Contents

9. Environmental and Socio-economic Baseline

This section provides a brief description of the project environment and is based on a review of the existing information, site visits undertaken by the project team and discussions with the public/stakeholders.

9.1 Geotechnical information

9.1.1 Geology

The lithology of the area comprises several geological sequences. The volcanic rocks in the area are represented by Upper Athi Series consisting of sediments and Lake Beds, Athi Tuffs and Kapiti phonolite. The thickness of these volcanics varies but generally decreases towards the south and southeast as they reach the limit of the lava flows.

Below the volcanics are the undifferentiated crystalline rocks of the Mozambique Belt that is the Basements System rocks consisting mainly of gneisses and schists. These are shallow seated and have been encountered by several of the numerous Boreholes drilled in the vicinity of the area.

The geological succession underlying the project area consists of the Cenozoic volcanics which, in geo-chronological order, consists of the following formations:

- Upper Athi Series
- Kapiti Phonolites
- Basement System

The Upper Athi Series forms part of the extensive Athi tuffs and lake beds. Its occurrence is as a result of consolidation of fragmental volcanic material which was deposited shallowly into water after eruption. Geaverts, 1964, classify the series as all the sediments and tuffs lying between the Nairobi and the Kapiti phonolite. They are taken to include beds of the Kerichwa Valley series where the phonolite and trachytes are absent.

Wherever the contacts of the Kapiti Phonolite are present, the unit underlies associated volcanic rocks and is consequently the oldest lava of the succession. This has been confirmed by numerous borehole sections, which reveal that the sub-volcanic floor over which the Kapiti Phonolite was extruded was irregular and cut in Precambrian rocks. The lava was laid down on an eroded surface covered in places by Tertiary conglomerates and grits (Fairburn, 1963), formed part of the first Miocene flood eruptions. The rock is distinctive in hand specimens by its large white crystals of feldspar and waxy-looking nephelines which are set in a fine grained dark green to black or dark bluish-grey groundmass.

The basement system comprises crystalline rocks of Precambrian age which are exposed in the south west of Kitengela where the volcanic cover has been removed by erosion. They are predominantly biotite gneises, frequently migmatitic and rich in hornblende.

9.1.2 Hydrogeology

The regional hydrogeology indicates that the most significant aquifer system west of the project area is the Upper Athi Series aquifer system. This is the main aquifer for boreholes in Nairobi and Kiambu areas and is composed of tuffs, lakebeds and sediments. Other aquifers in this area are found in the weathered inter-lava layers and in fractured zones. In the eastern part of the project area the volcanic rocks thin out exposing the metamorphic Basement System rocks where aquifers are predominantly found in fractured or deeply weathered zones. The Lukenya Range east and northeast of the project area is basically metamorphic Basement rocks composed mainly of granitic gneiss. The groundwater potential in the Basement System east of the project area is generally lower than that of the volcanic areas to the west.

The hydrogeology of the project area is variable as indicated by the interpreted Vertical Electrical Sounding (VES) data obtained at the site. On the basis of the VES data obtained from the project site, an aquifer could potentially exist between 70m and 100m below grade level. This is expected to be at the contact of the Kapiti Phonolites and the Basement rocks.

On the basis of test yields for boreholes sunk in the vicinity of the project site, it is envisaged that a borehole sunk there would yield between 5 and 15m^3 per hour of water. A map showing borehole yields is given in Figure 9-1.

9.1.3 Surface hydrology

The study area falls within the upper Athi River catchment as shown in Figure 9-1; the nearest river system to the project site is the Stony Athi River located about 700m east of the project site. The Stony Athi River flows towards the north and joins the main Athi River. Water quality in the Athi River is impacted by industrial and commercial activities predominantly in Nairobi where a variety of toxic pollutants are discharged.

9.2 Topography

The general terrain of the area is flat to gently undulating and lies at an altitude of 1500m to the east and 1530m towards the west.

9.3 Climate

The power plant site is situated in the upper Athi River catchments; it is dry but adjacent to the seasonal Stony Athi River to the south-east. The average annual rainfall in Machakos district ranges from slightly over 1000 mm in some highlands to slightly below 500 mm in low lying south and south east parts of the district. The rainfall in the area has a bimodal pattern with two rainy seasons occurring from March to May and November to December. A small portion of the district has potential for agriculture.

Athi River town and the greater Mavoko County Council fall under the agro-climatic zone V-4. This zone is characterized as semi-arid with average rainfall amounting to 450 – 900mm annually.

9.4 Vegetation, soils and land uses

9.4.1 Vegetation and soils

The main habitats within the Athi-Kapiti ecosystem are the Grass plain dominated by *Cynodon*, *Themeda*, *Cypress*, and *Digitaria* species; Dry forest, *Olea africana*, *Croton dichogamus*, *Brachylaena hutchinsii*, and *Calodendrum*; Riverine forest/valley forest, *Acacia xanthophloea*, *Euphorbia candelabrum*, *Apodytes dimidiata*, *Canthium schimperiana*, *Elaeodendron buchananii*, *Ficus eriocarpa*, *Aspilia mossambicensis*, *Rhus natalensis*, and *Newtonia* species. A map of the proposed power plant showing randomized species visible as given in Figure 9-2. The vegetation cover over the project area is described a bushland with the potential plant growth being medium to low.

