ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT STUDY REPORT FOR THE PROPOSED DEVELOPMENT (INCINERATOR AND AUXILLIARY FACILITIES) ON PLOT L.R. 23961 (PART) PORTION 11 ON EPZ LAND, KINANIE, MAVOKO SUB COUNTY, MACHAKOS COUNTY

Latitude: -1.352192 Longitude: 37.062226
DMS: 1° 35' 21.4'' S | 37° 06' 20'' E
Elevation: 1476 Metres ASL.
URL: https://www.google.com/maps/place/-1.352192,37.062226

PROPONENT

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OCTOBER 2023

DECLARATION

This ESIA report has been prepared by Emerald Consultancy Kenya Limited**,** a National Environment Management Authority (NEMA) licensed Firm of Experts (Reg. No. 10400) in accordance with the Environmental Management and Environmental Impact Assessment (EIA) study and the report submitted to NEMA for consideration.

We the undersigned, certify that the information contained in this report is accurate and a truthful representation of all findings as relating to the project.

I. PROPONENT

Plenser Waste Management Limited

(For and on Behalf of the proponent)

Official Stamp

Name: …… Designation: ……..……

Signed: **On this …… Day of ……2023.**

II. ENVIRONMENTAL CONSULTANT:

Emerald Consultancy Kenya Limited (NEMA EIA/EA Firm Reg. No. 10400)

1. **Name: Jacinta Kaliti-Environment and Public Health (NEMA EIA/EA Lead Expert Reg. No. 2065**)

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Signed: _____ Date: _____

2. **Name: Peter Oluoch Ouma-Environment and Climate Change Expert (NEMA EIA/EA Lead Expert Reg. No. 7872)**

Signed: _____ Date: _____

3. **Name: Francis Musembi-Environmental Studies and Community Development (NEMA EIA/EA Associate Expert Reg. No. 8806**

Signed: _____ Date: _____

LIST OF ACRONYMS

APCD	Air Pollution Control Device
CETP	Combined Effluent Treatment Plant
CGM	County Government of Machakos
CPP	Consultation and Public Participation
dBA	Decibels
DOSHS	Directorate of Occupational Safety and Health Services
EA	Environmental Audits
EHS	Environment, Health and Safety
EMCA	Environmental Management and Coordination Act
EPZA	Export Processing Zone Authority
ESIA	Environmental and Social Impact Assessment
ESMMP	Environmental and Social Management and Monitoring Plan
ESSs	Environmental and Social Standards
GBV	Gender Based Violence
GHG	Green House Gases
GRM	Grievance Redress Mechanism
HIV	Human Immunodeficiency Virus
HSE	Health and Safety Expert
KEBS	Kenya Bureau of Standards
KRA	Kenya Revenue Authority
NEMA	National Environment Management Authority
OHS	Occupational Health and Safety
OHSMS	Occupational Health and Safety Management System
OSHA	Occupational Safety and Health Act
PAPs	Project affected persons
PPE	Personal Protective Equipment
SEM	Sustainable Environmental Management
SEP	Stakeholder Engagement Plan
STI	Sexually Transmitted Infections
SOP	Standard Operating Procedures
SWM	Solid Waste Management
TOR	Terms of Reference
WC	Water Closet
WHB	Wash Hand Basin
WHO	World Health Organization
WIBA	Work Place Injuries and Benefits Act
WRA	Water Resources Authority

EXECUTIVE SUMMARY

Introduction

This Report presents the findings of an Environmental and Social Impact Assessment (ESIA) for the proposed development (incinerator and auxiliary facilities) on LR number 23961 (part) portion 11, Kinanie location, Athi-River, Machakos County (Site Coordinates **-1.352192 Longitude: 37.062226**). The ESIA Study Report is submitted to the National Environment Management Authority (NEMA) in conformity with the requirements of the Environmental Management and Coordination Act, Cap 387 and the Environmental (Impact Assessment and Audit) Regulations, 2003 as revised in 2019. Installation of the proposed incinerator and its auxiliary facilities will contribute to safe and proper treatment of biomedical and general waste from Machakos County and the surrounding Counties. The proponent has also considered inclusion of recycling and cogeneration component in the project. Incineration has numerous benefits especially in terms of treatment of biomedical and hazardous wastes and other life-risking wastes.

The objective of the proposed project is:

- To install a modern incinerator complete with APCD
- To provide safe treatment of biomedical and general wastes (Municipal, infectious medical wastes and industrial and other general waste deemed high risk).
- Collection for recycling of non-incinerable wastes that may find its way into the site.

This ESIA is undertaken in accordance with the Environmental Management and Coordination Act (EMCA), Cap 387 and subsidiary legislation under it. It serves several objectives that seeks;

1. To identify and assess all significant impacts of the proposed incinerator and auxiliary facilities on the biophysical and human environment.
2. To draw an Environmental Management and Monitoring plan with suitable mitigation measures;
3. To ensure environmental, health and safety factors are considered in the decision-making process; and
4. To inform the public and seek their views and concerns on the proposed project.
5. To inform basis for decision making by NEMA.

A participatory approach was employed to carry out the ESIA. This involved several desktop studies and review of all relevant available documents on the project activities and components. The Experts also reviewed all the available and relevant legal and policy documents, standards and guidelines. A reconnaissance visit was conducted to check the physical set up of the site and to collect views from all stakeholders within Kinanie location and wider Mavoko Sub County.

Anticipated (Potential) Positive Impacts

i. **Decreased quantities of waste:** The proposed incineration facility is expected to achieve a significant waste reduction of up to 95%. This reduction in waste volume also translates to a solid waste decrease of around 80-85%, depending on the composition of the solid waste materials. Although incineration does not eliminate the need for landfill entirely, it substantially reduces the amount of land required for waste disposal.

ii. **Reduced Pollution:** Studies have indicated that solid waste incinerators have a lower likelihood of polluting the environment compared to landfills. Research conducted during a 1994 lawsuit

in the United States demonstrated that a waste incineration site had a more environmentally friendly profile compared to a landfill. The landfill was found to release higher levels of greenhouse gases, nitrogen oxides, dioxins, hydrocarbons, and non-methane organic compounds. Moreover, landfills leach hazardous substances into groundwater, contaminating underground water systems. The proposed incinerator, equipped with advanced scrubber technology, will contribute to reducing air pollution and play a role in mitigating climate change.

iii. **Trapping of pollutants that would have otherwise been released if open burning was adopted**: While incinerating solid waste can release harmful compounds like dioxins, the modern incinerator facility will utilize filters to trap hazardous gases and particulate dioxins. Stringent pollution limits recommended by the National Environment Management Authority (NEMA) and international protocols will be adhered to.

iv. **Saving on Transportation of Waste within Athi-River and neighbouring Counties**: The strategically located proposed incinerator, situated within reasonable distance from Machakos County and Nairobi City, eliminates the need for long-distance waste transportation. This reduces transportation costs, allowing resources to be redirected towards community well-being and supporting waste generators. Additionally, it curtails harmful emissions associated with waste transportation, thereby significantly reducing the overall carbon footprint.

v. **Better control over odor and noise**: The proposed incinerator will be able to provide less bad smells because waste gets burnt, unlike landfills where waste is allowed to decay thereby emitting unpleasant smells, which cause air pollution. The production of methane in landfills may also lead to explosions that cause noise pollution, which is unheard-of when it comes to the use of incinerators.

vi. **Prevention of the production of methane gas**: In landfills, when the waste is decaying, methane gas is generated which if not controlled, may explode causing further global warming. Unlike landfills, incinerators do not produce methane, therefore making them safer.

vii. **Elimination of harmful germs and chemicals**: The proposed incinerator will function at very high temperatures of about 1,100 ºC that can destroy germs and chemicals that are harmful. Thus, it is a very effective method when it comes to eliminating clinical waste.

viii. **All weather operation**: The proposed incinerator can function in any type of weather. For instance, during a rainy season, waste cannot be dumped in a landfill because the rain will possibly wash down poisonous chemicals into the ground and consequently create leachate thus contaminating the underground water as well as the neighboring land. Waste can also not be dumped when it is windy since it will get blown into the surroundings. On the other hand, incinerator will not be limited to weather changes since it will burn waste without leakages. Incinerator also has the capacity to function 24 hours a day.

ix. **Effective for Metal Recycling:** When the proposed incinerator will be burning waste, the metals still remain whole because they have a high melting point. After the process of burning waste is done, it is expected that the workers remove the remaining metal and recycle it. This removes the need for separating out any metal before waste disposal.

x. **Computerized monitoring system:** The proposed modern incinerator has a provision for a computerized monitoring system device to allow for the troubleshooting of most problems. This will enable operators to discover a problem before it becomes more serious and much more expensive to repair.

xi. **Potential Uses of ash waste:** The ash resulting from waste combustion can be repurposed for construction, shipment, or even landfill disposal, presenting various potential applications.

xii. **Job creation:** The proposed incinerator plant is expected to directly or indirectly create employment opportunities for local residents.

i. **Blue print for Vision 2023:** The proposed project is aimed at having a clean and healthy environment for all. It also encourages private investments in environmental conservation within the country.

Potential negative impacts

i. **Degradation of the air quality and the environment: Incinerator produce smoke during the burning process that can pollute the environment if proper** filters or scrubbers are not installed. The smoke produced includes acid gases, carcinogen dioxin, particulates, heavy metals, and nitrogen oxide. These gases are poisonous to the environment. This is a potential impact that forms the whole basis for this assessment.

Note: The proposed incinerator is fitted with an APCD (wet scrubber) designed to remove two classes of pollutants which are particulate matter and acid gases. As the flue gas passes the scrubber a water jet sprays the flue gas and all soluble gases dissolve in the water and solid particulates are collected in the stainless steel reservoir tank.

ii. **Ash waste risk:** Even though the ash that remains from the process can be comparatively small in quantity, it contains a number of poisons and heavy metals which requires further treatment. If not disposed correctly, it can cause serious harm to the public and the environment. The proponent has proposed measures in place for ash management.

Other potential negative impacts include:

i. Impact to soil (soil erosion and degradation) especially when laying the foundation and other earthworks
ii. Potential contamination of soil and water; due to oil spills and other leakages/releases
iii. Ground water pollution, should leakages or spillages of fuel or hazardous materials not be adequately addressed
iv. The health and safety of workers and immediate residents and neighbors may be compromised due to accidents, pollution and disturbance.
v. Noise generation during the construction phase.

Environmental and Social Management and Monitoring Plan (ESMMP)

The ESMMP outlined in section eight of this report identifies issues of concern (potential negative impacts) and mitigation measures as well as responsibilities, costs and measurable indicators that can help to determine the effectiveness of actions to maintain and upgrade the quality of environment; as regards the proposed project. This monitoring is done in relation to the baseline environment. Regular monitoring is therefore necessary to monitor the change in parameters. The ESMMP has considered all project phases; installation/construction, operational and decommissioning.

Conclusion

Based on the evaluation conducted by the Environmental Impact Assessment (EIA) experts, it is affirmed that the suggested waste treatment incinerator in Kinanie, Athi-River is deemed appropriate.

This verdict is based on considerations spanning environmental impact, site selection, responses and outcomes of public health, as well as public participation. Employing a comprehensive multi-criteria assessment model encompassing economic, social, public health, and environmental aspects, this research underscores that the proposed incinerator project has taken substantial measures to prioritize both public health and environmental concerns. A thorough analysis of the site's suitability is also applied, shedding light on the potential effects of waste incineration facilities. This study culminates by offering pertinent recommendations aimed at refining the environmental impact assessment process and optimizing the advantages of the proposed waste incineration initiative. The ESIA report for the proposed project has revealed that potential significant issues could arise from;

i. Pollutant emissions, disposal (management) of fly and bottom ash, which causes serious pollution to the environment and is a threat to public interests and public health;
ii. Technology used in incinerators, the older generations of incinerators are often much more dangerous to public health. More advanced incinerators have flue gas and dust parameters cleaning systems to reduce the air pollution.
iii. Waste incineration deflects attention from more sustainable solutions, such as redesigning products for recyclability or eliminating toxic, hard-to-recycle plastics which is a holistic issue beyond the proponent of this project.

Recommendations

i. In terms of protecting the public health, improving the relevant techniques and standards of the incinerator is a necessity. The proposed incinerator is expected to meet dioxins emission standards as the introduction and development of more eco-friendly waste-incinerating techniques that promotes the efficiency of incinerators and plays a vital role in reducing fly ash.
ii. The ESMP should be implemented fully at all stages along the project cycle to maximize related positive environmental, economic, social, and public health influences of the proposed project.
iii. Plenser Waste Management Limited should explore the opportunities for co-generation as indicated in the design. Co-incineration offers new markets for waste-derived fuels using existing infrastructure. It is hard to measure how many facilities are currently using co-incineration in Kenya, since there is no law compelling incinerator operators to report it.
iv. The proposed incinerator should have a provision for a computerized monitoring system device to allow for the troubleshooting of most problems related to APCD (cyclone dust collector, bag filters and scrubber system). A computerized monitoring will also make operators work easily as they will be able to track the environmental and operational efficiency of the incinerator plant.
v. Social inclusion: Waste management system relies heavily on informal workers, who collect, sort, and even manage generated waste. The project proponent should address waste picker livelihoods through strategies such as integration into the formal system, as well as the provision of safe working conditions, social safety nets, child labor restrictions, and education.
vi. Climate change and the environment: The project should continuously strive to promote environmentally sound waste disposal. It should support greenhouse gas mitigation through adoption of scrubber technology that capture Greenhouse gases. The value chain should also support resilience by reducing waste disposal in waterways and safeguarding infrastructure against flooding. In this regard, Stack emission assessment should be conducted on quarterly basis.

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1 CHAPTER ONE: INTRODUCTION

1.1 Background Information

In accordance with the stipulations outlined in the Environmental Management and Coordination Act (EMCA), Cap 387, and its associated regulations, Plenser Waste Management Limited initiated an Environmental Impact Assessment (EIA) in 2019, as indicated under reference no. NEMA/PR/5/2/2/2212. Through subsequent review of this EIA, the National Environment Management Authority directed the proponent to undertake a comprehensive EIA study to facilitate an in-depth evaluation of potential impacts associated with the proposed project in compliance with EMCA Act Cap 387 section 58 and Regulation 10 of the Environmental (Impact Assessment and Audit (Amendment) Regulations, 2019. In view of this, the proponent, has therefore initiated this study report. The objective of this report is to build upon the previous assessment, review its findings, and obtain the necessary approvals for the project as required by regulatory procedures. This report presents the findings of an Environmental and Social Impact Assessment (ESIA) for the proposed development (incinerator and auxiliary facilities) on LR number 23961 (part) portion 11, Kinanie Athi-River, Machakos County.

The central objective of an Environmental Impact Assessment (EIA) is to allocate due consideration to the environment within the decision-making process, by conducting a thorough evaluation of the potential environmental outcomes of a proposed activity before any action is undertaken. Early identification and thorough characterization of significant environmental impacts empower both the public and governmental bodies to gauge the environmental viability of a proposed project. This approach helps determine the necessary conditions for mitigating or minimizing associated risks and impacts.

Incinerators find application in the management of various hazardous solid waste types, particularly industrial and medical waste like infectious materials, sharps, and highly infectious waste. Incineration involves subjecting waste to combustion, resulting in the conversion of waste into ash, flue gas, and heat. Waste incineration, a method for waste disposal, employs high temperatures to oxidize combustible components in waste. It offers advantages over alternatives like landfills and composting, such as efficient space utilization, waste volume reduction, and potential energy generation.

While the prospects for the waste incineration industry appear promising, challenges like improper siting, inadequate environmental impact assessments, and excessive fly ash production underscore the importance of proper site evaluation and an effective Environmental and Social Impact Assessment (ESIA) process. Therefore, ensuring that waste incineration is ecologically sound and safeguarding public health becomes paramount.

In line with this goal, the ESIA adheres to the requirements outlined in the Environmental Management and Coordination Act, Cap 387, and the Environmental (Impact Assessment and Audit) Regulations, 2003, as revised in 2019. The assessment indicates that the proposed incineration installation is anticipated to significantly enhance the secure and proper treatment of biomedical and hazardous waste sourced from EPZA surroundings, Machakos County, and neighboring counties. Incineration boasts a

multitude of benefits, particularly concerning the management of hazardous waste and other high-risk refuse.

In conclusion, this Environmental and Social Impact Assessment (ESIA) is being submitted to the National Environment Management Authority (NEMA) for review and determination, marking a pivotal step in the decision-making process overseen by the Authority.

1.2 The project proponent and track record

The project proponent is Plenser Waste Management Limited. It is a company incorporated in Kenya and has interest in solid waste management and more so the biomedical and general wastes and thus the urgency of installing a commercial incinerator in the proposed site. The proponent's anticipates to offer waste management services including incineration, recycling and value addition in the waste value chain in Machakos County and the country at large with initial focus on venturing on incineration services and later incorporating recycling of waste, waste water management consultancy and trainings on waste management technologies and current trends.

