for consideration.

The safety and health of both you and your co-workers depend upon your adherence to this policy. Our goal must be to achieve an accident and injury-free work place in all areas of our operations.

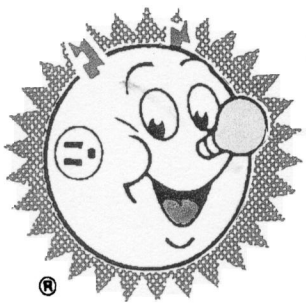
In the interests of the well-being of all employees, I am dedicated to and expe excellence in safety standards within Kenya Power and Lighting Company Ltd.

1990-07-09

Mr S. K. Gichuru,
Managing Director.

OLKARIA GEOTHERMAL PROJECT

EMERGENCY RESPONSE PLAN



INCIDENT OR ACCIDENT

OBSERVER

IMMEDIATE SUPERVISOR

SOUND THE ALARM & NOTIFY

AREA MANAGER CENTRAL RIFT

GEOTHERMAL DEVELOPMENT COORDINATOR

- Informs CPDM and assists as directed
- Standby to handle Olkaria Site requests/ approvals for manpower, equipment & funds.

GEOTHERMAL DEVELOPMENT MANAGER

- Notify & relay details of emergency to Area Manager, Geothermal Generation Engineer & Geothermal Development Coordinator
- Take command of the on scene rescue/control of operations

GEOTHERMAL SAFETY COORDINATOR

- Alert section heads etc as neccesary
- Assist GDM to coordinate external emergency services & mutual aid.
- Mobilise Emergency response equipment as needed.
- Mobilise KPC staff as required.

MUTUAL & EXTERNAL AGENCIES

- OLKARIA DISPENSARY
- NAIVASHA HOSPITAL
- KONGONI POLICE STATION
- ARMY FIRE SERVICE,GILGIL
- OSERIAN DEV. COMPANY
- KENYA WILDLIFE SERVICES
- NAIVASHA POLICE STATION
- AFRICA AIR RESCUE SERVICE

CHIEF PROJECTS DEVELOPMENT MANAGER

- Advices the Managing Director's office
- Provides support & approvals as required
- Monitor Development

MANAGING DIRECTOR

- Handle: Government affairs
- Press Media Release

- Arrange for contacting external medical/emergency services as required
- Suspend all but essential operations
- Mobilise other resources as required
- Coordinate resumption of operations

GEOTHERMAL GENERATION ENGINEER

- Standby & coordinate with the GDM for manpower & equipment resources if required.
- Notify Chief Generation Manager of nature of emergency

ON-SCENE EMERGENCY RESPONSE TEAMS

- Section heads & other senior staff
- Assistant Geothermal Safety Coordinator
- Security section
- External mutual aid assistance
- Olkaria Clinical Officer

EMERGENCY CLASSIFICATIONS

1. Serious injury or death
2. Damage or potential loss to Project facility
3. Loss of well control,borefield (blowout)
4. Major fires at project facilities & environment
5. Major environmental damages (floods & spills)
6. Severe storm / weather conditions

EMERGENCY OPERATIONS CENTRES

1. Administration Block
2. N370 Rig
3. Power Station
4. X-2 Camp
5. Rig & General Stores/Scientific Workshops
6. Motor Vehicle & Rig Workshops
7. Staff Housing Estates
8. Mvuke Primary School
9. High Lift Pumps- Olkaria

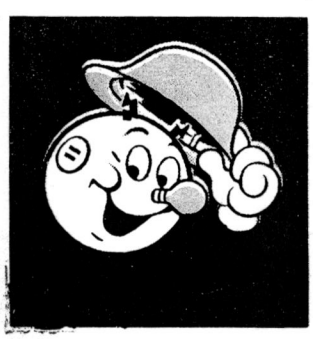
FIRE EMERGENCY

Fires are a Serious Hazard!

If you see a fire:

- **Call for assistance, and raise the alarm.**
- **If possible, restrict and extinguish the fire.**
- **If the fire is out of control, leave the area immediately and evacuate to safety.**
- **Ensure that all other employees working with you are evacuated from the fire Hazard Area.**
- **Stand-by, and await further Instructions from your supervisor, be prepared to fight the fire!**

Serious Fires can cause extensive damage to the Environment and Company Property; and can threaten Human Life BE ALERT!