The project area lies in an area of predominantly dark grey black cotton soil. The thickness of these soils varies and on the project plot it is between 0.6m and 1.2m in depth. They are poorly drained, have low infiltration rate and low permeability and are capable of significantly upholding any released contaminants to the groundwater.

Immediately below the vertisols is a orange-brown lateritic soil. This is a weathering product of the Kapiti Phonolite that underlies the vertisols containing rounded grains. A gradual transition from the weathered upper layer of the phonolite formation to a less weathered one occurs. It is noted that the shallow perched aquifer occurs between 0.5m and 1.5m below ground surface. This basically will occur because of the interphase between the clay layer and the phonolitic rock. The other main aquifers are deep and occur from a depth of about 50m onwards.

9.4.2 Land uses

The study area is dominated by industrial and commercial activities. Immediately towards the south of the site is a disused limestone quarry; to the north-west of the site are two steel plants and a new tile and carpet center, and to the east of the site is a residential complex.

Land use within the Municipal Council of Mavoko is divided into nine categories namely residential, commercial, industrial, recreational, educational, public purpose and public utility. The allocation and character of land use in the town is explained below. The land use as per the Athi River Development Plan prepared in 1970 is captured in Figure 9-3.

Residential: The Municipality acts as a dormitory town for Nairobi city, other nearby growing centers and also provides housing for the local industrial workers. According to the 1970 land use plan, residential use was divided into three sub-categories namely low, medium and high density and allocated approximately 2722 Ha of land comprising approximately 27% of total land area. There has been

significant development since 1970 that did not entirely conform to the planned land use.

Industrial: The area is primarily industrial in character with factories employing three quarters of the town's residents. There are many factories such as Kenya Meat Commission, East Africa Portland Cement, Bamburi Cement, Kapa Oil Refinery, EPZ Authority, Nation Media Group, Mabati Rolling Mills, Devki Steel Works Company, Athi River Steel Plant, Sun-Rose and Primarosa flower companies among others. In total there are over sixty factories. The factories are mainly steel, cement manufacturing, flower farms and textile manufacturers. The Export Processing Zone employs a majority of the women population.

According to the 1970 land use plan Industrial use was allocated approximately 2007 Ha covering 20% of the total land area. The development since 1970 did not conform to the plan.

Commercial: The area is characterized by a number of wholesale and retail businesses, small and medium scale enterprises and commercial service providers. According to the 1970 land use plan, commercial use was allocated approximately 102 Ha comprising 1% of the total land area.

Educational: The area is served with nursery, primary, secondary and tertiary educational services. There also exists training institutions. According to the 1970 land use plan, educational use was allocated approximately 348 Ha comprising 3% of total land area.

Recreational: Recreational land use was allocated approximately 818 Ha according to the 1970 plan, this comprised 8% of total planned area. The recreational activities provided according to this plan were parks, playing fields, public open spaces and a proposed stadium.

Public purpose: The 1970 plan provided for public purpose activities such as a social hall, Ministry of Works land, churches, land for administration and a proposed cemetery. The plan allocated approximately 250 Ha comprising 2% of total land area.

Public utilities: Public utilities consisting of water, sanitation and waste facilities had an allocation of approximately 76 Ha comprising 1% of total land area according to the 1970 land use plan.

Transportation: Approximately 510 Ha of land comprising 5% of total land area was provided for transportation according to the 1970 plan. This included land set aside for roads, railway, petrol services stations, lorry parks and car parks.

Deferred land: Deferred land was allocated approximately 3230 Ha comprising approximately 32 % of total planned area.

9.5 Macro-economic setting

Kenya’s economic blueprint is the Vision 2030 which recognizes the energy sector as one of the enablers of economic, social and political pillars underlying the vision. Sessional paper no. 4 of 2004 on energy also recognizes that affordable, quality and cost effective energy services is an important prerequisite for attainment of accelerated socio-economic growth and development.

The sales growth in electricity demand in Kenya shrank from 8.5% in 2006/7 to 3.5% in 2007/8 to 1.6% in 2008/9 primarily due to the depressed performance of the domestic economy over these periods. Additionally electricity sales in the country were affected by implementation of the load shedding program resulting from poor hydrology in the country's seven forks cascade which accounts for over 40% of the total installed capacity.

In order to provide cost effective and affordable energy, the Government of Kenya through the Ministry of Energy is committed to the development of a rolling twenty year least cost power development plan (LCPDP). This LCPDP will be updated annually to take into account new information and promising technologies with potential to generate power at competitive costs. In the current LCPDP, there is provision of operationalizing an 80MW medium speed diesel (MSD) power plant in 2010.

With the exception of 2008/2009, Kenya has experienced a significant increase in its economic growth over the past few years which in turn has increased the demand for electricity. Assuming a 5% economic growth rate in 2010, it is envisaged that Kenya should have an installed capacity of 1010MW. The proposed 84MW power plant would greatly contribute in meeting this peak load.

Capacity expansion projects such as the proposed power plant are aimed at reducing the effects of potential shocks to the economy due to load shedding programs. This reduces the risk of major electricity supply interruptions should hydrology around the seven forks cascaded affect the power generation there.