Through their years of operation and consistent market research, Plenser Waste Management Limited has demonstrated unwavering professionalism and has earned a robust reputation. This reputation has been established not only based on their expertise but also through their consistent delivery of exceptional service and comprehensive after-sales support.

The proponent has leased land within the EPZA zone in Kinanie (an EPZ dedicated for industrial parks), Athiriver-Machakos County with an aim of putting up a development that will comprise of an incinerator, an office building, a recycling plant, perimeter wall, staff court, visitor's parking and related components. The proponent's target market will comprise of the manufacturing sector; commercial establishments; institutions including schools, hospitals, colleges, research centres, refugee camps; security agencies and Government parastatals; municipalities and Non-Governmental Organizations.
Appendix 2: The pin and certificate of registration of the proponent.

1.3 The state of the proposed site and the neighbourhood

The proposed project site is situated within the EPZA land area, specifically in Kwa Mboo sub location of Kinanie location within Mavoko Sub County, Machakos County. This site is conveniently located near an existing wastewater treatment plant and can be accessed via an unpaved road that branches off from Mombasa Road in close proximity to Athi River town. The surrounding landscape is characterized by savannah-type vegetation, predominantly marked by acacia trees.

The EPZA land encompasses approximately 339 hectares, with the main site covering 292 hectares on Land Reference (LR) No. 18474 in Athi River (Mavoko) and an additional 301 hectares in Kinanie Location approximately 14 kilometers off Nairobi-Mombasa Highway and along the Mutonguni (E434) road that interconnects Kangundo Road earmarked for the leather industrial park, the EPZA sewage treatment ponds, waste treatment facilities, trade Centre among other supportive amenities.

The primary purpose of the EPZs is to provide infrastructure and services tailored for export-oriented industries situated within the zone. Additionally, these services extend to the broader community encompassing Mavoko and Kitengela. This zone benefits from excellent accessibility, as it is conveniently situated near two major highways-the Nairobi-Mombasa and Nairobi-Namanga routes. Furthermore, its proximity to Jomo Kenyatta International Airport and adjacency to the primary Nairobi-Mombasa railway line enhances its connectivity. This strategic location places the Athi River EPZ in close proximity to both Athi River town and Nairobi city.

The Athi River zone is characterized by three tiers of infrastructural development, encompassing zone infrastructure, off-site infrastructure, and ancillary development. The officially gazetted zone covers a total of 339 hectares, out of which 292 hectares pertain to the primary zone, and an additional 47 hectares are allocated for supporting development adjacent to the zone. Managed by the Authority, the EPZ public zones are equipped with infrastructure to facilitate enterprise development, comprising land, structures, water supply facilities, and sewerage systems.

1.4 Problem statement

Around the world, waste generation rates are rising. In 2016, the worlds' cities generated 2.01 billion tonnes of solid waste, amounting to a footprint of 0.74 kilograms per person per day. With rapid population growth and urbanization, annual waste generation is expected to increase by 70% from 2016 levels to 3.40 billion tonnes in 2050 (World Bank). In Kenya Urban area, the urban poor, are more severely impacted by unsustainably managed waste. In low-income countries, over 90% of waste is often disposed in unregulated dumps or openly burned. These practices create serious health, safety, and environmental consequences. Poorly managed waste serves as a breeding ground for disease vectors, contributes to global climate change through methane generation, and can even promote urban violence. In health sector alone, a number of medical centers in the country lack incinerators thus opting for open dumping or even burying. Medical waste consist of sharps (syringes), infectious and highly infectious waste such as placenta and anatomical wastes. Open dumping and burying exposes people and the environment to the harmful effects of these wastes which is not safe. The benefits of installing modern waste treatment facilities like incinerators are immeasurable and thus encouraged. With the nearby Leather Industrial Park and the very many health facilities in the area, the proposed incinerator project will go a long way in promoting safe and sustainable waste management.

Figure 1-1: Google earth View of the EPZA land in Kinanie where the incinerator is proposed for installation.

1.5 Justification of the project

Managing waste properly is essential for building sustainable and livable cities, but it remains a challenge for many developing countries and cities. Effective waste management is expensive, often comprising 20%-50% of municipal budgets. The proposed incinerator project by Plenser Waste Management Limited is founded on a multitude of justifications that highlight its significance and benefits. These justifications are rooted in environmental responsibility, efficient waste management, public health considerations, and economic advantages. Here are some key justifications for the proposed incinerator project:

i. **Effective Hazardous Waste Management:** Incinerators are proven to be highly effective in managing hazardous waste materials, such as medical waste, sharps, and industrial waste. The incineration process involves high temperatures that result in the complete destruction of harmful pathogens and pollutants, minimizing their potential negative impact on the environment and public health.

ii. **Waste Volume Reduction:** Waste incineration significantly reduces the volume of waste material, which is especially beneficial in dealing with bulky and space-consuming waste. This reduction in waste volume translates to decreased demand for landfill space, addressing the growing concern of limited land availability for waste disposal.

iii. **Energy Generation:** Modern incineration technology often includes energy recovery systems that convert the heat generated during the incineration process into electricity. This co-generation of energy not only contributes to the efficient use of resources but also provides an alternative energy source.

iv. **Air Pollution Control:** The proposed incinerator is equipped with advanced scrubber technology that effectively captures and reduces air pollutants. This ensures that the emissions released into the atmosphere are well within acceptable limits, mitigating air pollution concerns.

v. **Mitigation of Greenhouse Gas Emissions:** Waste incineration helps mitigate greenhouse gas emissions compared to traditional waste disposal methods like landfills. Incineration reduces the production of methane, a potent greenhouse gas emitted during waste decomposition in landfills.

vi. **Public Health Safeguarding:** The incineration process eliminates harmful pathogens and reduces the risk of disease transmission associated with improper waste disposal. This is particularly crucial for medical waste that contains infectious materials. The proposed incinerator will in overall improve public health and livelihoods by reducing open burning, mitigating pest and disease vector spreading, and preventing crime and violence. In Kenya, management of hazardous wastes is regulated under the Environmental Management and Co-ordination-EMC (Waste Management) Regulations (2006) and other related regulations. These regulations establish an order of preference for the management of hazardous wastes to be: minimization, recycling, treatment, and land filling. A number of waste generation facilities in the country lack proper waste management systems thus opting for open dumping or even burying. However, this is not safe thus the urgency of having quality and functional incinerators. Installation of the proposed incinerator will thus foster proper treatment and final disposal of biomedical and general waste within Kinanie, Athi River, the environs within Machakos County and the surrounding Counties.

vii. **Environmental Impact Assessment (EIA):** Plenser Waste Management Limited's commitment to conducting an Environmental and Social Impact Assessment (ESIA) aligns with regulatory requirements and demonstrates a responsible approach to environmental considerations.

viii. **Local Economic Opportunities:** The establishment of the proposed incinerator project has the potential to create job opportunities for local residents, thereby contributing to the economic growth and well-being of the community.

ix. **Reduction in Carbon Footprint:** The proposed project's utilization of waste as a source of energy contributes to the reduction of carbon emissions that would otherwise be generated by conventional energy sources.

x. **Demonstrated Professionalism:** Plenser Waste Management Limited's established track record of professionalism, expertise in incinerators, and commitment to providing exceptional service further strengthen the credibility and viability of the proposed project.

1.6 The scope and Objectives of the proposed Project

The proposed project aims to:

- To provide a suitable modern incinerator, being one of its kind in the country.
- To provide safe treatment of hazardous wastes (Municipal, infectious medical wastes and industrial and other general waste deemed high risk).

1.7 Objectives of the ESIA Process

This ESIA is undertaken in accordance with the Environmental Management and Coordination Act (EMCA), Cap 387 and subsidiary legislation under it. It serves several objectives that seeks;

- To identify and assess all significant impacts of the proposed project on the biophysical and human environment

- To draw an Environmental Management and Monitoring plan with suitable mitigation measures;
- To ensure environmental, health and safety factors are considered in the decision-making process; and
- To inform the public and seek their views and concerns on the proposed project;
- To inform basis for decision making by NEMA.

1.8 The ESIA Methodology

Environmental Impact Assessment (EIA) refers to a critical examination of the effects of a proposed project on the environment before its implementation. Impacts describe any negative and positive environmental influence caused by a project. EIA is applied on the basic principle that the effect of a project on the environment needs to be established before it is implemented. The basic assumption is that if a proper EIA is carried out then, the safety of the environment can be properly managed during the projects implementation, commissioning, operation and decommissioning. A project is defined as a specific set of human activities in a particular location and time frame intended to achieve an objective(s). The term environment is used in its broadest possible sense to embrace not only physical and biological systems but also socio-economic systems and their inter-relationships. In order to evaluate the proposed project in the environmental impact, this study constructed an analytical framework to explore related environmental, economic, social, and public health influences of the proposed waste incinerator and its auxiliary facilities. It also, based on the framework, created a quantified multi-criterion ESIA model and a location analysis for evaluating the existence of such a plant in Kinanie, Athi-River. The ESIA process took into account operational, social, cultural, economic, legal, health and safety, climate change and administrative considerations. Specifically, the process included the following:

- Identifying the anticipated Environmental Impacts and the scale of impacts of the proposed project.
- Identifying and analyzing alternative methods or technologies for implementing the proposed project;
- Proposing mitigation measures to be undertaken during and after the implementation of the project;
- Developing an Environmental Social Management and Monitoring Plan (ESMMP) with mechanisms for Monitoring and Evaluating the compliance and environmental performance, cost for mitigation and time frame of implementing the measures.

A participatory approach was employed to carry out the ESIA. This involved several desktop studies and review of all relevant available documents on the project activities and components. The Experts also reviewed all the available and relevant legal and policy documents, standards and guidelines. A reconnaissance visit was conducted to check the physical set up of the site and to collect views from the community. Attached at the appendix are samples of questionnaires administered to the community members. For the wider reach, it is anticipated that the proposed project will be advertised in two local dailies of wider reach, published in Kenya gazette and radio station of wider circulation.

The main output is an ESIA study report comprising of executive summary, assessment methodology, project description, study area, legal and institutional framework, and anticipated impacts and an

Environmental Social, Management and Monitoring Plan (ESMMP). The determination of 'significance' incorporates judgments of the above together with the potential magnitude of the impact. In addition, the frequency of impacts upon the receiving environment is a factor in determining the significance. An impact that is moderate in size but continuous can be more significant than one that is infrequent or rare. Project impacts were considered direct or indirect.

Direct: Effects directly attributable to the company activities or actions; and

Indirect: Effects not directly attributable to the company activities or actions.

The determination of significance is therefore dependent upon decisions of the following factors:

Table 1-1: ESIA significance factors considered

Significance Factors	Description
Extent/Magnitude	Potential impact was quantified with range limits wherever possible and relevant modeling may be undertaken in order to predict impacts for appropriate factors.
Reversibility	A reversible impact is one in which the condition which the impact effects can be returned to the baseline condition prior to the impact.
Duration	The length of time of an impact may be short, medium or long term. Typically, this is defined as <5 years, 5-15 years and >15 years respectively.
Standards	Complying with the national and international standards, which may exist for a particular impact, also helps define the potential significance of an issue.
Sensitivity of receptors	In many areas the sensitivity is further defined by consultation and baseline surveys, which helped detail the existing environment. Areas designated nationally or internationally should be considered as sensitive areas and impacts minimized wherever possible.

NB: In this ESIA study, all the aspects illustrated have been considered here (e.g. waste transport, occupational factors, greenhouse gases, risk perception etc.) and were part of a more complete and exhaustive exercise. However, we aimed to establish a baseline scenario that can be useful in the future for prognostic assessment of emission standards and waste management during facility auditing upon approval and operation as well as in identifying knowledge gaps, and providing a framework for future comparative risk assessment.

1.9 ESIA Experts

NEMA registered EIA/EA Experts undertook the ESIA and prepared a study report as provided for in the Environmental (Impact Assessment and Audit) Regulations of June 2003 revised 2019.

Appendix 3 is copies of experts' registration certificates and practicing licenses.

2 CHAPTER TWO: PROJECT DESCRIPTION

2.1 The nature and location of the Project

The proposed project will be located on L.R. No. 23961 (part) Portion 11 Kinanie within the Export Processing Zone Authority land parcel located in Kinanie, Athi-river, Mavoko Sub County-Machakos County. The project site is approximately 14kilometres off Mombasa Road on site coordinates 1°35'21.4"S and 37°06'20.5"E. The neighbours adjacent to the proposed site are a few residential dwellings some belonging to EPZA staff, EPZ Waste treatment works, CETP for the leather industrial park (under construction), Sanergy Organics recycling factory, Green city incinerators (under construction) and Boredo supplies-Kinanie.

Plate 2-1: Proposed Project Site

Plate 2-2, 2-3: Part of the project site and Ongoing Incinerator development by Green City Incinerators Ltd and Boredo Supplies Ltd

2.2 Project Design

The proposed project will incorporate the following components:

Table 2-1: Project Components

No	Project Component	Description
1.	Office Building	**Ground Floor Layout**: Comprising of: - Meeting room - Office 1 and 2 - A reception - A waiting area - A foyer - Hall - Sanitary facilities-separate for gents and ladies (Gents-1No WC, 1No urinal, 1No WHB; Ladies-1No WC, 2No WHB and a common lobby) - Changing rooms separate for gents and ladies each fitted with 2No showers, Lockers, 1No WC, 1No bench, common lobby and 2No WHB. 2No urinals provided in the gents changing room. **Mezzanine Floor Layout**: - 4No. offices - Lobby - Boardroom - Kitchen - Sanitary facilities-Gents-1No WC 1No urinal and 1No WHB; Ladies-1No WC, 2No WHB. A common lobby is provided. **Roof Level Terrace:** - Roof terrace provided with an outdoor sitting area - 2No 3200 litre plastic cold water reservoir tank **Stairwell connecting the floors**
2.	Incineration Go down	**Ground Floor Layout:** - Receiving office - Receiving area fitted with weighing scale, foot bath and lockers - Sorting area - 2No Workshops - 3No temporary storage bays - Fuel room - Incineration area
3.	Auxiliary Facilities	- Transformer house - Guard House - Weighbridge - Drive way

		✚ Ash collection area with 2No Ash pits ✚ Staff Court ✚ Visitor's parking ✚ Loading zone For Future Development: ✚ Recycling Plant that will comprise of a recycling yard, material drop off and a recycling material yard
4	Supportive Components	✚ Firefighting equipment ✚ Inspection chambers connected to the sewer-line ✚ Storm water drains ✚ Boundary wall

2.2.1 Technical Specifications

The proposed project will involve installation of a pyroflame 200PF manual load medical/general waste incinerator with a design capacity of 200kg/hr. The incinerator will handle mixed type waste group A, B, C, D, E and 0, 1, 2 and 3 hospital/clinical bio hazard waste with waste density range of 125-350Kg/m3. The incinerator is a modern waste disposal unit that employs a temperature based logic control system to provide optimum control of the operating conditions. To ensure the unit's effective destruction of the combustion products, the unit will incorporate a high capacity thermal oxidizing secondary chamber, designed to retain the exhaust gases for at least 2 seconds.

Table 2-2: Summary of technical specifications for the Incinerator

Incinerator	
Brand Type and Model	Pyroflame; 200PF
Burning Capacity	200Kg/hr
Type of Fuel	Diesel
Type of burner operation	2No diesel fired packaged primary burners and a single secondary after burner
Temperature: Primary Chamber Secondary Chamber	 1050°C 1100°C
Primary Chamber	
Type Material of Construction Refractory thickness Hot face material Insulation thickness Waste charging Ash removal Volume	Static solid hearth Mild steel plate and stiffened with rolled steel sections 100mm 25mm Manual $3m^3$
Secondary Chamber	
Refractory lining (Hot face refractory) Refractory thickness Insulation thickness	Coarse-grained 60% alumina castable 200mm 25mm
Burner	

No of burners Fuel Make	2No primary ignition burners and 1No secondary after burner Diesel Manufactured by Riello
Chimney	
MOC Height	Stainless steel 10 metres
Life span	10-15years
Weight	10,000kgs
Anticipated daily operating Period	8hours
Estimated ash residue	5-10%

2.2.2 Plant equipment

The equipment will comprise of:

- Manual Loading/ ash removal door
- 2 off diesel-fired primary ignition burners–temperature controlled
- 1 off diesel-fired secondary afterburner–temperature controlled
- Manually operated air system
- High capacity secondary combustion chamber 2 seconds @ >1050ºC
- Control panel–automatic operation
- Temperature indication primary and secondary chambers 0-1200ºC
- Combustion chamber
- Flue gas stainless steel chimney to a height of 10 Meters with a refractory lined section before the scrubber system
- Air distribution system with 3HP high speed fan
- Air pollution control system (wet scrubber)
- Flue gas sampling port including access ladder and platform
- Fuel tank of capacity 2400 liters complete with tank stand and level control system.