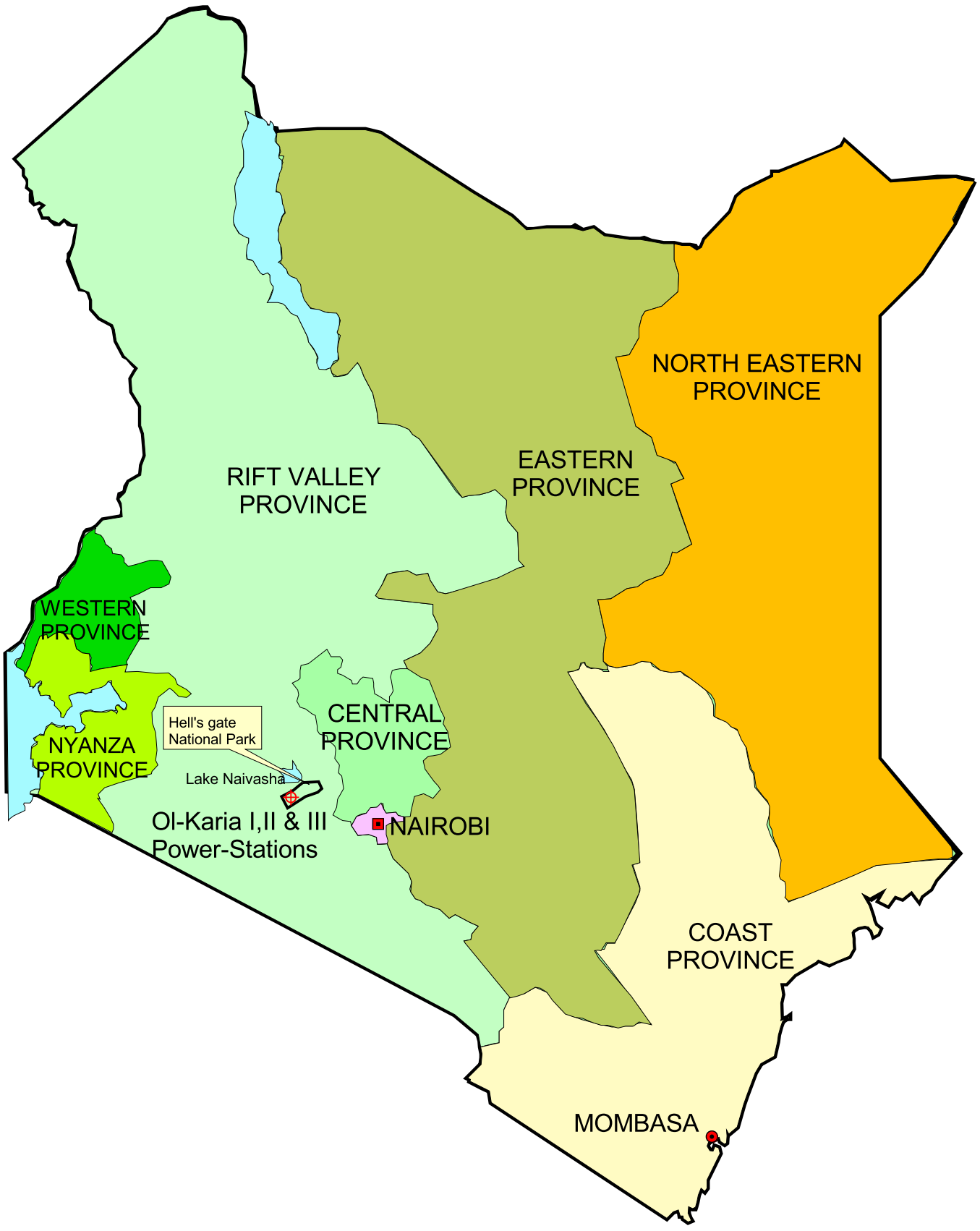


THE KENYA POWER & LIGHTING COMPANY LTD.