Of the estimated US$125 million project cost, it is predicted that there may be a sizeable local spend which could contribute significantly to the construction sector and engineering services during the construction phase and to the transport industry during the operational phase (resulting from HFO transport from Mombasa to the power plant).

The power plant is predicted to have both positive and adverse economic impacts. Positive impacts include a more stable power supply to the national grid and reduced load shedding. Adverse impacts include air and noise emissions, traffic related accidents and disruption in urbanized areas and road network due to construction activities.

The power plant aims to increase the availability of electricity in Nairobi and its environs. The Gulf Power project is a significant project envisaged in the current LCPDP for the stable supply of electricity.

9.6 Social and microeconomic characteristics

This section provides a socio-economic profile of the study area by reviewing demographic trends and economic performance.

9.6.1 Population dynamics

Machakos district has an estimated population of 416,415 and a population density of 139 per/km^2. It is predicted that the population density would increase to 147 per/km^2 in 2010 and 155 per/km^2 in 2012. The population within the

jurisdiction of the Municipal Council of Mavoko is approximately 65,000 according to 2008 estimates. Athi River division has the lowest population density compared to other divisions in Machakos district due to its expansive area. With its close proximity to Nairobi, Athi River town is urbanizing rapidly with the development of several industrial and commercial entities. The population density is therefore expected to rise to 72 per/km^2 in 2012.

9.6.2 Income distribution and poverty

According to a UN Habitat Report of 2006, people in the lowest income group within Athi River on average earn between KShs 3,000 and KShs 5,000 per month. Two welfare monitoring surveys were undertaken by others in 1994 and 1997 for Machakos district; the results indicated that 68.7% of the population lived below the poverty line in 1994 while 63.3% of the population lived below the poverty line in 1997. A similar exercise undertaken in 2000 indicated that 66.2% of the population lived below the poverty line. It is worth noting that the above welfare surveys were undertaken during periods of either extensive drought or bumper harvests.

Through a household survey in the project area in February 2010, it was established that about 33% of the surveyed households do not have a monthly income while 18% of the population earning less than KShs 10,000 per month. The skills levels vary in Mavoko Municipality and the industries present within Athi River tend to frequently use seasonal labor to control their operating costs.

9.6.3 Employment profile

About 8% of the total Kenyan working population of about 21 million resides in Eastern province. While approximately 70% of this population was absorbed by agricultural related activities, the remaining 30% migrate to urban centers such as Athi River town in search for employment. The national labor force absorption capacity (ability of the economy to provide employment) in 2007 was 44%; in Machakos district it was 33% and in Mavoko it was 28%.

From a GDP perspective, Machakos district generates approximately 70% of its income from agriculture and 11% through wage employment; the wage employment income is generated mainly in the urbanized Athi River town. There is an observable trend in increased urban migration to towns such as Athi River in search for wage employment especially during extended drought periods. This is leading to some adverse social problems such as escalation in crime rates and commercial sex activities.

9.6.4 Occupational profile

The occupational profile of the study area was obtained through a household survey conducted in February 2010 of about 100 households spread across a radius of 5km from the power plant site.

The survey results indicated that 42% of the sampled population is unemployed, 22% is self-employed, 22% is engaged in seasonal wage employment while 14% are students. The high unemployed percentage of persons will no doubt be looking for job opportunities during the construction and operational phases respectively of the power plant.

9.6.5 Economic performance

Between 2000 and 2007, the Kenyan economy grew steadily and reached a commendable annual growth rate of 7%. However between 2008 and 2009, the economy grew by a paltry 1.7% resulting from the post-election chaos, global financial meltdown, high crude oil prices and extended drought period.

Machakos district exhibited similarities to the growth rates stated above however due to the extensive drought in the district, agriculture was not a dominant source of GDP. Consequently it has been observed that to overcome inconsistent climatic conditions, manufacturing and informal trade is growing in towns such as Athi River where several new industries are mushrooming. It is therefore predicted that sectors such as transport & communications, construction and hotels & restaurants will drive economic performance of Athi River town and by extension Machakos district.

9.6.6 Housing

Housing is a challenge in both rural and urban centers in Kenya. According to the Ministry of Housing, the country currently has a requirement of 200,000 new medium and low cost houses annually. Unfortunately such housing cannot be provided in Nairobi as the land prices are extremely exorbitant with house prices being beyond the reach of many residents. Subsequently metropolitan areas such as Mavoko, Kiambu, Thika, Kitengela, etc. provide an opportunity for housing the hundreds of thousands of people that work in the city. With the dual carriage way between the JKI airport and Machakos currently under construction, Mavoko provides an ideal location for developers to construct affordable housing for people that work in Nairobi. On the ground it is observed that several developers have already constructed housing estates in the Mlolongo area towards Mavoko. About 700m eastwards from the power plant site is middle to high-income development known as Greenpark Estate that is under construction.

As part of the household survey that was carried out in February 2010 for the power plant project, it was established that most of the sampled residents had been living in the area for less than 10 years with the highest influx occurring over the last 3 years (2007 – 2010). Urban poverty is prevalent in Mavoko as a large percentage of its residents live in informal settlements. Subsequently it is not uncommon to see a mix of large informal settlements mixed with planned residential estates in Mavoko.