❖ **Primary Combustion System Operation**

The primary combustion chamber is the main structure of the incinerator, fabricated from mild steel plate and stiffened with rolled steel sections. It is carried from the floor level on a substantial steel support frame. The shell is lined with insulation and a hot face combination of high strength castable cement. The primary combustion system of the incinerator installation is where combustion of the waste in the solid phase takes place. It is essential that the combustion be closely controlled to ensure complete combustion of the solid waste to ash. It is also necessary to control the combustion in the gaseous phase, to limit the formation of gases which can only be controlled in the combustion phase e.g. carbon monoxide, nitrogen oxides, volatile organic compounds and to limit particulates which may be carried on the gas stream. In this chamber, waste will be charged manually via the main charge door.

Combustion air is blown through air ducts adjacent to the hearth, ensuring intimate mixing of air and waste for good combustion. The airflow is controlled to create the correct conditions within the chamber for combustion and the control of emissions.

A diesel-fired burner will ensure ignition of waste in the main primary chamber. This will be positioned strategically along the sidewall to provide maximum hearth coverage. This burner will be closely controlled to enable accurate fuel and air input to be maintained. Ash removal from the chamber is carried out via the load/ash door.

- **Secondary Chamber**

The secondary chamber is designed to minimise and destroy the partial products of combustion, such as carbon monoxide and the containment combustion products such as nitrogen oxides, volatile organic compounds and particulate. To ensure the products of combustion are sufficiently heated and oxygenated to complete combustion in the gaseous phase, both heat and oxygen in the form of air are added to the secondary chamber. Heat input from the afterburner is controlled directly by the control system, such that in the event of temperatures in excess of 950°C ~ 1,200°C being transferred from the primary chamber the afterburner will switch off to conserve fuel.

During low temperatures i.e. less than 900°C, the afterburner will be signalled to fire at high rate to maintain combustion temperatures above 1050°C. These operating temperatures are infinitely adjustable to promote higher operating temperatures where required. To ensure the combustion gases are subject to adequate oxidising conditions, high-pressure air is introduced into the chamber via several jets. These air jets input turbulence into the gases and together with several internal baffles and changes

- **Burners**

The plant is fitted with two diesel fired packaged primary burners and a single secondary after burner. The burners manufactured by Riello are flange mounted to the incinerator casing and incorporate an individual ignition system, flame detector and control unit. They are designed to fire light oil having a viscosity of 6mm^2/s. To preserve fuel and maintain the optimum combustion conditions the burners are temperature controlled. As waste in the primary chamber increases the chamber temperature, the burners will be signalled to switch off.

As heat is released from combustion of waste and as the refractory lining becomes "soaked" with heat, the required heat input from the secondary burner will be progressively reduced. There are substantial changes in the required auxiliary heat input as the nature and feed rate of waste changes. The burners accommodate these changes by varying its output according to a series of temperature signals interpreted by the control equipment.

- **Control**

The total installation will be policed by a time and temperature dedicated control system, housed within an incinerator mounted control cabinet. The control panel will incorporate visual display of both the primary and secondary temperatures and will provide status indication of the plant cycles.

- **Chimney**

A stand-alone chimney having an overall height of 10 metres from firing floor level and an internal bore will be provided. The chimney is manufactured in stainless steel sections. External lifting lugs will be fitted to aid chimney erection.

❖ **Load door**

This will be in form of a full sized hinged door. The loading door will be installed in such a way that immediately the door is unclamped the ignition burner will cut out.

❖ **Wiring**

All items on the incinerator would be wired up to the incinerator mounted control panel. The wiring would be carried out in PVC sheathed cable run in steel conduits and trunking.

❖ **Pipe work**

The unit will be completely piped and tested prior to despatch. Each burner will incorporate individual filters and isolation valves.

❖ **Electrical Supply**

The electrical equipment provided would be suitable for an electricity supply of 415 Volts, three phase and 50Hz/60Hz.

❖ **Other tools**

One off 1.5 metre long rake, ash bin, ash tray, weighing scale, fire extinguisher (fire hydrant) and signage.

❖ **Air Pollution Control System (Wet Scrubber)**

A wet scrubber is a simple, yet extremely versatile air pollution control device that limits gaseous emissions by creating contact between exhaust gases and injected water. A wet scrubber removes particulate matter and acid gases from waste gas streams of stationary point sources such as waste incinerators. The pollutants are removed primarily through the impaction, diffusion, interception and/or absorption of the pollutant onto droplets of liquid. The liquid containing the pollutant is then collected for disposal.

As they pass through the scrubber unit hot flue gases are rapidly cooled by atomized water that is forcibly injected under pressure through one or more spray nozzles. Any dust particles (particulates) within the gas stream are instantly and effectively captured within the water droplets, after which they are deposited in the scrubber re-circulation reservoir. In addition to particulates this process also arrests heavy metals and to a large extent, acids in the form of sulphur and chlorine.

The air pollution control system (wet scrubber) will be attached on the horizontal section of the flue gas chimney. It will comprise:

- Stainless steel reservoir tank with makeup water inlet complete with stainless steel ball valve. The Stainless steel plate will have a thickness of 3mm.
- Refractory lined T section. The refractory thickness will be between 75-100 mm.
- Stainless steel spray nozzle.
- Hot water circulation pump, this is a centrifugal multistage horizontal electric pump of 1.2 Cu M at 20 M head or 4.8 Cu M at 8M head.
- Galvanized piping.

- Pump controls that should monitor the water flow rate in the system.

As the flue gas passes the scrubber a water jet sprays the flue gas and all soluble gases dissolve in the water and solid particulates are collected in the stainless steel reservoir tank which has a nominal capacity of 0.28 cubic meters.

2.3 Proposed product and process description

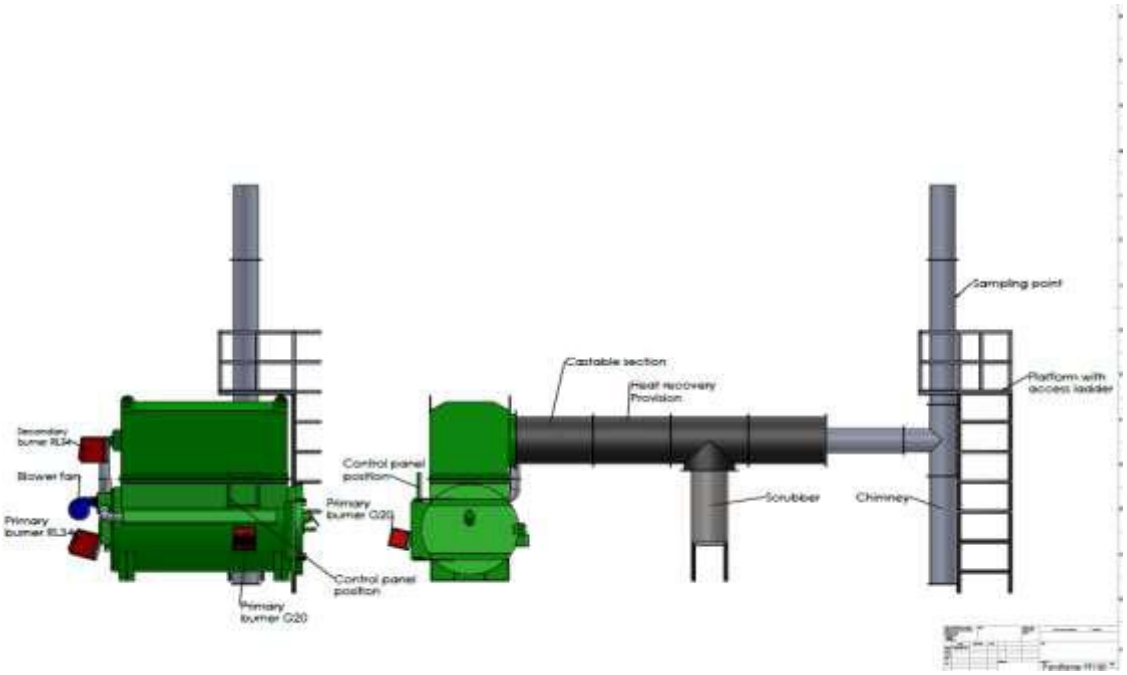
Incineration is a high-temperature heat treatment technique, in which a certain amount of excess air is oxidized in the incinerator when the waste is being treated. Toxic and harmful substances in the waste are damaged by oxidation and pyrolysis at a high temperature. This treatment technology can realize the harmlessness, reduction, and recycling of hazardous waste to the maximum extent at present.

The Pyroflame PF200 is an incinerator brand, designed and manufactured by the proponent certified by the Kenya Bureau of Standards (KEBS) and approved by NEMA. The brand is highly robust, easy to operate and economical. The incineration process is as detailed below:

Bagged or loose waste is ***introduced*** into the primary chamber via the interlocked load door where it is deposited on the hearth of the chamber. Ignition is provided by an oil fired burner positioned to ensure efficient coverage of the hearth. Combustion air is also provided in the form of high pressure, high velocity air, to strategic areas of the fire bed and secondary chamber. The products of combustion from the primary chamber are ***exhausted*** into the secondary chamber located directly above the primary chamber for ***treatment***. Within the secondary chamber additional heat and air are added to promote ***combustion*** in the gaseous phase. These gases reside within the chamber at a minimum temperature of 1050°C to ensure complete combustion of the volatile and solid particulate.

Treated gases then exit the secondary chamber, directly into the secondary chamber mounted exhaust chimney. This process is carried out throughout the day, until the last charge has been introduced. Once introduced, a ***Cool Down cycle*** is selected which automatically ensures completion of the incineration process and cycles the unit through a controlled ***cooling*** and shut down process to enable safe removal of the ash.

The whole system is controlled and policed by a central relay logic time and temperature control system.



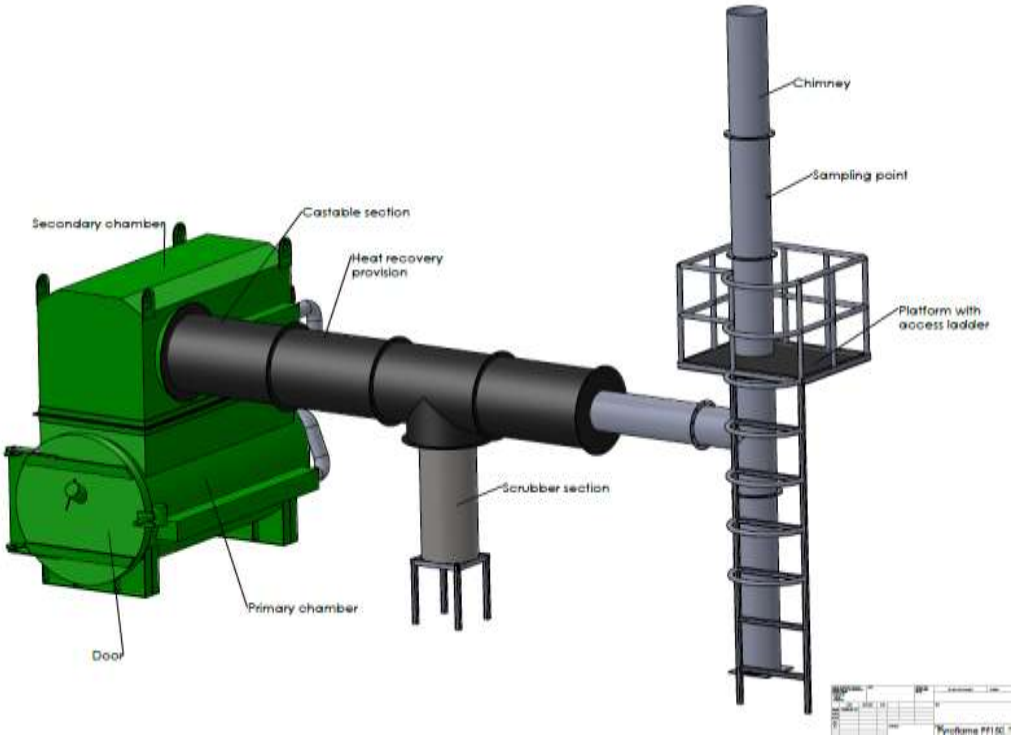


Fig 2-1, 2-2: Schematic diagram of the Pyroflame PF200 Incinerator

2.3.1 Means of Monitoring temperature in both primary & secondary chambers

The proposed incinerator will have 2 main ignition burners and one after burner with a capacity of 790Kw with electronic temperature control from 0 to 1,200ºC.

2.3.2 Methods of Disposing off the Incineration ash.

At the plant facility, two ash pits will be constructed where the ash will be placed after incineration. If full, the ash will be collected for reuse i.e. making of bricks or by the registered Mavoko Municipality waste collection company bins and taken to a land fill that is NEMA approved.

2.4 Detailed Incineration Process Flow and Environmental Releases

The waste-incineration facility will include the following basic operations:

- Waste storage and feed preparation
- Combustion in a furnace, producing hot gases and a bottom ash residue for disposal.
- Gas temperature reduction, frequently involving heat recovery via steam generation.
- Treatment of the cooled gas to remove air pollutants, and disposal of residuals from this treatment process.
- Dispersion of the treated gas to the atmosphere through an induced-draft fan and stack.

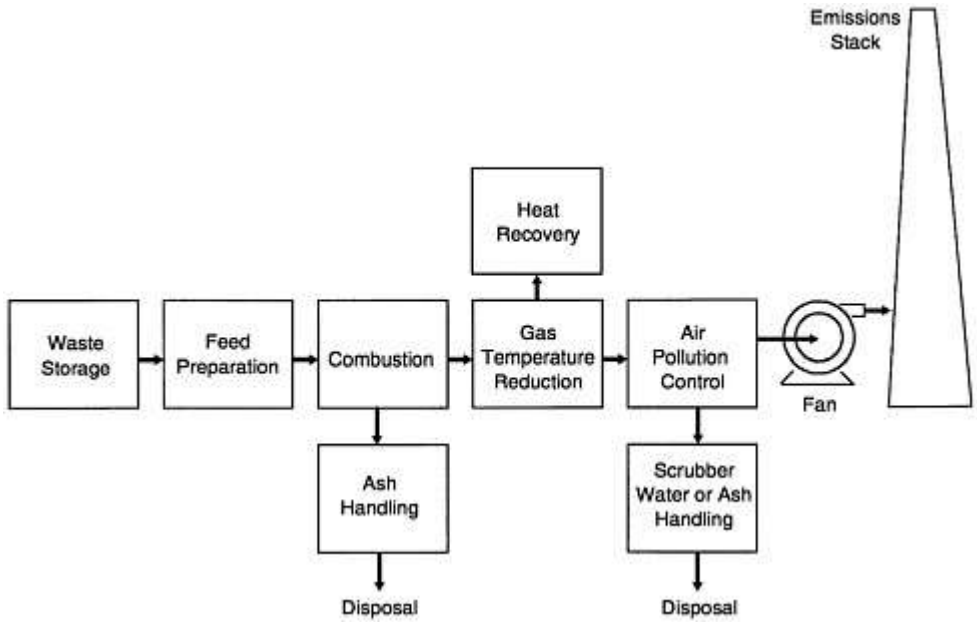


Fig 2-3: Proposed waste-incineration facility schematic Flow

2.5 Proposed Project Activities

2.5.1 Description of the proposed project construction activities

- **Pre-Construction Stage Project Approvals**

The architectural drawings have been submitted and approval by lead agencies for implementation such as the Physical Planning Department, Fire Department and the Public Health Department-Mavoko Sub-County. The proposed project will be submitted to the National Environment Management Authority for review and approval.

The pre-construction will also involve getting to collaborative agreements with key stakeholders including project manager, architects, quantity surveyors, engineers /contractors (structural, mechanical, electrical), material suppliers, landscapers, and financiers).

- **Construction Phase**

The following are processes that will be undertaken during the construction phase of the project.

- **Recruitment of staff**

The commencement of the construction works of the proposed development will require both skilled and semi-skilled labour. Cheap labour will be sourced from the Kinanie area locals and surrounding environs.

- **Site preparation**

This will involve clearing any existing vegetation, levelling the ground and proper site hoarding. Clearing of the site mainly bushes or shrubs leaving more indigenous trees.

- **Transportation of building materials**

Building materials will be transported safely from the distributors to the project site by the use of lorries. These materials include building stones, sand, cement, rubble, ballast, glass, tiles and cabro. These materials will be sourced from the nearest sources and distributors to give both environmental and economic logic to the proponent. The proponent intends to source these materials from hardware shops within Kinanie area and the surrounding environs, in order to minimize the materials' carbon footprint and reduce transportation costs.