P.O. BOX 30099
NAIROBI - KENYA
TELEPHONE: 221251
TELEX: 22253
FAX: 337351

OLKARIA GEOTHERMAL PROJECT 4:92

KPLC
ON PUBLIC SERVICE



LEGEND

⊕ Geo-Thermal power stations

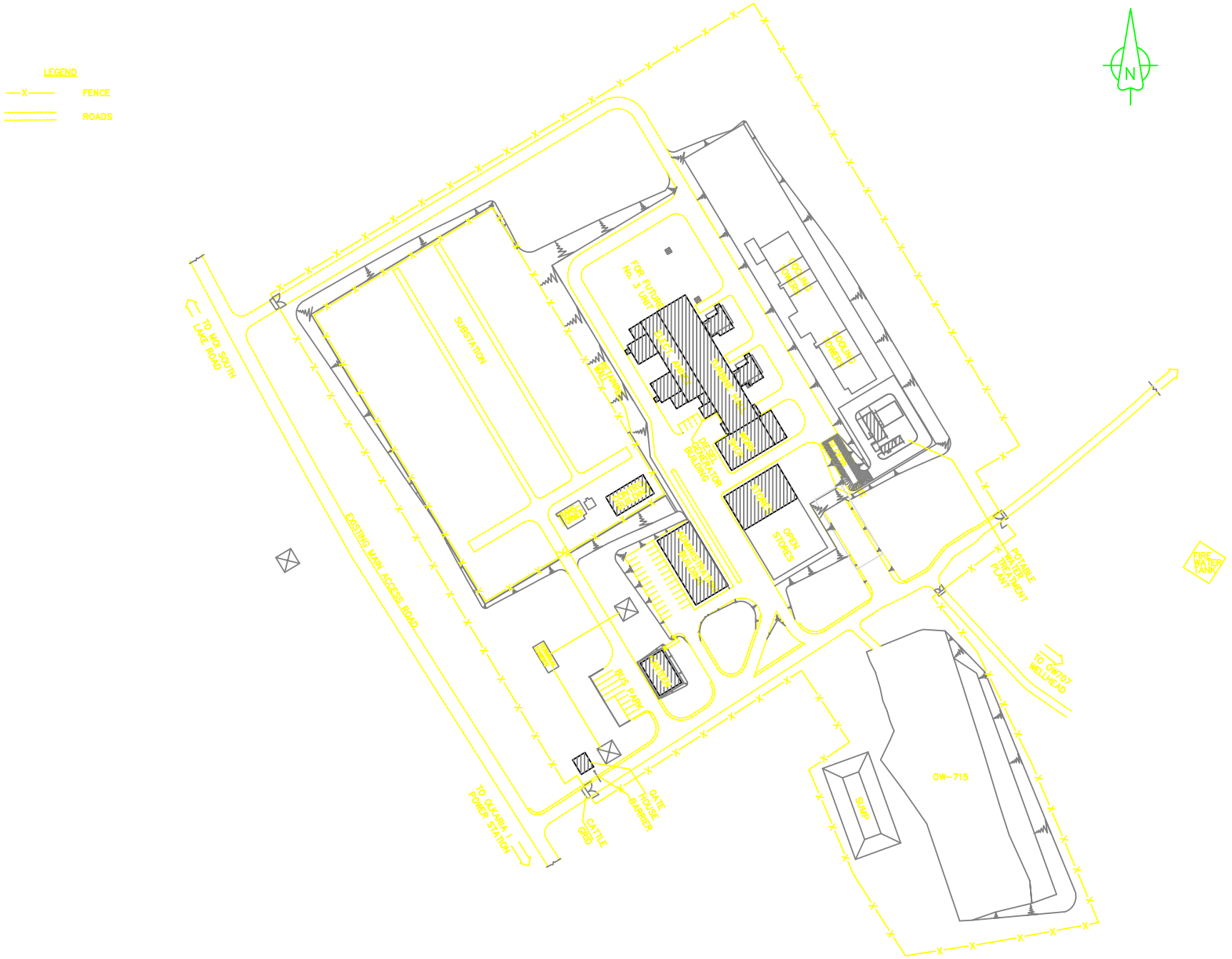
N

GIBB
CONSULTING • DESIGN • MANAGEMENT

LOCATION OF OLKARIA GEOTHERMAL
POWER PLANT

Figure 1

5 0 5 10 15 20 Kilometers



No.	DESCRIPTION	DATE	No.	DESCRIPTION	DATE

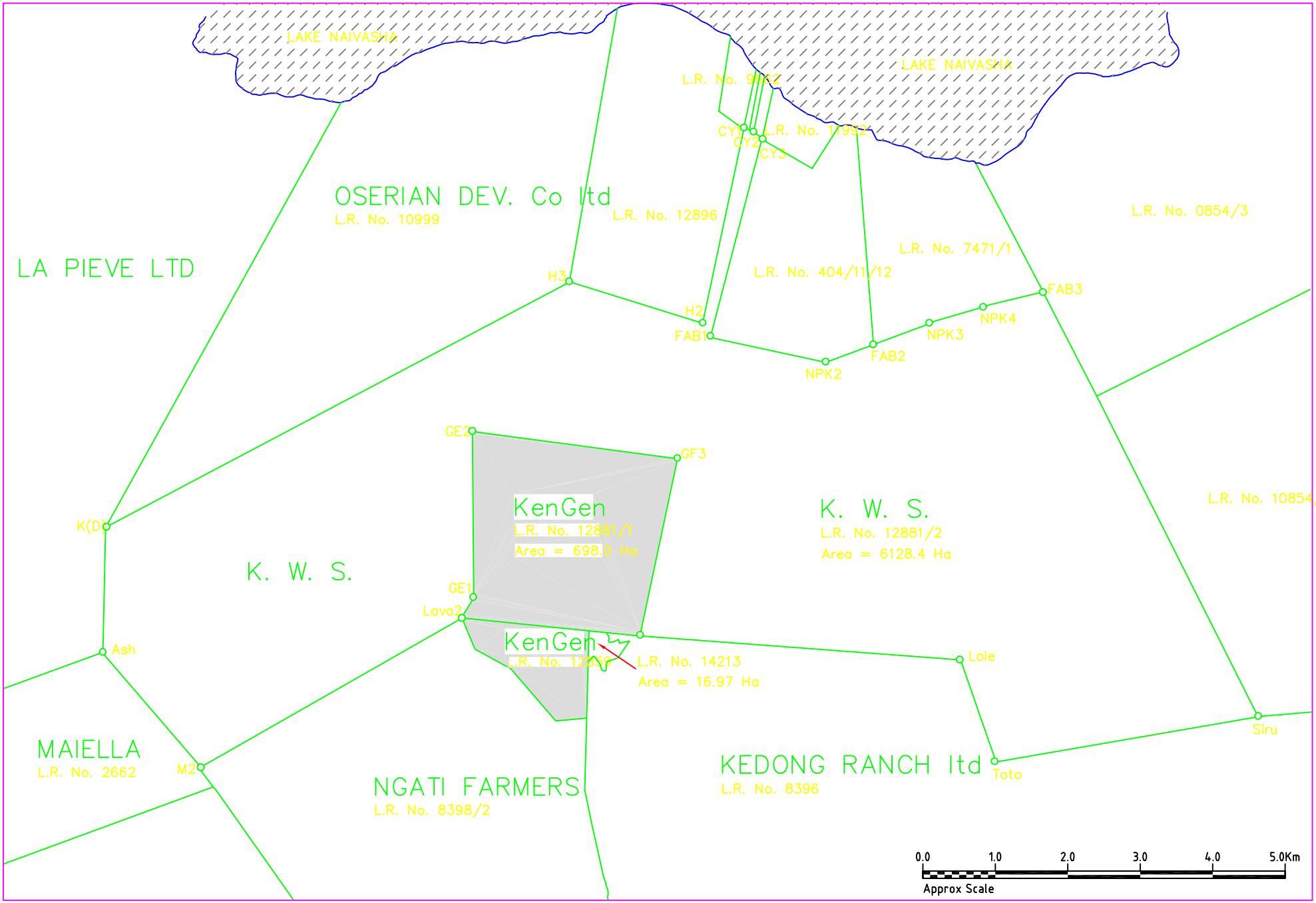
GIBB Africa
CONSULTING • DESIGN • MANAGEMENT
P.O.Box 30020
Tel; 33899/2/3, 250577
FAX : 215894
NAIROBI, KENYA.

CLIENT: KenGen
Kenya Electricity Generating Company Ltd

PROJECT: ENVIRONMENTAL IMPACT ASSESSMENT FOR OKARIA II THIRD UNIT EXTENSION PROJECT

DRG TITLE: OLKARIA 2 GEOTHERMAL SITE PLAN

DATE	MAY 2004
SCALE	NTS
DRAWN	CKK
CHECKED	EAN
APPROVED	STA
JOB No.	K1186A
CAD FILENAME	1186/Cad
FIG. No.	2
REV.	



No.	DESCRIPTION	DATE	No.	DESCRIPTION	DATE

GIBB Africa
CONSULTING • DESIGN • MANAGEMENT
P.O.Box 30020
Tel: 338992/3, 250577
FAX : 215894
NAIROBI, KENYA.

CLIENT: KenGen, Kenya Electricity Generating Company Ltd

PROJECT: ENVIRONMENTAL IMPACT ASSESSMENT FOR THE CONVERSION OF KIPEVU GAS TURBINE

DRG TITLE: LAND OWNERSHIP STATUS AROUND OLKARIA GEOTHERMAL PLANT

DATE	JUNE 2004
JOB No.	K1186
SCALE	As shown
DRAWN	SNK
CAD FILENAME	1186/Reports/Olkaria project
CHECKED	GWK
FIG. No.	3
REV.	0
APPROVED	STA