9.6.7 HIV/AIDS prevalence

While the HIV/AIDS prevalence rate in Eastern province is below the national average, the Mavoko area has a high potential prevalence rate due to its proximity to the Mombasa – Nairobi highway. Sex workers and truck drivers are identified as one of the core group and bridge for the infection to spread to the general population. This implies that the transmission between Nairobi and Mavoko area could easily be linked to the behaviors of workers between the workplace and their dormitories.

9.7 Infrastructure and services

There are huge demands on the Mavoko Municipal Council as indicted in their 2005 – 2010 Strategic Plan. The stakeholders have identified the following key strategic issues affecting the delivery of efficient services to the residents:

- Low satisfaction of community with the council's services,
- Low accountability of Mavoko Municipal Council to revenue contributors,
- Insufficient personal; and
- Inadequate specialized skills and inadequate revenue collections and allocation procedures.

The Mavoko Municipal Council undertook a SWOT analysis for the 6 year plan period. The strengths and opportunities identified after implementation of the strategic plan include good leadership and management, proximity to the Jomo Kenyatta International Airport, its situation at the junction of a regional road network, the industrializing profile, and availability of key natural resources. The weaknesses and threats include low policy development status, inadequate planning and infrastructure, uncontrolled industrial emissions, emergence of slums, the adverse effect of disease especially HIVAIDS on socio-economic development and overall low capacity.

The inadequate planning and infrastructure includes provision of planned housing units, water supply and sewage services, roads, telecommunications and electricity for the residents.

9.7.1 Roads and rail

The main A109 national highway is aligned in a north-west to south-east direction and is situated immediately to the north of the power plant site. The A109 which is referred to as the Nairobi – Mombasa highway is part of the northern corridor linking the port of Mombasa to Uganda, Sudan and the Great Lakes region. The A109 is currently a single carriage way with one lane in either direction and is presently being upgraded to a dual carriage way with two lanes in each direction. The single carriage way has surfaced shoulders, is generally of good riding quality and was designed to carry heavy loads.

The main Nairobi – Mombasa railway line is situated to the south of the power plant several kilometers away and passes through Athi River town. There are no other railway lines in the vicinity of the power plant.

9.7.2 Electricity

The inherent worth of electricity and its contribution to the development of Kenya cannot be overemphasized. Currently in Kenya the net reserve capacity is extremely low compared to international benchmarks and subsequently alternative measures need to be put in place in order to combat this. The nominal maximum demand from KP&LC's intake sub-stations such as Embakasi occasionally gets exceeded as the network is continually expanded and interruptions in supply experienced. Concurrently the KP&LC has set itself an ambitious target of connecting about 200,000 new customers annually. In order to meet the growing demand of electricity in the country, the energy generation companies will need to come up with alternative sources of energy.

9.7.3 Water Supply

The Mavoko Water and Sewage Company is responsible for supplying potable water to the residents and businesses in Athi River town and its environs. Currently the town receives water from a variety of sources with the bulk of the water coming from Nairobi through a piped system. The other source of water is the Nol-Turesh water pipeline that emanates from Mt. Kilimanjaro. A third source of water supply is boreholes that the Mavoko Water and Sewage Company contracts out to various service providers. The water from boreholes generally has a high saline content which then requires treatment prior to supply to consumers. The water services company is also exploring ways of rehabilitating a disused dam to generate a considerable amount of water for the growing population in Athi River town and its surroundings.

Despite the above sources, water rationing is carried out by the Mavoko Water and Sewage Company. The Mavoko Water and Sewage Company supplies about 35,000m^3 of water per month to 3,000 existing customers. They potentially have 9,000 customers that require water monthly.

9.7.4 Traffic

The proposed power plant is located in Mavoko in Machakos district near the Stony Athi River. The present land use for the study area is not defined by the Ministry of Lands as they have not developed a zoning plan for the area. Subsequently it was observed that there are currently mixed uses of land in the vicinity of the study area. The power plant is situated adjacent to the main Nairobi – Mombasa highway (A109) which carries a significant amount of daily traffic.

The existing A109 fronting the power plant is a single carriageway with one lane in either direction. The A109 is currently being upgraded to a dual carriage way between the Machakos turnoff (C97) and JKI Airport. At present the section of this road (A109) fronting the power plant is under construction. The contractor has excavated several sections of the road and is dumping soil within the power plant site. The existing section of road fronting the power plant is in poor condition and the ambient noise levels are generally high resulting from vehicle movements. Traffic along the A109 is heavy throughout the day and night as it is

the international trunk road linking Mombasa to Nairobi, western Kenya and beyond.

The traffic which the power plant will generate will vary between the construction and operational phases. Damage to the A109 and Namanga Road (A104) is likely to be the highest during pre-construction and construction phases of the project due to the transport of heavy machinery, equipment and components. In addition to this there will be a marginal increase in the in traffic volumes due to the influx of employees traveling to and from the power plant on a daily basis. Other developments within the area for example the new Tile & Carpet Centre, Greenpark estate and Athi River Steel Plant will also contribute significantly to the current traffic load. The heavy traffic generated by the power station during the operational phase will consist of about 10 – 15 HFO tank truck deliveries per day. Consequently during the pre-construction and construction phase, the increase in traffic volumes on the A104 and A109 is likely to contribute to their deterioration as well as impact on the safety of the road users. During the operational phase, the number of HFO tank trucks will have an increased impact on the A109 especially since they will be transporting the HFO from Mombasa to Nairobi.