- **Storage of the construction material**

Construction material will be stored on site and guarded for safety purposes. The bulky materials such as the stones, ballast, steel and tiles will be piled in the site while the less bulky material such as cement, paints and glasses will be kept in the store. All these will be stored in an orderly manner to observe good housekeeping. Many accidents and near misses may occur due to poor housekeeping. Additionally, the proponent will order for material in considerable quantities to minimize stockpile on site. Careful design, planning and good site management would be maintained to minimize over-ordering and waste of raw materials such as ready mixed concrete, mortars and cement grouts.

- **Installation of utility services**

This will include plumbing works to install piping for water and waste water drainage, electrical supply and wiring, communication and information cables.

- **External works**

This will entail the completion of the driveways, footpaths, parking lots, water supply, wastewater drainage, and solid waste disposal facilities. Landscaping will also be undertaken to restore and improve the aesthetic value of the site. This will include the renewal of the topsoil, establishment of flower gardens and grass lawns. A proper gate will be installed to limit access to the site to authorized personnel only and enhance security.

- **Structural Steel Works**

The buildings will be reinforced with structural steel for stability. Structural steel works will involve steel cutting, welding and erection.

- **Roofing and Sheet Metal Works**

Roofing activities will include sheet metal cutting, raising the roofing materials such as GI sheets and structural timber to the roof and fastening the roofing materials to the roof.

2.5.2 Description of the proposed project operation activities

Once the incineration plant is completed, the proponent will use the facility to conduct incineration for various clients. Maintenance activities will include facility cleaning, routine checks and other necessary repairs. Workers will be fully employed onsite including the truck drivers who will be transporting the waste for incineration.

- **Operation of the proposed incinerator**

Waste reception, weighing and sorting

Once received, all waste will be first weighed and documented then sorted to different waste types. Recyclable waste materials for general waste will be stored separately awaiting collection and transport to the recycling area. The rest of the waste will be directed to a temporary storage bays awaiting the incineration process.

Waste storage, feed preparation, and feeding

There are common waste storage, waste staging, feed preparation and feeding practices for incinerators. These practices are highly waste-and facility-specific. Proper design and operation of these "front-end" plant operations have been considered and are important for several reasons:

- While the plant is operating, the potential for worker exposure to hazardous materials is the greatest in this part of the facility especially during manual loading. Without appropriate engineered and administrative controls, including personnel protective equipment, operators can be exposed to hazardous dust and vapors.
- This part of the plant is the highest potential source of fugitive dust and vapor emissions to the environment, and the greatest potential fire hazard.
- Without proper waste preparation and feeding, the furnace combustion performance may be impaired.

Note: The waste feeding process will be manual.

- **Ash Removal**

Fly ash will be generated from the incineration process. This is likely to be toxic if by any chance it escape into the environment during handling or removal. This should thus be contained at all times both inside and outside the facility. In the facility, water will be used to quench the ash, simultaneously reducing dust generation and minimizing the possibility of ash-dust inhalation or ingestion by workers. In the proposed incinerator, a closed system of conveyor to transport the ash from the furnace to trucks to minimize worker exposure will be adopted.

- **Recycling activities**

The proponent will set up a recycling area in future to undertake recycling activities for waste materials that can be reconditioned for other uses.

- **Solid waste management**

The project proponent will provide facilities for handling solid waste generated within and around the facility. These will include dustbins/skips for temporarily holding waste within the premises before final disposal at the designated dumping site by NEMA approved solid waste handling company.

- **Effluent and waste water management**

The area is served by a sewer system. Waste water generated from the incineration plant mainly from washroom will be discharged into the sewerage system of EPZA who have waste water treatment. While storm water from the project area will be channeled into the storm water drainage system or directed to natural water courses with consideration of downstream effects. Inorganic waste generated from the facility such as oil and fuel should however be treated before release to the system.

- **Cleaning**

The proponent will be responsible for ensuring regular washing and cleaning of the pavement of the entire facility. Cleaning operations will involve the use of substantial amounts of water, disinfectants, detergents etc.

- **General Repairs and Maintenance**

The buildings and associated facilities will be repaired and maintained regularly during the operational phase of the project. Such activities will include repair of building walls and floors, repairs and maintenance of electrical gadgets and equipment, repairs of refrigeration equipment, repairs of leaking water pipes, painting, maintenance of flower gardens and grass lawns, and replacement of worn out materials among others.

2.5.3 The combustion processes

2.5.3.1 Proposed considerations

Combustion is a rapid, exothermic reaction between a fuel and oxygen (O_2). In incineration applications, the fuel is predominately waste (although fossil fuels may be co-fired) and the oxygen source is air. Combustion produces many of the same stable end products, whether the material burned is natural gas, coal, wood, gasoline, municipal solid waste, industrial wastes, hazardous waste, or medical waste. The flame zone of a well-designed incinerator is sufficiently hot to break down all organic and many inorganic molecules, allowing reactions between most volatile components of the waste and the oxygen and nitrogen (N_2) in air. The predominant reactions are between carbon (C) and oxygen, producing carbon dioxide (CO_2), and between hydrogen (H) and oxygen, producing water vapor (H_2O). Incomplete combustion of organic compounds in the waste feed stream produces some carbon monoxide (CO) and carbon-containing particles. Hydrogen also reacts with organically-bound chlorine to produce hydrogen chloride (HCl). In addition, many other reactions occur, producing sulfur oxides (SO_x) from sulfur compounds, nitrogen oxides (NO_x) from nitrogen compounds (and, a little, from the nitrogen in the air), metal oxides from compounds of some metals, and metal vapors from compounds of others.

The furnace is designed to produce good mixing of the combustion air and the gases and vapors coming from the burning waste. Nevertheless, in parts of the furnace where combustion is not complete (for example, near the walls of the furnace), combustible components of organic compounds are burned off, leaving the incombustible particulate matter known as fly ash entrained in the flue gas. The incombustible portion of the waste (known as bottom ash) is left behind.

The proposed incinerator facility incorporate a number of general methods for ensuring proper combustion and reducing emissions. A steady situation with no major fluctuations in the waste-feed supply rate, combustion-air flows, or other incineration conditions promotes efficient combustion. Inefficient combustion can result in higher levels of products of incomplete combustion. Similarly, the more often the facility is started up and shut down (for maintenance or because of inadequate or varying waste stream volume), the more uneven the combustion and the greater the potential for increased emissions.

Optimal design and operation of a furnace requires attention to incineration temperature, turbulence of the gas mixture being combusted, and gas-residence time at the incineration temperature. To achieve efficient combustion, every part of the gas stream must reach an adequately high temperature for a sufficient period of time, and there must be adequate mixture of fuel and oxygen.

The temperature achieved is the result of heat released by the oxidation process, and has to be maintained high enough to ensure that combustion goes to completion, but not so high as to damage equipment or generate excessive nitrogen oxides. Temperatures will be controlled by limiting the amount of material charged to the furnace to ensure that the heat-release rate is in the desired range, and then tempering the resulting conditions by varying the amount of excess air.
Turbulence will be needed to provide adequate contact between the combustible gases and oxygen across the combustion chamber (macroscale mixing) and at the molecular level (microscale mixing). Proper operation is indicated when there is sufficient oxygen present in the furnace, and the gases are highly mixed. Cool spots can occur next to the furnace's walls; where heat is first extracted from the combustion process. Such cool spots on walls are more substantial in water-wall furnaces than in refractory-lined furnaces.

2.5.3.2 Furnace Type

The proposed furnace types will consider all sources of hazardous wastes. Furnace designs have evolved over the years from simple batch-fed, stationary refractory hearth designs to continuous feed, reciprocating (or other moving, air-cooled) grate designs with water wall furnaces for energy recovery. The newer incinerators like the proposed are waste-to-energy plants that produce steam for electric power generation.

2.5.3.3 Furnace Design Considerations for the proposed Incinerator

The design of the furnace is critical to optimal combustion. Furnace configurations depend on what they were designed to burn. Older designs, many of which are still used, do not generally permit as efficient combustion as newer designs.

Sizing

Poor combustor design can prevent stable, optimal combustion conditions. Sizing a furnace to match the quantity of waste fed to the incinerator is important with respect to temperature, turbulence, and time. If the heat input from the waste is too low for the furnace size, the temperature in the furnace may drop to such an extent that complete combustion is not achieved, particularly in waterwall furnaces. If the furnace is too small for the quantity of waste fed, the temperature will be high and there may be difficulty in supplying sufficient oxygen for complete combustion, and the quantities of unburnt residues might be increased.

Grates

In older incinerator systems, traveling grates simply transported refuse into the combustion zone. Newer grate systems are designed to agitate the waste in various ways, causing it to be broken into smaller pieces as combustion proceeds. This process permits exposure of a larger surface area of waste to air and high temperatures, assisting complete combustion by preventing unburnt material from simply being transported through on the grate.

Air-Injection Systems

For complete combustion to occur, air must be injected into the furnace in at least two locations: under the grate that carries burning waste (primary or under fire air) and above the grate to mix additional oxygen with the combustion gases (secondary or over-fire air). Additional controls have been provided in the modern proposed incinerator by Plenser Waste Management Ltd to better regulate both the under-fire air at various points on the grate, depending upon burning conditions, and the over-fire air in response to temperature and heat transfer taking place in the furnace

Arches and bull Noses

To achieve complete combustion, gases produced must remain in the high-temperature zone of the furnace for a minimal residence time, usually 1-2 seconds. Achieving that residence time is usually accomplished by designing the furnace to retard the upward flow of gases, for example, by installing irregularities into the furnace walls. The proposed incinerator is configured to achieve improved combustion efficiency by using arches and bull noses. Arches, which are structures above the burning and burnout zones, are used to prolong the stay of combustion gases above the grate area. Bull noses are protrusions that are built into the furnace walls, usually near the point of injection of over-fire air, to upset the normal upward flow of the heated gases volatilizing from the burning waste. The induced gas redirection retards the movement of the combustion gases out of the furnace and promotes mixing with air.

Flue-gas Recirculation

Flue-gas recirculation systems are used to recycle into the furnace relatively cool flue gas (extracted after the heat exchangers have reduced its temperature) that contains combustion products and an oxygen concentration lower than air. The process is used to lower nitrogen oxide formation by limiting the flame temperature and by slightly diluting the flame oxygen concentration. Care must be taken to ensure that not too much flue gas is recirculated, lest the combustion process be adversely affected.

2.5.4 De-commissioning Phase

- **Demolition works**

Upon decommissioning, the project components including buildings, pavements, drainage systems, parking areas and perimeter fence will be demolished. This will produce a lot of solid waste, which will be reused for other construction works or not reusable, disposed of appropriately by a licensed waste disposal company.

- **Dismantling of equipment and fixtures**

All equipment including the incinerator, electrical installations, furniture, finishing fixtures partitions, pipe-work and sinks among others will be dismantled and removed from the site on decommissioning of the project. Priority will be given to reuse of these equipment in other projects. This will be achieved through resale of the equipment to other building owners or contractors or donation of these equipment to schools, churches and charitable institutions.

- **Site restoration**

Once all the waste resulting from demolition and dismantling works is removed from the site, the site will be restored through replenishment of the topsoil and re-vegetation using indigenous plant species.

2.6 Other Incinerator Considerations

2.6.1 Gas-temperature reduction techniques

The most common combustion-gas cooling techniques for incinerators are waste-heat boilers, and direct-contact water-spray quenches. Gas cooling techniques are integral to incineration system design, and will be important with respect to emissions of certain pollutants. As discussed later in the subsection, emissions of mercury and dioxins and furans can be affected by the rate of gas cooling and the air pollution control device (APCD) operating temperature. Combustion gases will be quenched by water sprays atomized into the hot gas flow.

2.6.2 Air-pollution control techniques

Incinerator APCDs were designed to remove two classes of pollutants which are particulate matter and acid gases. More recently, some method for improving the removal of dioxins and/or mercury is considered necessary. In Kenya, NO_x emission limits have been established for incinerators. Increasingly stringent regulations proposes use of more than one particulate-control device or more than one type of scrubber in a given incineration facility, and emissions have typically been reduced more than would be expected with the single device alone. The Proposed incinerator will use a wet scrubber system for removal of particulate matter and acid gases. The pollutants will be removed primarily through the impaction, diffusion, interception and/or absorption of the pollutant onto droplets of liquid. The liquid containing the pollutant will then collected for disposal.

- **NO_x Controls**

NO_x emissions will be reduced by combustion-furnace designs, combustion-process modifications, or add-on controls. Combustion-furnace designs that reduce thermal NO_x include

a variety of grate and furnace designs, bubbling and circulating fluidized-bed boilers, and boiler designs, especially those with automatic controls, that permit flue-gas recirculation. Combustion-process modifications that reduce NO_x formation include controlling the amount of oxygen available during the combustion process, and operating within a specific temperature range. For minimizing NO_x production in the combustion process, it is recommended that there be a lower-oxygen condition just above the grates (or in the primary chamber of a dual-chamber facility) coupled with a higher excess-oxygen condition at the location of over fire air injection (or in the secondary chamber of a dual-chamber facility). Municipal solid-waste incineration facilities tend to create the most NO_x when furnace temperatures are higher than is necessary (higher than 2,000°F) to destroy products of incomplete combustion (PICs). To minimize NO_x formation, and the formation of PICs, the furnace will be operated within fairly narrow ranges of temperature and excess oxygen (9-12%) with turbulent (well-mixed) conditions.

Wet scrubbers for NO_x removal are comparable to wet acid gas absorbers in configuration. They use strong oxidizers in aqueous solution to convert NO to NO_2 (which is water soluble in caustic solution) or NO_3-(nitrate), which is water-soluble. The exact chemistries of these systems are considered proprietary by the vendors.

2.7 Principles of system operation

Many variables that affect incinerator operation are controlled by operators, so the combustion conditions that control emission rates may be substantially affected by operator decisions. Poor operator control either of the furnace (by permitting temperature or oxygen concentration to decrease) or of the stoking operation can cause reduced combustion efficiency. In the proposed incinerator, mixing and charging of waste into the incinerator, grate speed, over-fire and under-fire air-injection rates, and selection of the temperature set-point for the ignition burners and after burner will entirely or partially be controlled by plant personnel. In addition, the extent of emission control achieved by post-combustion APCDs depends on how the devices are operated. Suboptimal operation can be caused by poorly trained or inattentive operators, faulty procedures, and equipment failure. Operators must be attentive to the flow rate of waste into the incinerator and furnace operation so as to allow for effective function of the APCDs. There will always be a need for the operator to deal with unexpected situations. The incinerator will require calibration and maintenance, as the combustor parts can wear out or malfunction. Examples of what can go wrong include clogged air injection into the incineration chamber and a clogged scrubber nozzle.

2.7.1 Worker Training

In compliance with OSHA 2007, proponent will undertake worker training in hazardous-material management. Annual refresher courses will also be required, as is supplemental training for supervisory personnel. The training is an important requirements for inspection plans and worker-training plans for the proposed incinerator that manages hazardous waste, including combustion facilities. The inspection plans address facility maintenance, leak inspections, and calibration schedules for monitoring equipment. The training plans are intended to address hazardous-material safety and facility operations.

2.8 Monitoring and Data Collection

Environmental regulations particularly EMCA Air Quality Regulation of 2014 as well as Waste Management Regulations of 2006 have led to extensive monitoring of key incineration process conditions, including waste feed rates; feed rates of ash, chlorine, and toxic metals (determined by sampling and analysis of the waste stream); combustion temperatures; gas velocity (or gas residence time); facility-specific air-pollution control-system operating measures; and stack-gas concentrations of O_2, CO, total hydrocarbons, HCl, NO_x, and SO_x, and opacity.

The ESIA experts proposes that Plenser Waste Management Limited adopts a computerized system that collect and record, process data, automatically control such process conditions as combustion temperature (by varying fuel feed and air flow rates), and automatically cut off waste feeds if operating conditions stray outside limits set by permits.

Incinerators require continuous monitoring of important air-pollution control-system operating conditions. Stack-gas monitors are often used to monitor the performance of the air-pollution control system directly for such measures as HCl, SO_2, NO_x, and opacity. With electronic transmission of such sensor outputs, the performance of the control and monitoring systems could be more-readily displayed and monitored. Reliable continuous emission monitors (CEMs) for dioxins and furans or for metals would be desirable, because automatic devices electronically linked to such devices (for example, to optimize the injection of alkaline and carbon reagents and water in the emissions control devices) could directly control those emissions of greatest potential health consequence. Such arrangements have been in use for continuous automatic control of acid gases for some time. CEMs for mercury have undergone in-use testing in Europe, for example see Felsvang and Helvind (1991).