9.7.5 Air quality

Air quality in the Athi River area appears to be inconsistent resulting in a haze over the landscape especially in the morning. The study area is located in the vicinity (about 4km) of Athi River town which is rapidly growing with new industrial and commercial entities. The landscape behind the power plant is degraded following extraction of limestone by a nearby cement manufacturing company.

Air quality has been identified as an issue relating to environmental and health quality in the study area. Key sources of pollution are generated by commercial limestone mining, dust arising from road construction, industry and vehicle emissions.

A baseline ambient air quality survey was undertaken at power plant site for nitrous oxides (NO_2) and sulfur oxides (SO_x). The survey was undertaken by mounting specific diffusion tubes for SO_x and NO_2 at various locations within the power plant and as far as Athi River town as shown in Figure 9-1.

The results of the ambient baseline air quality survey (see table below) indicated minimal to non-detectable ambient concentrations of the criteria pollutants mentioned above.

Lab Sample ID	**MDL**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	
Client ID		**GL 406**	**GL 401**	**GL 405**	**GL 402**	**GL 404**	**GL 403**	
Units								**Units**
Sulphur Dioxide	0.5	2.40	1.00	2.40	0	0	0	**µg**
Q_{298}		119.0	119.0	119.0	119.0	119.0	119.0	**$ml.min^{-1}$**
Q_{300}		119.0	119.0	119.0	119.0	119.0	119.0	**$ml.min^{-1}$**
Exposure period		10080.0	12960.0	12960.0	12960.0	12960.0	12960.0	**minutes**

Average Concentration		**2.00**	**0.65**	**1.56**	**0.00**	**0.00**	**0.00**	**µg.m^{-3}**
Lab Sample ID	**MDL**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	
Client ID		**GL 406**	**GL 401**	**GL 405**	**GL 402**	**GL 404**	**GL 403**	
Units								**Units**
Nitrogen Dioxide	0.25	6.20	2.80	5.20	4.9	2.5	3.6	**µg**
Q_{298}		78.0	78.0	78.0	78.0	78.0	78.0	**ml.min^{-1}**
Q_{300}		78.5	78.5	78.5	78.5	78.5	78.5	**ml.min^{-1}**
Exposure period		10080.0	12960.0	12960.0	12960.0	12960.0	12960.0	**minutes**
Average Concentration		**7.83**	**2.75**	**5.11**	**4.81**	**2.46**	**3.54**	**µg.m^{-3}**

As the proposed project is an MSD power plant which will use HFO, air dispersion modeling of the stack emissions was undertaken for SO_x, NO_x, PM_{10} and $PM_{2.5}$. The results of the air dispersion model were then compared with the European Community Directive 2008/50/EC on ambient air quality. The two internationally recognized methods namely AERMOD and ADMS4 were used for undertaking the air dispersion modeling. The reason for undertaking the modeling using the two methods was to understand the responses given by the two models.

Emissions rates for PM_{10} and $PM_{2.5}$ were assumed to be the maximum emissions according to the World Bank I guidelines. Emission rates for SO_x and NO_x were calculated using the US EPA AP42 emission factors for large stationary diesel engines based on the usage of about 341 metric tons/day of HFO with a calorific value of 42,700 kJ/kg.

The results of the air dispersion modeling indicated the following:

- The ADMS4 prediction is slightly more conservative than AERMOD in the vicinity of the power plant; the AERMOD prediction is more conservative further away at the elevated areas such as Lukenya hills;
- At the nearest sensitive receptor which was Athi River town and a partially developed housing estate near the Stony Athi River, none of the EC limit values were exceeded;
- AERMOD predicted exceedences of SO_2 and NO_2 hourly limits at Lukenya Hills; the frequency of exceedence for SO_2 was 24 times in a year which is given as the allowable limit. For NO_2 the frequency of exceedence under the EC directive is 18 times in a year, while the model predicted 24 times in a year.

In the event that a major spill, fire or explosion incident occurs, air quality will be affected by toxic fumes and particulates from smoke. A fire will impact on visibility, impacting traffic safety and aesthetic (visual and odor) impacts. Movement of the plume of smoke could potentially affect a large geographic area dependent on climatic factors and prevailing weather conditions. This can result in risks to people, animals, plants and the general environment.

While the proposed power plant will have a continuous emission monitoring system for monitoring the quality of stack emissions, the Proponent will construct an air quality monitoring station about 10km from the power plant to assess the local impacts on air quality resulting from emissions of the power plant. The monitoring station will be designed to monitor sulfur dioxide, oxides of nitrogen, ozone, fine particulate matter and the relevant meteorological parameters comprising wind speed, wind direction and ambient temperature.

Gas emissions from the nearby Athi River Steel Plant and dust emissions from the construction phase of the power plant as well as emissions from the surrounding mining activities and road construction are likely to enhance the impact on air quality in this area significantly. It will have to be assessed whether or not the cumulative effects on air quality from these activities will fall within guideline limits once the activities are fully operational.

9.7.6 Visual

There is little variation in the landscape with the topography being characterized as rolling and undulating.

The study area is relatively undeveloped and is dominated by interspersed industrial and commercial activities. There are isolated homesteads across the landscape. The Athi River Steel Plant, proposed Tile & Carpet Centre and Greenpark Estate are highly visible developments in the largely open landscape. A disused limestone mining quarry exists immediately to the south of the power plant site and one has to climb the top of the quarry to be able to see Athi River town situated to the west of the project site.

Empirical research has indicated that the visibility of an element in the landscape, and in turn the severity of visual impact, decreases with increased distance between the observer and the element. This is because the further an observer is located from an element in the landscape, the less area it occupies in the observer's visual field, and the less significant the element becomes in relation to the rest of the viewed landscape. The majority of residents near the power plant are pastoralist *Maasai* communities are farm residents, who are scattered sparsely across the study area. About 4km west of the study area in Athi River town, a higher density of residents occurs. Due to the low density of people in the study area, there is a low number of affected viewers. However, the topography provides little visual absorption or screening capacity, hence the visibility of the power plant will be high.

9.7.7 Noise

There are various factors that will contribute to ambient noise levels during construction and operation of the power plant. The Equivalent sound level (L_{eq}) is used to indicate the average sound level over a period of time and is commonly used in environmental noise studies.

Legal Notice (LN) 25 titled "The Factories and Other Places of Work (Noise Prevention and Control) Regulations, 2005 guide the maximum permissible noise levels that workers can be exposed to. Additionally this regulation provides limits for maximum permissible community noise levels. LN 25 stipulates that an Occupier shall not expose a worker to 90dB(A) over an eight-hour time weighted average period. It further stipulates that noise emanating from a workplace shall not exceed 55dB(A) at the fence line and 45dB(A) at night.

LN 61 titled "Environmental Management and Coordination (Noise and Excessive Vibration Pollution) Regulations, 2009 stipulates the maximum permissible noise levels that can exceeded by any person. The maximum permissible noise levels under the First Schedule of the Regulations are reproduced below.

Zone		Sound level limits dB(A) L_{eq} 14 hours		Noise rating level (NR) L_{eq} 14 hours	
A.	Silent zone	40	35	30	25
B.	Places of worship	40	35	30	25
C.	Residential				
	Indoor	45	35	35	25
	Outdoor	50	35	40	25
D.	Mixed residential (with some commercial and places of entertainment)	55	35	50	25
E.	Commercial	60	35	55	25

The environmental guidelines of the World Bank and World Health Organization specify 55 dB(A) during the day (06:00 to 22:00) and 45 dB(A) during the night (22:00 to 06:00) for residential purposes.

Due to the relatively flat terrain, there are no natural features that will assist in the attenuation of noise. The current main sources of noise in the vicinity of the power plant site include road traffic and the Athi River Steel Plant.

A baseline noise and vibration survey was undertaken in February 2010 at the power plant site and its environs. The nearest sensitive receptor to the power plant was the Greenpark residential estate located about 700m due east of the power plant site. The findings of the noise survey are summarized as follows:

- The site of the proposed development is located in a predominantly rural environment. The proposed site is however fronted by the A109 highway and is bordered to the north-west by the Athi River Steel Plant Limited.
- The main source of noise in the area is from traffic on the A109, particularly heavy motor vehicles and trailers travelling on uneven road surfaces. The Athi River Steel Plant Limited is the main development in the immediate environment of the proposed development site. Noise emissions from the steel plant appear to be only audible in relatively close proximity to the site.

- The closest sensitive receptor is the Green Park Village, a residential complex located approximately 700 m from the proposed site. As the area is largely flat, offering little topographical screening against noise, consideration should be given to natural screening between the proposed site and the residential complex.
- The World Bank Guideline of 55dB(A) during the day was exceeded at 5 of the 16 sample points. The highest equivalent noise measurement of 66.7dB(A) was recorded at the approximate entrance to the proposed site. Exceedances at each of these locations were attributed to the proximity to the road and impacts from traffic, particularly heavy motor vehicles on uneven road surfaces.
- The World Bank Guideline of 45dB(A) during the night-time was exceeded at 9 of the 16 sample points. The highest equivalent noise measurement of 64.2dB(A) was similarly recorded at the approximate entrance to the proposed site. Relatively higher noise levels were attributed to the proximity of the proposed site to the road and impacts from traffic, particularly heavy motor vehicles on uneven road surfaces.

Construction of the power plant is expected to have an adverse impact on ambient noise. Day-to-day sources of noise will be caused by large-scale equipment and vehicles used for clearing and for construction activities (the typical noise levels of construction equipment at a distance of 15 m, lie in the range of 75 – 100 dB(A)). A one-hour equivalent noise level of between 75-78 dB(A) 50 m away from construction would be typical for the earthmoving phase.

These noises will pose a health risk to construction workers and are likely to present noise disturbance effects on people living in the surrounding rural areas for up to 750 m from the construction (see table below). A night-time source of noise would be from the construction camp.

These noise levels assume that the equipment is maintained in good working order. Conservative attenuation conditions have been applied.