2.9 Possible process emissions

The principal products of combustion are CO_2, water vapor, and ash, which are respectively oxidation-reaction products of carbon, and hydrogen, and non-combustible materials in the fuel. However, when the combustion reactions do not proceed to their fullest extent, other substances, some of which are potentially harmful, can be produced. The types and concentrations of contaminants in the waste stream (flue gas) flowing from any incineration process depend on the process type, the waste being burned, and combustion conditions. Such pollutants derive from three sources: they or their precursors are present in the waste feed, they are formed in the combustion process because of incomplete oxidation, or they are created by reformation reactions in the gas cooling or APCD. As discussed in earlier in this subsection , the products of primary concern, owing to their potential effects on human health and the environment, are compounds that contain sulfur, nitrogen, halogens (such as chlorine), and toxic metals. Specific compounds of concern include CO, NO_x, SO_x, HCl, cadmium, lead, mercury, chromium, arsenic, beryllium, dioxins and furans, PCBs, and polycyclic aromatic hydrocarbons. In addition, the total quantities of particulate matter and acid particles (which may largely be liquids condensed after emission) that escape the APCD are also considered independently. The following discussion focuses on the source and control of the following pollutants: particulate matter, acid gases, mercury (Hg), lead (Pb), and products of incomplete combustion. They are used to represent the pollutants from incineration that are of concern for possible health effects.

2.9.1 Particulate Matter

Particulate matter consists primarily of entrained noncombustible matter in the flue gas, and the products of incomplete combustion that exist in solid or aerosol form. Particle concentrations in the flue gas in the absence of control devices have been found to range from 180 to more than 46,000 mg per dry standard cubic meter (0.08 to more than 20 grains per dry standard cubic foot). Particulate matter from waste combustors includes inorganic ash present in the waste and carbonaceous soot formed in the combustion process. The inorganic-ash fraction of the particulate matter consists of mineral matter and metallic species. These materials are conserved in the combustion process and leave the combustion chamber as bottom ash or fly ash. Soot is a product of incomplete combustion that consists of unburned carbon in the form of fine particles or as deposits on inorganic particles. High-molecular-weight organic compounds condense on the surface of the particles, particularly on the carbon, downstream of the combustor.

The following four methods are proposed for limiting particulate emissions from the incinerator;

- Limiting the ash content of the waste feed via source control or selection.
- Designing and operating the primary combustion chamber to minimize fly-ash carryover.
- Designing and operating the combustion chamber(s) in accordance with good combustion practice to minimize soot formation.
- Using well-designed and well-operated fine-particle APCDs.

Source control of ash-producing waste constituents is an obvious method to reduce particulate emission, but it is impractical for waste combustors. However the incinerator will be able to meet particulate matter emission limits by stringent source selection alone. The first three methods listed above are effective in reducing particle loadings in the combustion gas but are generally not sufficient by themselves to meet current and proposed maximum-available-control-technology (MACT) emission standards for particulate matter. Add-on particulate control is expected to be needed to meet the proposed MACT standards for the incinerator.

Fine-particle control devices are in three general categories: filtration collectors, including primary fabric filters (baghouses); electrostatic collectors, including dry and wet electrostatic precipitators (ESPs) and ionizing wet scrubbers; and wet inertial-impaction collectors, including venturi scrubbers and advanced designs that use flux-force condensation-enhancement techniques.

2.9.2 Acid Gases

Acid gases are flue-gas constituents that form acids when they combine with water vapor, condense, or dissolve in water. Acid gases include NO_x, SO_x, HCl, hydrogen bromide, hydrogen fluoride, and hydrogen iodide. HCl and SO_2 are often present in uncontrolled flue-gas streams in concentrations ranging from several hundred to several thousand parts-per-million-by-volume. The concentrations of NO_x, hydrogen fluoride, and sulfur trioxide are typically below several hundred parts-per-million-by-volume. Free halogens such as chlorine, bromine, and iodine can also be produced at low concentrations from combustion of wastes that contain compounds of those elements. Emissions of SO_2, HCl, and the other halogen acids can only be controlled through the use of add-on APCDs, which have been previously described in this chapter.

There are two sources of NO_x from incineration (and other combustion) processes, commonly referred to as thermal NO_x and fuel NO_x. Thermal NO_x is formed by the reaction of nitrogen and

oxygen in the combustion air. Its ation is favored by high temperature (i.e., flame zone temperature), relatively large residence time at this temperature, and higher oxygen concentration. Fuel NO_x is formed by the oxidation of chemically-bound nitrogen in the waste (or fuel). Conversion of bound nitrogen to NO_x is strongly influenced by the localized oxygen concentration; it is less sensitive to temperature than thermal NO_x formation. Fuel NO_x formation can exceed thermal NO_x formation by an order of magnitude in incinerators burning wastes containing bound nitrogen.

Note: NO_x formation can be reduced, to a degree, by furnace design and combustion process changes as described earlier in the chapter. Add-on controls are required for more effective removal.

2.9.3 Mercury

Heavy metals in waste are not destroyed by incineration. Metallic elements with high vapor pressures, or with compounds that have high vapor pressures, can be converted to the vapor phase in the combustion chambers and tend to condense as the flue gas is cooled. They can adsorb onto fine (generally sub-micrometer) particles. It is likely that mercury remains in the vapor phase in the air-pollution control section of the incineration process, depending on temperature, and the same may be true for some of the more-volatile metal compounds.

Mercury emission from waste combustors is determined largely by the mercury feed rate and by whether mercury-specific APCDs are used. Virtually all mercury species found in wastes are volatile at combustion temperatures, so there is a high degree of partitioning to the gas phase, regardless of the chemical form of mercury or the combustion-system operating conditions. There is evidence that mercury is present primarily as elemental mercury vapor at incinerator combustion temperatures. The rate of cooling in the air pollution system and the HCl/Cl_2 concentrations in the gas affect the conversion of elemental mercury to water-soluble mercuric chloride (Gaspar et al. 1997; Chambers et al. 1998; Gaspar 1998).

Mercury emission will be limited through operator control of waste feed rates. Conventional APCD such as fabric filters, ESPs, inertial-impaction scrubbers, and other wet scrubbers are at best only partially effective for mercury removal at normal operating temperatures. Traditional wet-scrubber APCDs have provided moderate (20-90%) mercury control efficiencies. The most-modern facilities use powdered activated-carbon injection into the gas stream for mercury removal. The best performances of conventional APCDs are typically those of wet scrubbers operating at saturation temperature or lower. Lower scrubber-water temperatures lead to vapor condensation, and reduced mercury vapor pressure. Soluble forms of mercury, such as $HgCl_2$, are preferentially removed in wet scrubbing systems.

2.9.4 Lead

Lead (Pb) emissions from waste incinerators are influenced by the concentration of Pb in the waste feed, the chemical form of Pb, the physical matrix of the waste, the degree of ash carryover from the primary combustion chamber, thermal conditions in the primary and secondary combustion chambers that affect Pb volatilization, and the air-pollution control system efficiency for fine-

particle removal from the gas. The method of feeding waste to the combustor chamber (in batches vs. continuous feeding) can have an indirect effect on Pb emissions.

The concentration of Pb in the waste is important because Pb is conserved in the combustion process; all the Pb fed to the combustor exists with the bottom ash, is collected as fly ash, or is emitted as fine particles in the stack gas. The chemical form of Pb, the feed location and physical waste matrix, and local temperature in the combustion system are important because they affect the extent to which Pb is vaporized in the combustion process. Volatile forms of Pb, such as $PbCl_2$, might vaporize completely in the combustion process, whereas nonvolatile species, such as PbO, tend to partition to the bottom ash in the primary combustion chamber. Pb in liquid wastes fed through burners is exposed to flame temperatures and is, thus, more likely to vaporize than Pb in solid wastes. Pb in combustible solid wastes (e.g., paper or plastics) will vaporize to a greater extent than Pb in mostly noncombustible items, such as glass. The combustion-chamber temperature profile also affects the vapor pressure and degree of volatilization of the Pb species.

The extent of Pb vaporization in the combustion process is important because it affects the distribution of Pb among the fly-ash particle-size fractions. Pb that does not vaporize during combustion either partitions to the bottom ash or carries over as fly ash with a particle-size distribution characteristic of the incoming waste material. Pb that does vaporize, however, recondenses in the cooler downstream air-pollution control environment and adsorbs to the finer particles. The finer particles are more difficult to remove from the gas. Thus, Pb-removal efficiency tends to be lower than the overall particle-removal efficiency. The behavior of Pb and other metals in the combustion environment has been extensively studied by EPA and others (Campbell et al. 1985; Barton et al. 1987, 1990, 1996; Fournier et al. 1988; Fournier and Waterland 1989; Carroll et al. 1995).

The design and operation of the primary combustion chamber as they affect ash carryover and the design and operation of the APCD also influence Pb emissions. The principles are the same as those described earlier for particulate-matter emission control. In summary, there are four general methods proposed for limiting Pb emissions from waste combustors:

- Limiting the Pb content of the waste feed via source control.
- Designing and operating the combustion process to minimize Pb vaporization.
- Designing and operating the primary combustion chamber to minimize fly-ash carryover.
- Using well-designed and properly operated APCDs.

From a practical standpoint, the second method is likely to be the most difficult to implement because the objective of the combustion process is to burn all the waste completely.

Note: The most-reliable methods of limiting Pb emissions are source control and good particulate APCD performance.

2.10 Products of Incomplete Combustion

Organic and inorganic substances that are broken down into free-radicals (molecular species possessing an unpaired electron) in the combustion unit sometimes do not combine with oxygen

or hydroxyl radicals and instead combine among themselves to form many organic compounds. Most of these compounds can be destroyed in the post flame zone of a well-designed incineration system. Such compounds that are not combusted and released into the exhaust gas are called products of incomplete combustion (PICs). PIC emissions heavily depend on combustion conditions, which, in turn, depend on the design and operation of the combustion device. Depending on the temperature, some of the heavy organic constituents can condense onto fine particles. Examples of PICs are CO and trace organic chemicals. (The latter can also be remnants of the original feed stream.) PICs include simple compounds (e.g., methane, ethane, acetylene, and benzene), dioxins and furans, partially oxidized organic compounds (e.g., acids and aldehydes), and polycyclic aromatic hydrocarbons.

2.10.1 Dioxins and Furans

As discussed in earlier in this section dioxins and furans are the most-hazardous organic PICs that have been found in the flue gas of any combustion device. ("Dioxins and furans" refers collectively to polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs)). For poorly designed and poorly operated incineration facilities, the flue-gas dioxin and furan concentrations can be much higher than those generated by typical combustion devices. The polybrominated analogues have also been found in incineration emissions (see for example, Sovocool et al. 1989).

The proposed incinerator can produce dioxins and furans from three points in the process: stack-gas emissions, bottom ash, and fly ash. Often, bottom ash and fly ash are mixed for waste management purposes, but they may contain different amounts of dioxins and furans. The incineration facility is able to achieve zero discharge with respect to aqueous waste, so there are no major contaminated waste water streams.

Three possible sources of dioxin and furan emissions are the following: (1) un-combusted components of the original fuel (dioxins and furans are present in the materials that are thermally treated, and some quantity of this material survives thermal treatment); (2) formation from precursor compounds (dioxins and furans are formed from the thermal breakdown and molecular rearrangement of particular precursor compounds); and (3) de novo synthesis (dioxins and furans are synthesized from a basic chlorine donor, a molecule that takes chlorine to the predioxin molecule, and the formation and chlorination of a precursor) (EPA 1994b).

All types of organic chemicals, including polychlorinated dioxin and furans, can be destroyed under high-temperature oxidizing conditions. Destruction can occur at around 1800°F or higher if oxygen and organic molecules are well mixed as in practical combustion devices. Destruction of polychlorinated dioxins and furans present in the waste feed stream can take place at temperatures as low as 1350°F if oxygen and organic molecules are perfectly mixed (Duvall and Rubey 1977; Dellinger et al. 1984). However, dioxins and furans are also produced within the incineration process from precursors that are not destroyed below 1,800°F. Lahl et al. (1990) suggest that, although dioxins and furans may be present in the incoming mixture, most of the dioxins and furans in the exhaust gases are the products of formation within the incinerator and not persistence of the compounds present in the waste stream.

It is known that the presence of catalytic metals (e.g., copper, nickel, zinc, iron, and aluminum and their salts) and the temperature range of 450-750°F can promote dioxin and furan formation (e.g., Stieglitz and Vogg 1987; Vogg et al. 1992). Other requirements for dioxin and furan formation include prolonged gas-residence time in the stated temperature range, the presence of carbon as gaseous PICs or particles, and the presence of chlorine as HCl, Cl_2, or metal salt. Some types of organic compounds, such as chlorophenols and chlorobenzenes, tend to act as precursors for this type of secondary dioxin and furan formation. There is evidence that sulfur and ammonia can inhibit dioxin and furan formation.

As noted above, three sources have been proposed for the dioxins and furans found in the products of combustion. In addition, a substantial amount of research has been performed on effects of combustion conditions, facility configuration, waste stream composition, and pollution-control equipment. Siebert et al. (1988) investigated various factors associated with the operation of municipal solid-waste combustors and found APCD outlet temperature, presence of acid-gas controls, and the startup year of the facility to be the most-important determinants of dioxin and furan formation. Fangmark et al. (1993) studied the effect of bed temperature, oxygen concentration, variations in HCl and water, and temperature and residence time in the post-combustion zone on dioxin and furan formation and concluded that post-combustion temperature was the most important. A study conducted for the American Society of Mechanical Engineers, ASME (1995), indicated that there was no statistically significant cross-incinerator correlation between chlorine content of the waste stream fed to incinerators, and the dioxin and furan concentration in the emissions of those incinerators. Numerous factors have been associated with dioxin and furan formation, including the presence of particulate carbon, metal catalysis, combustion efficiency, temperature, and presence of precursors. The only consensus at this point seems to be that good combustion efficiencies and low post-combustion temperatures reduce the secondary dioxin formation.

Note: In the proposed incinerator, dioxin and furan emissions can be controlled through good combustion practice and rapid cooling of the combustion gas to air-pollution control system temperatures (generally ranging from 285°F to 300°F). Rapid combustion-gas cooling is inherent in many wet-scrubbing system designs, except for units equipped with waste-heat boilers. Dioxins and furans, as well as mercury, are also removed by injection of powdered activated carbon in a number of municipal-waste incinerators and a few hazardous-waste incinerators.

2.11 Fugitive emissions

The most common fugitive emissions are (from liquid wastes) vapors from tank vents, pump seals, and valves; and (from solid wastes) dust from solid-material handling, together with possible fugitives from particulate APCDs. The magnitude of those emissions and their control mechanisms are similar to those in other process industries that handle hazardous materials and are therefore regulated under **EMCA, Air quality Regulations of 2014.** However, the high-temperature seals on rotary-kiln incinerators are a potential source of vapor and dust emissions peculiar to such incineration facilities; these emissions are controlled by maintaining a negative

pressure in the kiln. Fugitive emissions, consisting of vapors or particles from waste tipping, waste feeding, incineration, and ash handling are mitigated by designing buildings to be under negative pressure. Air is drawn from the waste-handling areas into the combustion chamber, where it is mixed with the combustion gases. Potential fugitive emissions collected in this manner and drawn through the combustion chamber and emission-control devices leave the plant with odors virtually destroyed and dust removed by the particle-control devices.

Fugitive dusts can also be created in the bottom-ash pits and the fly-ash hoppers. Enclosed ash-handling areas are part of incinerator designs. In the proposed incinerator system, emissions created in the ash-handling areas (bottom ash and fly ash) will be drawn through the emission control devices so that workers are not unnecessarily exposed to dust from the ash. Such dusts, particularly fly-ash dusts from particulate APCDs, may be enriched in toxic metals and contain condensed organic matter.

2.12 Ash and other residues

Types of Ash and Other Residues

Residues that will be generated by incinerator include bottom ash, fly ash, scrubber water, and various miscellaneous waste streams. Bottom ash is the remains of the solid waste that is not burned on the grate during the combustion process and consists of unburned organic material (char) and inorganic fine particles. Bottom ash is collected in a quench pit beneath the burnout section of the grate. Fly ash is the solid and condensable vapor-phase matter that leaves the furnace chamber suspended in combustion gases and is later collected in APCDs. The APCDs in use will capture a high percentage of the contaminants in the flue-gas stream. Fly ash is a mixture of fine particles with volatile metals and metal compounds, organic chemicals, and acids condensed onto particle surfaces. It can also contain residues from reagents, such as lime and activated carbon, themselves with condensed or absorbed contaminants. Fly ash is collected in hoppers beneath the APCDs.

Scrubber water is a slurry that results from the operation of wet scrubbers and contains salts, excess caustic or lime, and contaminants (particles and condensed organic vapors) scrubbed from the flue gas.

In addition, there are various other waste streams that may be generated by the incinerator. The initial sorting of municipal-solid waste produces a stream of large items unsuitable for burning (such as whole refrigerators, gas stoves, and auto batteries).

Ash Handling

Two concerns of on-site ash management at incineration facility are the safety of workers and the possibility that fugitive ash will escape into the environment during handling or removal of the ash for disposal. Both concerns require that the ash be contained at all times both inside and outside the facility, as described above. In the facility, water will be used to quench the ash, simultaneously reducing dust generation and minimizing the possibility of ash-dust inhalation or ingestion by workers. In the proposed incinerator, a closed system of conveyor to transport the ash from the furnace to trucks to minimize worker exposure will be adopted.