Plant/equipment	Typical operational noise level at a given offset, dB(A)							
	5m	10m	25m	50m	100m	250m	500m	1000m
Air compressor	91	85	77	71	65	57	51	46
Compactor	92	86	78	72	66	58	52	46
Concrete mixer	95	89	81	75	69	61	55	49
Concrete vibrator	86	80	72	66	60	52	46	40
Crane (mobile)	93	87	79	73	67	59	53	47
Dozer	95	89	81	75	69	61	55	49
Loader	95	89	81	75	69	61	55	49
Mechanical shovel	98	92	84	78	72	64	58	52
Pump	86	80	72	66	60	52	46	40
Pneumatic breaker	98	92	84	78	72	64	58	52
Rock drill	108	102	94	88	82	74	68	62
Roller	84	78	70	64	58	50	44	38

Trucks	-	81	73	67	64	60	57	54

Noise level limits during the operational phase are expected to be high as the power plant is a thermal MSD type. The power house will need to be acoustically designed to limit noise levels generated at the fence line to be in compliance with Kenyan legislation as a minimum.

9.7.8 Archeology and cultural heritage

A baseline archeological and cultural heritage impact assessment was conducted in February 2010. The area around Lukenya hill contains some of the most important Later Stone Age archaeological sites found in Kenya. The variety of assemblages identified in the archaeological record show that the area was favored for human habitation, and was continuously inhabited for nearly 100,000 years. Artifacts that have been recovered here include stone artifacts, domestic animal remains, iron smelting sites, ostrich eggshell beads, stone bowls, pollen samples, rock art as well as human remains. Historically, there is however little evidence of habitation and the land has been privately owned since the early 1900s. A survey of the site did reveal a scatter of archaeological debris that is similar to other scatters found on the plains surrounding Lukenya hill. However the artifact density was found to be very low and very thinly spread on the surface to warrant further excavation of the site. The rest of the site was totally devoid of any cultural material, partly due to the fact that part of the land is covered by heaps of soil that have been dumped here from elsewhere. The only other evidence of human occupation here are the remains of a Maasai *Manyattta*, a temporary settlement which leaves no cultural artifacts. No other activities are presently going on at the site, and the proposed development will not therefore interfere with economic or agricultural activity, neither will it involve the displacement of any group of people.

Figure 9-1: Baseline ambient air quality measurement locations

Figure 9-2: Image of Catchment area and boreholes in the vicinity of the project site