Ash and Scrubber-Waste Disposal

Fly ash from the waste incineration is characteristically more likely than bottom ash to exhibit the toxicity characteristic as defined by the leaching test as a result of high concentrations of lead or cadmium. It is important for ash to be tested to determine whether it is hazardous. If it is hazardous according, it must be disposed of as hazardous waste. All residues generated by hazardous-waste incineration, except waste burned for metal recovery, are considered hazardous waste. That stems from the "derived-from" rule, which states that residues generated by the treatment of hazardous waste remain hazardous until delisted. Ash from hazardous-waste combustion must be handled and disposed in a secure hazardous-waste landfill that is designed to ensure that there will be no groundwater pollution. The proposed management method for ash that will be generated by incineration is landfill disposal, or alone in an ash monofill, although some ash may be used in production on construction materials, roadbeds, or experimental reefs upon testing. Dry and spray-dry scrubber waste is incorporated in the fly ash, because the APCD is where the injected material is collected. Wet-scrubber wastewater should be discharged to on-site wastewater-treatment systems already owned by EPZA.

2.13 Proposed best practices for reducing incineration emissions for the proposed project

The EIA Experts proposes the proponent;

- Screen incoming wastes at the plant to reduce incineration of wastes (such as batteries) that are non-combustible and are likely to produce pollutants when burned.
- Maintain a continuous, consistent thermal input rate to the incinerator to the extent possible.
- Optimize furnace operation, including temperature, oxygen concentration, and carbon monoxide concentration. This can be done by optimizing grate speeds; under fire and over fire air-injection rates, locations, and directions; and operating auxiliary burners.
- Survey furnace emission-control devices and related equipment regularly to ensure that they continue to be operative and properly sealed and insulated.
- Select correct type of nitrogen-reducing reagent (either ammonia or urea) and optimize the injection rate and location, if add-on of NOx control is required.
- Select correct alkaline reagent (e.g., lime slurry, dry lime, Na_2CO_3 or $NaHCO_3$) to maximize absorptive capacity and optimize injection rate and location.
- Optimize type of sorbent (such as carbon) used (to maximize adsorptive capacity) and optimize injection rate and location for removal of mercury and dioxins and furans.
- Optimize voltage and other electric conditions of an ESP (to maximize capture of particles).
- Optimize wet-scrubber pressure drop, pH, and liquid-to-gas ratio.
- Maintain a maximum gas flow-rate limit to ensure adequate residence time in the combustion chamber and proper operation of the air pollution control equipment.
- Implement a training and certification program for plant operators.

- Inspect and calibrate continuous emission monitors and other process instrumentation.
- Adequate operator training and certification is needed with monitoring of performance conditions to ensure that emission targets are met.

2.14 Project Location Suitability

Following the current conditions of the site environment illustrated above on the site, the proposed site is the only location found suitable. This conclusion has been arrived at due to the following considered reasons;

- The land has been leased to the proponent as shown by the land ownership documents. This makes the development more feasible to the proponent,
- There are no significant settlements around the site because of the industrial zoning by the Government Authorities to ensure minimal social impacts.
- There are no significant delicate ecosystems around the site (no surface water it is, therefore, likely to have minimal environmental impacts,
- The proponent is ready to abide by the law for a long term suitability of the site.

2.15 Project Cost

The proposed project is estimated to cost a total of forty million Kenya Shillings (**KSh.50, 343, 530**).

3 CHAPTER THREE: POLICY, LEGAL ADMINISTRATIVE FRAMEWORK

3.1 Introduction

This section has examined relevant standards applicable to the project. Additionally, the section outlines the legal instruments and stakeholder institutions involved in the project. The policy, legal, and regulatory framework refers to the comprehensive set of laws, regulations, policies, and guidelines established under Kenya Government and relevant authorities to govern various aspects of a particular sector or area in this case incinerator development. This framework provides the foundation for decision-making, operations, and interactions within that sector, ensuring compliance, accountability, and the achievement of specific goals. In the context of environmental and social impact assessment (ESIA) and management, a robust framework is essential to guide the evaluation and mitigation of potential negative impacts on the environment and society.

3.1.1 Milestone to Policy, Legal, and Regulatory framework in Kenya

This section provides an overview history of the administrative and legal framework that pertains to the proposed project starting with National Environmental Action Plan. The progression from the National Environmental Action Plan (NEAP) in 1994 to the enactment of the Environmental Management and Coordination Act (EMCA) in 1999 marked a significant step forward in Kenya's approach to environmental management and conservation. The NEAP, established in 1994, was a comprehensive blueprint for addressing environmental challenges and promoting sustainable development in Kenya. It was developed to assess and address the country's environmental issues, including pollution, resource degradation, and biodiversity loss. The NEAP aimed to provide a strategic framework for integrating environmental concerns into development planning and decision-making processes.

Key Objectives of NEAP;

- Identify environmental challenges and priorities in various sectors.
- Develop strategies and policies for sustainable natural resource management.
- Enhance public participation in environmental decision-making.
- Promote the integration of environmental considerations into development policies and programs.

Environmental Management and Coordination Act (EMCA)-1999**:** The Environmental Management and Coordination Act (EMCA) was a landmark legislation enacted in 1999 in Kenya. EMCA provided a legal framework for the effective management, conservation, and sustainable use of the environment and natural resources. It replaced several outdated laws and regulations related to environmental management and consolidated them into a single comprehensive statute.

3.1.2 The Significance

The evolution from NEAP to EMCA was significant because it demonstrated Kenya's commitment to addressing environmental challenges in a systematic and holistic manner. NEAP laid the groundwork for recognizing the importance of environmental conservation, while EMCA institutionalized these principles into law, ensuring that environmental concerns were taken seriously and legally enforced.

By enacting EMCA, Kenya aimed to streamline environmental management, establish clear guidelines for development projects, and enhance public participation in environmental decision-making. The legislation provided a platform for fostering sustainable development, protecting ecosystems, and mitigating the impacts of human activities on the environment. Overall, the evolution from NEAP to EMCA represented a pivotal moment in Kenya's environmental governance, signaling a more comprehensive and integrated approach to environmental management and conservation.

3.2 Policy Framework

Policy documents outline the overarching principles, objectives, and strategic direction of a particular sector. In the context of ESIA and environmental management, policies might focus on sustainable development, conservation of natural resources, community well-being, and other related goals. The establishment of a policy framework in Kenya holds significant rationale, importance, and objectives across various sectors and aspects of governance. Policy framework in Kenya is of paramount importance due to its ability to guide decision-making, foster economic growth, promote social equity, ensure accountability, and contribute to sustainable development. The rationale behind policies lies in creating a coherent and predictable environment that upholds the rule of law and supports the nation's progress. The objectives encompass strategic direction, regulation, resource allocation, stakeholder engagement, innovation, and risk management. A robust policy framework serves as the cornerstone of effective governance and the foundation for a prosperous and equitable society. Policies address environmental, social, and economic concerns, promoting sustainable development that balances current needs with those of future generations.

Table 3-1: Policy framework

Policy	Provision	Relevance
Vision 2030	▪ Integrated Waste Management: Vision 2030 emphasizes the adoption of integrated waste management practices that involve reducing, reusing, recycling, and proper disposal of waste. This approach ensures that waste is managed in a holistic and environmentally responsible manner. ▪ Infrastructure Development: The vision highlights the need for improved infrastructure, including waste management facilities such as landfills, recycling centers, and waste-to-energy plants. Developing modern waste management infrastructure is vital for efficient and sustainable waste handling. ▪ Public Health and Quality of Life: Proper waste management directly impacts public health and the quality of life for citizens. Vision 2030 aims to improve the living conditions of Kenyan citizens by ensuring that waste is managed in a way that minimizes health risks and environmental hazards. ▪ Economic Growth: Effective waste management practices can lead to economic benefits through the creation of jobs, resource recovery from waste, and potential revenue generation from recycling and waste-to-energy projects. Vision 2030 recognizes the economic potential in waste management and seeks to capitalize on it. ▪ Policy and Regulatory Framework: The vision emphasizes the importance of establishing and enforcing policies and regulations related to waste management. This ensures that waste management practices are standardized, regulated, and aligned with international best practices. ▪ Innovation and Technology: Vision 2030 encourages the adoption of innovative technologies and approaches in waste management. This includes exploring waste-to-energy solutions, smart waste collection systems, and other advancements that enhance efficiency and sustainability. ▪ Public Awareness and Education: The vision recognizes the significance of public awareness and education in promoting responsible waste management behaviors among citizens. Education campaigns and community engagement initiatives are essential components of achieving effective waste management. ▪ Partnerships and Collaboration: Vision 2030 underscores the importance of collaboration between government agencies, private sector entities,	Vision 2030 acknowledges that proper waste management is an integral part of achieving a sustainable, prosperous, and healthy future for Kenya. By integrating waste management practices into its overall development agenda, Kenya aims to enhance environmental sustainability, public health, economic growth, and overall quality of life for its citizens.

	communities, and civil society organizations to achieve sustainable waste management goals	
National Environmental Policy, 2013	The policy promotes the use of environmental and social assessment tools such as ESIA/EA necessary to ensure environmental quality and resource productivity on long term basis. Further it calls for management in use of hazardous and toxic chemicals as well as radiation regulations	The Policy requires the project which is likely to have significant environmental and social impacts to undergo ESIA in order to establish sound environmental management practices.
The National Occupational Safety and Health Policy, 2012	The Policy seeks to reduce the number of work-related accidents and diseases, and equitably provide compensation and rehabilitation to those injured at work or who contract occupational diseases.	The policy requires the provision of appropriate and adequate PPE, avail First Aid services on site as well as development of Safety and Health Emergency Contacts at the site and workplace registration.
Sessional Paper No. 01 of 2017 on National Land Use Policy	The overall goal of the national land use policy is to provide legal, administrative, institutional and technological framework for optimal utilization and productivity of land related resources in a sustainable and desirable manner at national, county and community levels. The Policy is premised on the philosophy of economic productivity, social responsibility, environmental sustainability and cultural conservation. Key principles informing it include efficiency, access to land use information, equity, elimination of discrimination and public benefit sharing. The Policy is cognizant of numerous factors that affect land use in Kenya which include geographic and ecological features, population distribution, social, historical, cultural and economic factors. Other key factors are administrative, institutional and policy instruments, investment, urbanization and land tenure	Key measures shall be taken by the Plenser Waste Management Ltd and all land users. These include, sound land use practices, conservation and enhancement of the quality of land and land-based resources and the proper management of demographic and health parameters. Plenser Waste Management Ltd is expected to put the land to productive use and encourage the application of efficient technology for the intensification of land use. Urban land use will be improved through measures such as establishing transparent, accountable, sustainable, comprehensive and participatory governance structures and decision-making processes
Sessional Paper No. 06 of 1999 on Environment and Development	The comprehensive policy provides a clear direction on how to manage and protect the environment. The Environment Policy deals with emerging national as well as international key issues	Plenser Waste Management Ltd must consider; Biological diversity, Sustainable land use systems, Water resource management, Sustainable fisheries and marine resource management, Pollution control and waste management, Energy (renewable and efficiency), Climate change and variability, Disaster preparedness and risk management, Integrated planning and management, Environmental information management, Environmental education and

		public participation and Environmental economics.
The Kenya National Policy on Gender and Development (NPGD)	The goal of the policy is to "achieve gender equality and women's empowerment in national development so as to enhance participation of women and men, boys and girls, vulnerable and marginalized groups for the attainment of sustainable development. The policy calls upon the National and County Governments, Constitutional Commissions and Independent Offices, Faith Based Organizations (FBOs) and Civil Society Organizations (CSOs) and the private sector to work together in ensuring its implementation	Plenser Waste Management Ltd to ensure that gender equality and women's empowerment is integrated into sectoral policies, planning and programmes, the policy identifies key thematic areas, namely: labour and employment, education, health, land, housing, agriculture, environment and natural resources, peace and security, governance, power and decision making, information and communications technologies, respect for the human rights, sexual and Gender Based Violence; the girl child and the boy child, intersectional discrimination, media and access to justice.

3.3 Legal Framework

The legal framework in Kenya encompasses a comprehensive network of laws, regulations, policies, and institutions that govern the nation's activities, operations, and interactions. This framework is designed to promote transparency, accountability, justice, and the protection of rights across diverse sectors. At the heart of this legal framework is the Constitution of Kenya, which provides the fundamental principles and values that guide governance, democracy, and human rights. Legal framework in Kenya serves as a vital mechanism for promoting good governance, protecting rights, and fostering a just and equitable society. It reflects the country's commitment to upholding democratic values, facilitating economic growth, and safeguarding the well-being of its citizens.

Regulatory bodies, established by these laws, oversee the implementation and enforcement of regulations within their respective sectors. These bodies play a crucial role in monitoring compliance, issuing licenses, and ensuring that standards are upheld. For example, the National Environment Management Authority (NEMA) is tasked with overseeing environmental management and conservation as stipulated by the Environmental Management and Coordination Act (EMCA). To enhance the legal framework's effectiveness, policies and guidelines are developed to provide detailed instructions for implementing laws and regulations. These policies facilitate consistent interpretation and application of the law across different scenarios. Furthermore, the legal framework prioritizes justice and access to legal remedies. Kenyan citizens can seek redress through the judicial system, which comprises various courts and tribunals, including the High Court, Court of Appeal, and Supreme Court. The judiciary upholds the rule of law, protects human rights, and ensures that legal disputes are resolved fairly.

3.3.1 Constitution of Kenya 2010

The Constitution sets the foundation for the country's legal system, defining the structure of government, delineating the separation of powers, and ensuring the rule of law. Complementing the Constitution are numerous laws and statutes that address specific areas of interest, including criminal law, property rights, business regulations, environmental protection, labour rights, and more. These laws are enacted by the Kenyan Parliament and other legislative bodies to provide clear guidelines and regulations that citizens, businesses, and organizations must adhere to. The Constitution as the supreme law of Kenya, and it provides the overall legal framework for all activities, including incinerator installation and operation. While the Constitution does not specifically mention incinerator installation and operation, it contains several provisions that are relevant to environmental protection, natural resource management, and the rights of communities living in areas where incinerator installation and operation may take place. In the Constitution of Kenya, 2010 Part II (Environment and Natural Resources), (I) the State clearly undertakes to carry out the following:

- **Environmental Rights:** Article 42 of the Constitution recognizes every person's right to a clean and healthy environment. Incinerator operation activities must be conducted in a manner that does not harm the environment and ensures the protection of natural resources.

- **Sustainable Development:** The Constitution emphasizes sustainable development in Article 10. Incineration development should be carried out in a manner that is economically, socially, and environmentally sustainable, taking into account the needs of present and future generations.
- **Devolution and Community Participation:** Article 174 of the Constitution establishes the principle of devolution, which grants significant powers and responsibilities to county governments.
- **Protection of Natural Resources:** Article 69 of the Constitution obligates the state to ensure sustainable exploitation, utilization, management, and conservation of natural resources, including incinerator resources.
- **Right to Information:** Article 35 of the Constitution grants citizens the right to access information held by the state and other public entities. This provision is relevant for communities and individuals seeking information about incinerator projects and their potential impacts.
- **Compensation and Fair Benefit-Sharing:** Article 40 of the Constitution protects the right to own property and provides for prompt and just compensation in case of compulsory acquisition of property, including land where incinerator installation and operation activities occur.
- **Public Participation:** Article 118 of the Constitution requires public participation in matters of governance, including decision-making on matters that may affect communities, such as incinerator projects.

3.3.2 Environmental Management and Coordination Act

The legal framework for Environmental and Social Impact Assessment (ESIA) in Kenya is primarily governed by the Environmental Management and Coordination Act (EMCA) of 1999. This comprehensive legislation provides the legal basis for environmental management, conservation, and sustainable development in the country. Under the EMCA, ESIA is a critical process aimed at identifying, assessing, and mitigating potential adverse environmental and social impacts of proposed development projects. The EMCA empowers the National Environment Management Authority (NEMA) to oversee and regulate the ESIA process. NEMA is responsible for developing guidelines, setting standards, and issuing permits related to ESIA. These guidelines provide detailed procedures for conducting ESIA studies, ensuring consistency and a standardized approach throughout the assessment process. Projects falling under specific categories as defined by the EMCA and its subsidiary legislation are required to undergo ESIA before approval and implementation. The ESIA process includes project screening, scoping, impact assessment, and the development of appropriate mitigation measures. Public participation is an integral component of the ESIA process, ensuring that affected communities and stakeholders have the opportunity to provide input and express concerns. EMCA, as the principal Act, underwent amendments, and Section 58 was replaced with Section 43 of the amended Act. As per this amendment, it is mandatory for proponents planning to implement projects specified in the Second Schedule of the Act to conduct an Environmental Impact Assessment (EIA) study. Such projects have the potential to cause significant environmental impacts. The EIA study evaluates the potential impacts of the proposed project on the environment and helps in making informed decisions regarding its implementation. Additionally, Section 68 of EMCA requires operators of existing

projects or undertakings to conduct Environmental Audits (EA). The EA is conducted to assess the level of compliance with the statements made during the EIA study. It ensures that the project is operating in adherence to the environmental guidelines and regulations set during the planning phase.