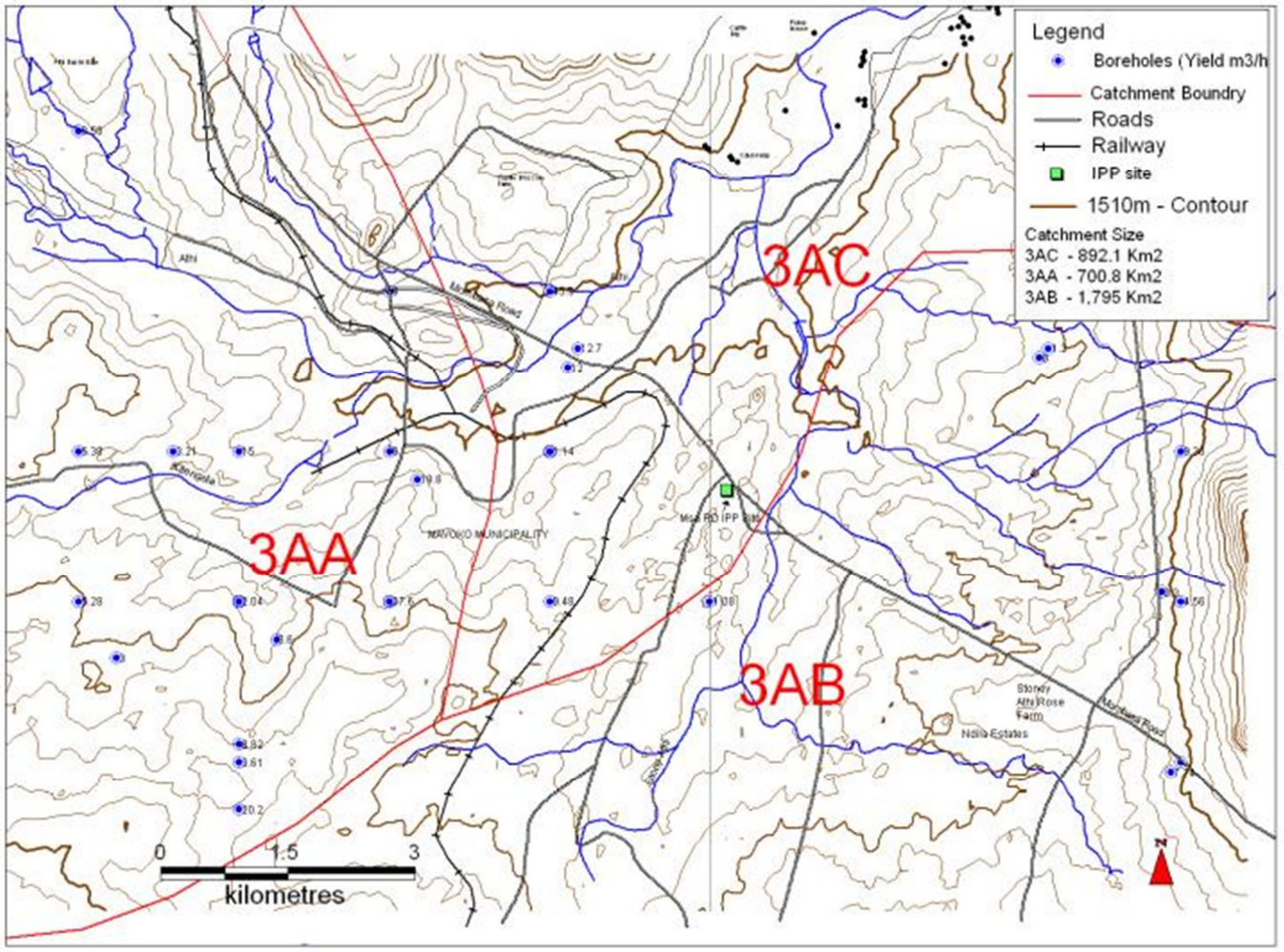

Figure 9-3: Map of the proposed power plant site with randomized points showing representative species

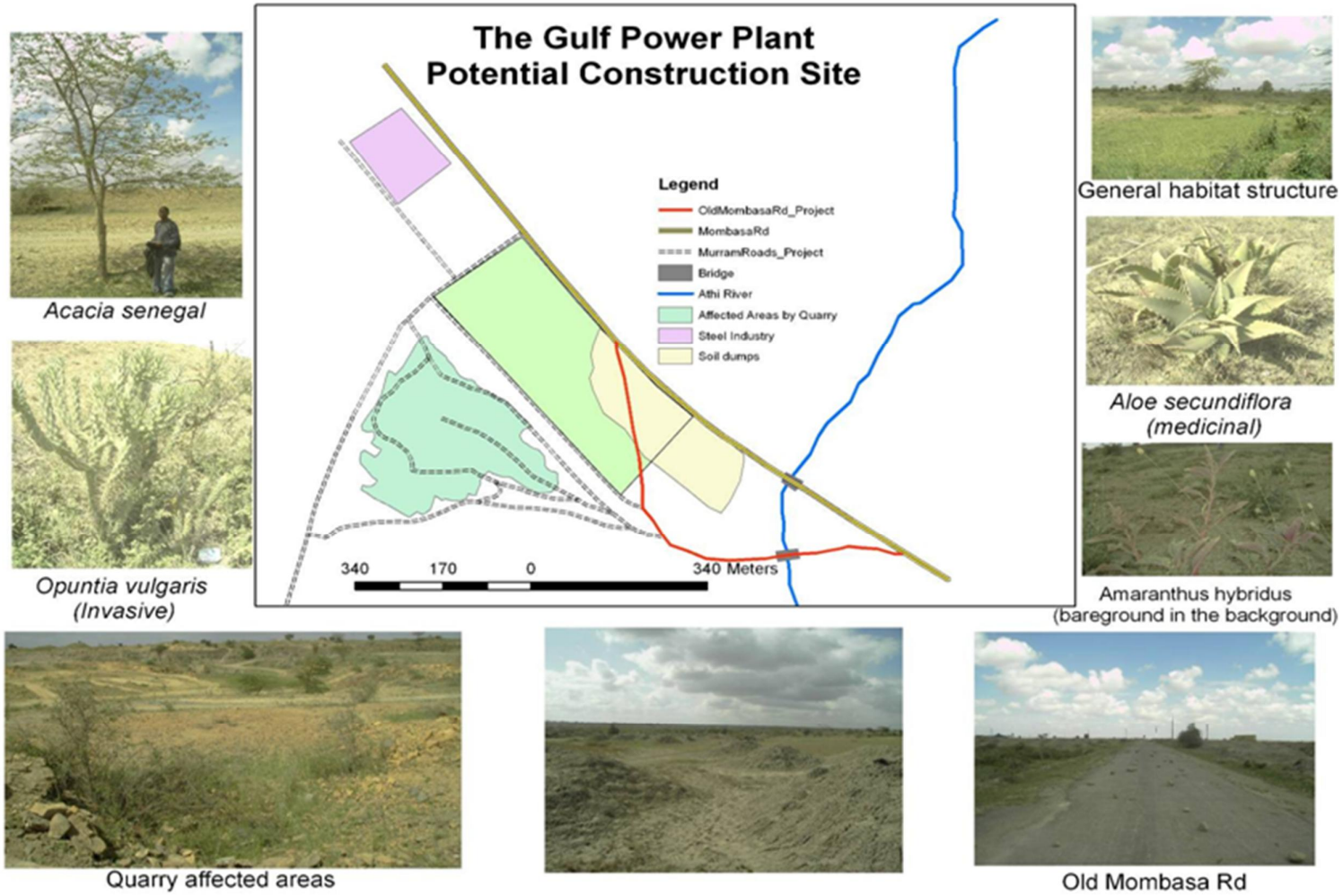

Figure 9-4: Map showing land uses in Athi River Town and in the vicinity of the project site