3.3.3 Environmental (EIA and EA) Regulations, 2019

The Regulations operationalize the provisions of the EMCA on environmental impact assessment and auditing. These Regulations stipulate how an EIA will be undertaken and what the EIA study Report should contain. They provide details regarding Environmental Audits, auditing and monitoring, which the project will be required to undertake later on. The regulations are thus important to the project with regard to EIA and EA.

3.3.4 Environmental Management and Co-ordination (Water Quality) Regulations, 2006)

This regulation was published in the Kenya Gazette Supplement No. 68, Legislative Supplement No. 36, and Legal Notice No. 120 of 29 September, 2006. The regulation provides for sustainable management of water resources including prevention of water pollution and protection of water sources (lakes, rivers, streams, springs, wells and other water sources). Some provisions of the Water Quality Regulations include:

- **Water Quality Standards:** The regulations set out specific water quality standards that water bodies, including rivers and lakes, should meet. These standards are designed to protect water resources from pollution and degradation.
- **Pollution Control**: The regulations include provisions for controlling pollution sources that may affect water quality.
- **Discharge Permits**: The regulations require permits for any discharge of pollutants or wastewater into water bodies.

3.3.5 Environmental Management and Co-ordination (Waste Management) Regulations, 2006

This regulation was published in the Kenya Gazette Supplement No. 69, Legislative Supplement No. 37, and Legal Notice No. 121 of 29th September, 2006. The regulations provide details on management (handling, storage, transportation, treatment and disposal) of various waste streams including domestic waste, industrial waste, hazardous and toxic waste, pesticides and toxic substances, biomedical wastes, and radioactive waste. The following regulations are crucial in the protection of environment:

- Regulation 5 (1) provides categories of cleaner production methods that should be adopted by waste generators in order to minimize the amount of waste generated;
- Regulation 6 requires waste generators to segregate waste by separating hazardous waste from non-hazardous waste for appropriate disposal;
- Regulation 15 prohibits any entity from discharging or disposing of any untreated waste in any state into the environment; and
- Regulation 17 (1) makes it an offence for any person to engage in any activity likely to generate any hazardous waste without a valid Environmental Impact Assessment license issued by NEMA.

3.3.6 Environmental Management and Coordination Act (Noise and Excessive Vibration Pollution) (Control) Regulations, 2009

These regulations were published as legal Notice No. 61 being a subsidiary legislation to the Environmental Management and Co-ordination Act, 2019. The regulations provide information on the following:

- Prohibition of excessive noise and vibration beyond defined thresholds;
- Provisions relating to noise from certain sources;
- Provisions relating to licensing procedures for certain activities with a potential of emitting excessive noise and/or vibrations; and
- Noise and excessive vibrations mapping.

According to regulation 3 (1), no person shall make or cause to be made any loud, unreasonable, unnecessary or unusual noise which annoys, disturbs, injures or endangers the comfort, repose, health or safety of others and the environment. Regulation 4 prohibits any person to: (a) make or cause to be made excessive vibrations which annoy, disturb, injure or endanger the comfort, repose, health or safety of others and the environment; or (b) cause to be made excessive vibrations which exceed 0.5 centimeters per second beyond any source property boundary or 30 meters from any moving source.

Regulation 5 further makes it an offence for any person to make, continue or cause to be made or continued any noise in excess of the noise levels set in the First Schedule to these regulations, unless such noise is reasonably necessary to the preservation of life, health, safety or property.

Regulation 12 (1) makes it an offence for any person to operate a motor vehicle which- (a) produces any loud and unusual sound; and (b) exceeds 84 dB(A) when accelerating. According to sub-regulation 2 of this regulation, no person shall at any time sound the horn or other warning device of a vehicle except when necessary to prevent an accident or an incident.

3.3.7 Environmental Management and Coordination (Air Quality) Regulations, 2014

The Environmental Management and Coordination (Air Quality) Regulations, 2014 are a set of regulations established under the Environmental Management and Coordination Act (EMCA) of 1999 in Kenya. These regulations specifically address air quality management and aim to mitigate the adverse impacts of air pollution on the environment and public health. The regulations provide guidelines, standards, and measures for controlling and improving air quality throughout the country. These Regulations cover air quality standards that are requisite to protect human health and allow an adequate margin of safety. These Regulations specify priority air pollutants, mobile and stationary sources as well as stipulate emission standards.

The regulations provide specific air quality standards for various pollutants, including particulate matter (PM10 and PM2.5), sulfur dioxide (SO2), nitrogen dioxide (NO2), carbon monoxide (CO), lead, and ozone. These standards set maximum permissible levels for these pollutants in ambient air, ensuring public health and environmental protection. The regulations establish emission limits for various sources of air pollution, such as industries, vehicles, and other stationary sources. These limits outline the maximum allowable emissions of pollutants from specific sources to prevent excessive pollution.

The regulations require the establishment of air quality monitoring networks to assess compliance with the established standards. Monitoring data must be collected, analyzed, and reported regularly to relevant authorities for informed decision-making.

3.3.8 Water Act, 2016

The Water Act 2016 provides for the management, conservation, use and control of water resources and for acquisition and regulation of rights to use water; to provide for the regulation and management of water supply and sewerage services. Section 143 of the Act makes it an offence to obstruct, interfere with, divert or obstruct water from any watercourse or any water resource, or negligently allow any such obstruction, interference, diversion or abstraction. It also prohibits anyone to throw or convey or cause or permit to be thrown or conveyed, any rubbish, dirt, refuse, effluent, trade waste or other offensive or unwholesome matter or thing into or near to water resource in such a manner as to cause, or be likely to cause, pollution of the water resource.

3.3.9 County Governments Act, 2012

The Act states in Section 108 under County Integrated Development Plan, (2) (b) requires each County Integrated Development Plan to at least identify (as informed by the strategies and programmes set out in the plan), any investment initiatives in the County; and any development initiatives in the County, including infrastructure, physical, social, economic and institutional development. While the County Governments Act, 2012 does not specifically mention incinerator development, county governments in Kenya play a crucial role in the management and utilization of natural resources, including incinerator energy, within their respective counties.

3.3.10 Occupational Safety and Health Act, 2007

This is an Act of Parliament to provide for the safety, health and welfare of all workers and all persons lawfully present at workplaces, to provide for the establishment of the National Council for Occupational Safety and Health and for connected purposes. It applies to all workplaces where any person is at work, whether temporarily or permanently. The purpose of this Act is to:

- Secure the safety, health and welfare of persons at work; and
- Protect persons other than persons at work against safety and health arising out of, or in connection with the activities of persons at work.

The scope of Occupational Safety and Health 2007 has been expanded to cover all workplaces including offices, schools, academic institutions, factories and plantations. It establishes codes of practices to be approved and issued by the Directorate of Occupational Safety & Health Services (DOSHS) for practical guidance of the various provisions of the Act.

3.3.11 Climate Change Act No. 11 of 2016 and related polices and Plans

The Climate Change Act of 2016 in the Republic of Kenya establishes a regulatory framework aimed at improving the country's response to climate change and promoting low-carbon climate development. The act puts forth various measures to achieve these objectives. One of the key requirements of the act is that both the national and county governments, as well as the private sector, must integrate climate change responses into their development planning, decision-making processes, and implementation across all sectors of the economy. In essence, the act mandates that climate change considerations should be incorporated into the strategies, policies, and actions of

governmental and private entities to address the challenges posed by climate change effectively. By mainstreaming climate change responses, the aim is to enhance the country's resilience to climate impacts, promote sustainable development, and reduce greenhouse gas emissions to mitigate the effects of climate change on the environment and society.

Overall, the Climate Change Act of Kenya emphasizes the importance of a coordinated and holistic approach to tackle climate change at all levels of governance and within various sectors of the economy. It serves as a critical instrument for steering Kenya towards a more sustainable and climate-resilient future.

3.3.12 The Physical and land use planning Act 2019

The Physical and Land Use Planning Act, 2019 (the 2019 Planning Act) came into force on 5 August 2019, repealing the Physical Planning Act of 1996 (the 1996 Act). The 2019 Planning Act now governs matters relating to planning, use, regulation and development of land in Kenya. The Act requires projects to undergo a rigorous planning and approval process. This involves conducting environmental impact assessments, engaging with relevant stakeholders, and obtaining necessary permits before commencing development. The act also emphasizes the integration of environmental and social considerations into land use planning, aligning with the project's need to balance development objectives with environmental preservation. Additionally, the act encourages public participation in land use planning, ensuring that the concerns and aspirations of local communities are considered.

3.3.13 Land Planning Act Cap. 303

The operative clauses of this Act are contained in the Development and Use of Land (planning) Regulations, which provide that land be dealt with either under an area plan or a town plan, superintended by an interim planning authority. Under this Act, all developments or any form of land use in the designated areas are subject to approval by the interim planning authority or the Central Authority (the overall governing body under the Act) in the absence of an interim planning authority. The Central Authority decides instances when the proposal is to be referred to the relevant Local Authority.

Any change of use or actual development without authority is prohibited. Similarly, deposition of refuse, scrap or waste materials in a designated area without the consent of the planning authority or the relevant local authority is prohibited under this Act.

3.3.14 Public Health Act (Cap 242)

Public Health Act (Cap 242) addresses various aspects of public health and provides a legal framework for the promotion and protection of public health within the country. Its provisions are designed to ensure that individuals, communities, and institutions contribute to maintaining a healthy environment and minimizing health risks. It covers a wide range of areas, including sanitation, waste management, disease prevention and control, food safety, health facilities, and more. The Act outlines measures to control and prevent the spread of diseases. This includes provisions for reporting and responding to notifiable diseases, vaccination programs, and quarantine measures to isolate and contain disease outbreaks. The Act addresses sanitation and environmental health concerns by setting standards for hygiene, waste disposal, and clean water supply. The Act includes provisions related to food safety and hygiene. It establishes regulations

for the handling, preparation, and sale of food products to safeguard public health. The Act may include provisions related to licensing and regulation of health facilities, ensuring that healthcare facilities meet certain standards to provide safe and quality services. The Act might include provisions for public health education and awareness campaigns to inform the public about health risks, disease prevention measures, and their responsibilities in maintaining public health. The Act empowers designated public health officers to enforce the provisions of the Act, carry out inspections, and take necessary actions to maintain public health standards.
The Act outlines penalties for violations of its provisions. These penalties could include fines, imprisonment, or other appropriate actions as determined by the legal system.

3.3.15 The Sustainable Waste Management Act, 2022

The Sustainable Waste Management Act 2022 seeks to provide for the sustainable management of waste. It provides for the creation of extended producer responsibility schemes as well as a circular economy for the reduction of waste. The Act provides for take back schemes and the labelling of products that may cause pollution. It provides for the creation of material recovery facilities in every county as well as the creation of incentives to encourage recycling. It provides for the creation of material recovery facilities in every county as well as the creation of incentives to encourage recycling.

3.3.16 Land and environment Court Act 2012

This act establishes the Land and Environment Court as a specialized court with jurisdiction over matters related to land and environment. Its primary objective is to provide a legal avenue for resolving disputes and issues concerning land use, environmental protection, and natural resource management. The Act give effect to Article 162(2)(b) of the Constitution; to establish a superior court to hear and determine disputes relating to the environment and the use and occupation of, and title to, land, and to make provision for its jurisdiction functions and powers, and for connected purposes. The principal objective of this Act is to enable the Court to facilitate the just, expeditious, proportionate and accessible resolution of disputes governed by this Act. (2) The Court shall, in the discharge of its functions under this Act give effect to the principal objective in subsection. The court has powers to deal with disputes relating to land administration and management. The court is also empowered to hear cases relating to public, private and community land and contracts, choses in action or other instruments granting any enforceable interests in land.

Table 3-2: Relevance of the Legal Framework to Plenser Waste Management Ltd

SN	Legal Framework	Relevance to Plenser Waste Management Ltd
1.	Environmental Management and Coordination Act (EMCA)	**1. Environmental Impact Assessment (EIA):** EMCA CAP 387 mandates that certain projects, including waste management facilities like incinerators, undergo an Environmental Impact Assessment (EIA) process. The proposed incinerator project falls within this category and requires a thorough EIA study to assess its potential environmental impacts, propose mitigation measures, and involve public participation. **2. Licensing and Permits:** EMCA CAP 387 stipulates that any person or entity undertaking activities that may significantly impact the environment, such as constructing and operating an incinerator, must obtain relevant licenses and permits from the National Environment Management Authority (NEMA). Plenser Waste Management Ltd would need to obtain the necessary approvals and permits under this law. **3. Environmental Conservation:** The act underscores the importance of conserving and protecting the environment. In the context of waste management, the proposed incinerator must adhere to guidelines to minimize pollution, control emissions, and prevent adverse impacts on air, water, and soil quality. **4. Waste Management:** EMCA CAP 387 promotes sustainable waste management practices. The proposed incinerator must comply with waste handling, transportation, and disposal regulations to prevent harmful impacts on public health and the environment. **5. Public Participation:** EMCA CAP 387 emphasizes the involvement of the public in environmental decision-making processes. For the proposed incinerator, Plenser Waste Management Ltd must conduct public consultations to gather feedback and address concerns from local communities and stakeholders. **6. Environmental Audits and Monitoring:** The act requires regular environmental audits and monitoring of projects to ensure ongoing compliance with environmental standards. Plenser Waste Management Ltd would need to establish monitoring mechanisms to assess the incinerator's environmental performance. **7. Enforcement and Penalties:** EMCA CAP 387 outlines penalties for non-compliance with environmental regulations. Plenser Waste Management Ltd must adhere to the law's provisions to avoid potential legal consequences. **8. Environmental Offsets:** In certain cases, the act allows for environmental offsets to mitigate adverse impacts of projects. If the proposed incinerator project poses unavoidable negative effects, Plenser Waste Management Ltd might need to explore options for compensatory measures.
2.	Environmental (EIA and EA) Regulations, 2019	**1. Environmental Impact Assessment (EIA):**

		• **Mandatory EIA:** The regulations stipulate that certain types of projects, including waste management facilities like incinerators, fall under the category of projects that require a mandatory EIA study. The proposed incinerator project is subject to this requirement. • **Scope of EIA Study:** The regulations outline the scope of the EIA study, including the assessment of potential environmental impacts, identification of mitigation measures, and the need for public participation. Plenser Waste Management Ltd must adhere to these requirements when conducting the EIA study for the incinerator project. • **Public Participation:** The regulations emphasize the importance of public participation in the EIA process. Plenser Waste Management Ltd must engage local communities and stakeholders to gather their input, address concerns, and incorporate feedback into the project design. • **Submission and Review:** The regulations provide guidelines for the submission and review of the EIA report by the National Environment Management Authority (NEMA). Plenser Waste Management Ltd must follow these procedures to obtain the necessary approvals for the incinerator project. **2. Environmental Audit (EA):** • **Post-Construction Assessment:** If the proposed incinerator project is approved and constructed, the Environmental (EIA and EA) Regulations, 2019, require the conduct of an Environmental Audit (EA) within a specified timeframe after construction. This audit assesses the project's compliance with environmental conditions and standards. • **Audit Process:** The regulations detail the audit process, including the preparation of an audit report, its submission to NEMA, and the involvement of registered environmental auditors. Plenser Waste Management Ltd must ensure that the incinerator project undergoes the required EA in accordance with these regulations. **3. Mitigation and Monitoring:** • **Mitigation Measures:** The regulations emphasize the identification and incorporation of mitigation measures to minimize adverse environmental impacts. Plenser Waste Management Ltd must design the incinerator project with effective mitigation strategies as outlined in the regulations. • **Monitoring and Reporting:** The regulations require ongoing environmental monitoring and reporting to ensure that the project remains in compliance with environmental standards. Plenser Waste Management Ltd must establish monitoring mechanisms for the incinerator's operations and submit regular reports to NEMA as per the regulations. **4. Compliance and Enforcement:** • **Non-Compliance Penalties:** The regulations specify penalties for non-compliance with EIA and EA requirements. Plenser Waste Management Ltd must adhere to the regulations to avoid potential legal consequences.

3.	Environmental Management and Co-ordination (Water Quality) Regulations, 2006)	▪ Plenser Waste Management Ltd operations must comply with these pollution control measures to prevent contamination of nearby water sources. ▪ Plenser Waste Management Ltd must obtain the necessary permits to discharge any wastewater safely, ensuring it does not harm the environment or water quality. ▪ Plenser Waste Management Ltd may require regular monitoring and reporting of water quality to ensure compliance with the set standards. Plenser Waste Management Ltd may need to monitor their operations' effects on water quality and report the findings to NEMA and other relevant authorities. ▪ Incinerator operation activities may involve the use of water for cooling or other purposes, and these activities must adhere to the regulations to prevent over-extraction or depletion of water resources.
4.	Environmental Management and Co-ordination (Waste Management) Regulations, 2006	**1. Waste Licensing:** • **Waste Licensing Requirements:** The regulations require any person or entity involved in waste management activities, including the operation of waste treatment facilities like incinerators, to obtain a waste management license from the National Environment Management Authority (NEMA). Plenser Waste Management Ltd would need to secure the appropriate waste management license for the incinerator project. **2. Hazardous Waste Management:** • **Identification and Categorization:** The regulations provide guidelines for identifying and categorizing hazardous waste, including waste generated by incineration processes. Plenser Waste Management Ltd must accurately categorize and manage hazardous waste in accordance with these regulations. • **Storage and Handling:** The regulations prescribe specific storage and handling requirements for hazardous waste to prevent environmental contamination and public health risks. Plenser Waste Management Ltd must ensure that hazardous waste generated by the incinerator is stored and handled in compliance with these guidelines. • **Transportation:** The regulations also address the transportation of hazardous waste, including packaging, labeling, and transport documentation requirements. Plenser Waste Management Ltd must follow these regulations when transporting hazardous waste from the incinerator site. **3. Waste Treatment:** • **Incineration Standards:** The regulations provide standards and guidelines for the incineration of waste materials, including emission limits, air quality standards, and waste incineration technologies. Plenser Waste Management Ltd

		must ensure that the incinerator's operations adhere to these standards to prevent air pollution and minimize environmental impacts. **4. Monitoring and Reporting:** • **Record Keeping:** The regulations require waste generators, including incinerator operators, to maintain records of waste generation, treatment, and disposal. Plenser Waste Management Ltd must keep accurate records of waste incineration activities as per these requirements. **5. Environmental Audits:** • **Waste Management Audits:** The regulations mandate the conduct of waste management audits to assess compliance with waste management requirements. If the proposed incinerator is established, Plenser Waste Management Ltd would need to undergo waste management audits as outlined in the regulations. **6. Compliance and Enforcement:** • **Non-Compliance Penalties:** The regulations specify penalties for non-compliance with waste management requirements. Plenser Waste Management Ltd must adhere to the regulations to avoid potential legal consequences.
5.	Environmental Management and Coordination Act (Noise and Excessive Vibration Pollution) (Control) Regulations, 2009	**1. Noise Pollution Control:** • **Emission Limits:** The regulations prescribe permissible noise levels for different areas and times of the day. The proposed incinerator's operations must adhere to these emission limits to prevent excessive noise pollution in the surrounding environment. • **Measurement and Assessment:** The regulations provide guidelines for measuring and assessing noise levels. Plenser Waste Management Ltd must conduct noise assessments to ensure that the incinerator's operations comply with the prescribed noise limits. • **Mitigation Measures:** If the incinerator's operations are expected to generate significant noise, Plenser Waste Management Ltd may need to implement mitigation measures, such as noise barriers or soundproofing, to reduce noise emissions to acceptable levels. **2. Vibration Pollution Control:** • **Emission Limits:** The regulations establish permissible vibration levels to prevent excessive vibration pollution. If the incinerator's operations result in vibration emissions, Plenser Waste Management Ltd must ensure that these emissions do not exceed the specified limits.

		• **Assessment and Monitoring:** The regulations outline methods for assessing and monitoring vibration levels. Plenser Waste Management Ltd may need to conduct vibration assessments to ensure compliance with the prescribed standards. • **Vibration Mitigation:** If the incinerator's operations generate excessive vibrations, Plenser Waste Management Ltd may need to implement vibration isolation measures to minimize the impact on nearby structures and the environment. **3. Public Health and Safety:** • **Health Impact:** The regulations aim to protect public health by preventing noise and vibration pollution that could lead to adverse health effects. Plenser Waste Management Ltd must ensure that the incinerator's operations do not pose health risks to nearby communities. **4. Permitting and Compliance:** • **Permit Requirements:** If the incinerator's operations are expected to generate noise or vibration emissions, Plenser Waste Management Ltd may need to obtain the necessary permits from the relevant authorities.
6.	Environmental Management and Coordination (Air Quality) Regulations, 2014	**1. Emission Standards:** • **Particulate Matter and Gaseous Emissions:** The regulations establish permissible limits for various pollutants, including particulate matter (PM), sulfur dioxide (SO2), nitrogen oxides (NOx), and other gaseous emissions. Plenser Waste Management Ltd must ensure that the incinerator's operations adhere to these emission standards. **2. Monitoring and Reporting:** • **Air Quality Monitoring:** The regulations outline requirements for air quality monitoring. Plenser Waste Management Ltd may need to establish air quality monitoring systems to regularly assess the concentration of pollutants emitted from the incinerator. • **Emission Inventory Reporting:** If the incinerator's operations result in significant emissions, Plenser Waste Management Ltd may be required to submit emission inventory reports to the relevant authorities. **3. Mitigation Measures:** • **Emission Control Techniques:** The regulations encourage the use of emission control technologies and measures to minimize air pollutant emissions. Plenser Waste Management Ltd may need to implement appropriate technologies to reduce emissions from the incinerator. **4. Public Health and Environmental Protection:**

		• **Health Impact:** The regulations aim to protect public health and the environment by preventing air pollution that could lead to adverse health effects and environmental degradation. Plenser Waste Management Ltd must ensure that the incinerator's operations do not pose health risks to nearby communities. **5. Permitting and Compliance:** • **Air Quality Permit:** Depending on the potential air emissions of the incinerator, Plenser Waste Management Ltd may need to obtain an air quality permit from the relevant authorities.
9	Water Act, 2016	Plenser Waste Management Ltd to assess the potential impacts on water sources and take measures to avoid over-exploitation or pollution to ensure their availability for present and future generations. This includes ensuring the protection of water quality, minimizing water consumption, and mitigating any potential negative effects on water sources and aquatic ecosystems. Effluent Standards: The act prescribes effluent standards to prevent water pollution. If the incinerator generates wastewater or leachate, Plenser Waste Management Ltd must ensure that the discharged effluent meets the water quality standards set by the act. Permits for Discharge: The act requires permits for discharging effluents into water bodies. Plenser Waste Management Ltd may need to obtain a permit if the incinerator's operations generate wastewater that is discharged into water bodies. Water Resource Conservation: The act emphasizes the sustainable management and conservation of water resources. Plenser Waste Management Ltd must ensure that water used for incinerator operations or any cooling processes is managed efficiently and without causing water scarcity. Pollution Prevention: The act aims to prevent pollution of water resources. Plenser Waste Management Ltd must take measures to prevent any runoff or leachate from the incinerator site that could contaminate nearby water bodies.
10	County Governments Act, 2012	The County Governments Act empowers county governments to enact laws, by-laws, and regulations within their jurisdictions. County government of Machakos have the authority to develop and enforce regulations related to waste management, environmental protection, and public health, which could impact the incinerator project. Land Use Planning and Development: County governments have the responsibility for land use planning and development control within their counties. This includes zoning and land allocation decisions. The county government's land use plans and decisions could influence the location and establishment of the proposed incinerator.
10	Occupational Safety and Health Act, 2007	During the construction and operation stages, the project will attract a large work force which will require to be managed in accordance to the OSHA. Plenser Waste Management Ltd must demonstrate its commitment to the welfare of its workforce and the surrounding community. This includes implementing proper safety measures, providing appropriate training, maintaining a safe working environment, identification and assessment of potential hazards, the establishment of safety

		committees, and the provision of necessary personal protective equipment (PPE), promoting accident prevention, minimizing occupational health risks, and fostering a culture of safety.
11	Climate Change Act No. 11 of 2016	The Act encourages the development and utilization of low-carbon energy sources, as such as Plenser Waste Management Ltd development reduces greenhouse gas emissions associated with fossil fuel-based energy generation. However, Consideration of climate risk assessment in Plenser Waste Management Ltd should include: ▪ Understanding Climate Vulnerability: Climate risk assessment will help identify the vulnerabilities of Plenser Waste Management Ltd to various climate-related hazards, such as extreme weather events, changes in precipitation patterns, and rising temperatures. It also assesses the potential impacts of these hazards on the project's infrastructure and operations. ▪ Climate Change Adaptation: Climate risk assessment helps in designing Plenser Waste Management Ltd that are resilient to climate change impacts. This involve considerations such as choosing suitable locations for incinerator plants, designing infrastructure to withstand extreme weather events, and incorporating climate projections into project planning. ▪ Long-Term Viability: The incinerator is expected to have a long lifespan, spanning several decades. Climate risk assessment ensures that the project is designed to withstand future climate conditions to maintain long-term viability and avoid potential stranded assets. Incorporating climate risk assessment into Plenser Waste Management Ltd planning and decision-making will ensure that the project is climate-resilient, contribute to climate change mitigation efforts, and is aligned with the goals of sustainable development. Collaboration with climate scientists, environmental experts, and local stakeholders is crucial to conduct comprehensive and effective climate risk assessments for the project.
12	The Physical and land use planning Act 2019	All applications for development permission be to be made in the Machakos county in line with the County Spatial Plan. Zoning Regulations: The act enables county government of Machakos to develop land use zoning regulations. Plenser Waste Management Ltd may need to obtain a development permit from Machakos County government for the construction and operation of the incinerator facility. By complying with the act's provisions, the project aligns with Kenya's commitment to sustainable land management and development.
13	Land Planning Act Cap. 303	The relevance of the Land Planning Act, Cap. 303 to the Plenser Waste Management Ltd incinerator project lies in its capacity to guide the project's land use planning processes, ensuring that development is carried out in a manner that is both beneficial and sustainable for the environment, communities, and long-term development goals
14	Public Health Act (Cap 242)	Plenser Waste Management Ltd's responsibility is to manage its operations in a manner that minimizes health risks and promotes a safe working environment by ensuring proper waste disposal, managing potential sources of pollution, and implementing measures to mitigate any health risks associated with project operations, provision of clean water and sanitation facilities, which

		are essential for the health and well-being of both workers and nearby communities. Plenser Waste Management Ltd must ensure that waste generated from the incinerator is managed and disposed of in accordance with the act's requirements. The act outlines sanitation standards for premises, including those related to waste storage, handling, and disposal. Plenser Waste Management Ltd must adhere to these standards to prevent the spread of diseases and maintain public health. Plenser Waste Management Ltd must take steps to prevent any potential disease transmission associated with waste generated from the incinerator. Plenser Waste Management Ltd may be subject to health inspections to ensure that the incinerator's operations do not pose health risks to the community. The act allows health officers to collaborate with other authorities to address health-related matters. Plenser Waste Management Ltd should collaborate with health authorities to ensure that the incinerator's operations are consistent with public health requirements.
16	The Sustainable Waste Management Act, 2022	Plenser Waste Management Ltd is expected to have 3-year waste management plans and submit annual monitoring reports to NEMA. The project is obligated to identify and eliminate potential negative impacts of their product; enable the recovery and reuse of the product where possible; reclaim and recycle; incorporate environmental concerns in the design, process and disposal of the product as well as collect and segregate hazardous from non-hazardous waste prior to disposal. Disposal should be done in a facility provided by the county government or NEMA. During disposal, they should transfer the waste to a person licensed to transport and dispose of the waste and clean up and restore the site they were using to its natural state. When it comes to their operation premises, the project should provide waste segregation receptacles for organic, plastic and general dry waste.
17	Land and environment Court Act 2012	In the event of disputes or conflicts arising from land use, the Environment Court provides a specialized forum for resolving these issues in accordance with the law. If the Plenser Waste Management Ltd faces allegations of non-compliance with environmental requirements, the Land and Environment Court may become involved to address these matters.

3.4 Regulatory Framework

Regulatory framework aims to balance economic development with environmental protection, ensuring that industries and activities are conducted in a sustainable and responsible manner. It establishes the legal basis for regulatory agencies, permits, environmental assessments, and enforcement mechanisms to ensure compliance with environmental standards and regulations. The Environmental and Social Impact Assessment (ESIA) regulatory framework in Kenya provides a structured process for evaluating and addressing potential environmental and social impacts of development projects. It ensures that projects are designed, implemented, and managed in a manner that safeguards the environment, protects communities, and promotes sustainable development. The regulatory framework is primarily governed by the Environmental Management and Coordination Act (EMCA) of 1999 and its subsidiary legislation, as well as guidelines established by the National Environment Management Authority (NEMA).

3.4.1 National Environment Management Authority (NEMA)

2002 - Present: Embracing Technological Innovations and Sustainability In recent years, NEMA has embraced technological advancements to improve its monitoring and enforcement capabilities. The authority has been working on integrating digital tools and platforms to enhance data collection, analysis, and reporting related to environmental compliance. NEMA has also been active in promoting sustainability, encouraging industries and communities to adopt green practices and reduce their ecological footprint.

i. Purpose and structure

NEMA's primary purpose is to promote and coordinate sustainable environmental management and conservation in Kenya. It serves as the central agency responsible for overseeing environmental matters, ensuring compliance with environmental laws and regulations, and promoting public awareness and education regarding environmental issues. NEMA is structured to carry out its responsibilities effectively. The key components of its structure include:

- **Board of Management:** NEMA is governed by a Board of Management comprising various stakeholders, including government representatives, experts, and representatives from civil society. The board provides oversight and strategic direction for NEMA's activities.
- **Director-General:** The Director-General is the chief executive officer of NEMA and is responsible for the day-to-day operations and management of the authority.
- **Departments and Divisions:** NEMA is organized into different departments and divisions, each focused on specific aspects of environmental management. These divisions may include Environmental Compliance, Environmental Impact Assessment, Pollution Control, Biodiversity Conservation, and more.

ii. **Functions**

NEMA's functions encompass a wide range of activities related to environmental management and conservation, including:

- **Environmental Impact Assessment (EIA):** NEMA is responsible for overseeing the EIA process for various projects and activities to ensure that potential environmental impacts are assessed and mitigated before project implementation.

- **Environmental Audits:** NEMA conducts audits to assess the compliance of projects and activities with environmental laws and regulations.
- **Licensing and Permits:** NEMA issues licenses and permits for various activities that have environmental implications, ensuring that these activities adhere to environmental standards.
- **Pollution Control:** NEMA monitors and regulates pollution sources, sets emission standards, and takes measures to control pollution.
- **Biodiversity Conservation:** NEMA is involved in the conservation and management of Kenya's rich biodiversity and protected areas.
- **Public Awareness and Education:** NEMA promotes public awareness and education on environmental issues, encouraging sustainable practices and behaviors.
- **Policy Development:** NEMA contributes to the development of environmental policies and guidelines, aligning with national and international environmental priorities.
- **Research and Data Collection:** NEMA gathers data and conducts research on various environmental aspects to inform decision-making and policy formulation.

3.4.2 Water Resources Authority

Water Resources Authority (WRA) is a state corporation established under Section 11 of the Water Act, 2016. It is mandated through delegated Authority on behalf of the National government to safeguard the right to clean water by ensuring that there is proper regulation of the management and use of water resources, in order to ensure sufficient water for everyone now and in the future. The Authority has been in existence for 17 years following its establishment under the Water Act, 2002 as Water Resources Management Authority (WRMA). Through ESIA processes, WRA ensures that projects are conducted in a manner that protects water quality, quantity, and ecosystems, while also considering the socio-economic needs of communities that rely on water resources. WRA's regulatory role in this context includes:

- **Water Resource Management:** WRA is responsible for the management, protection, and sustainable use of water resources in Kenya. This includes rivers, lakes, groundwater, wetlands, and other water bodies. When projects are proposed that could impact water resources, WRA ensures that their potential effects on water availability, quality, and ecosystems are thoroughly assessed through the ESIA process.
- **Review of ESIA Reports:** WRA reviews ESIA reports for projects that have the potential to affect water resources. This review assesses the potential impacts of projects on water quantity and quality, including potential contamination, depletion, and changes in flow patterns. WRA evaluates the adequacy of proposed mitigation measures to safeguard water resources.
- **Water Allocation and Permitting:** WRA manages water allocation and permitting processes. For projects that require water use, WRA assesses the potential impact on available water resources and issues permits based on the sustainability of water use. This

ensures that projects do not excessively deplete water sources and cause negative impacts on aquatic ecosystems and communities that depend on water.

- **Erosion and Sedimentation Control:** WRA addresses erosion and sedimentation issues caused by construction activities that could degrade water bodies. Projects that are likely to contribute to erosion or sedimentation must incorporate measures to prevent soil runoff and siltation into watercourses.
- **Wetland Protection and Conservation:** WRA is responsible for the protection and conservation of wetlands, which are critical ecosystems that provide various ecological services. Projects near wetlands or that might impact wetland areas are subject to ESIA review to assess potential impacts on these valuable habitats.
- **Public Participation:** WRA encourages public participation in ESIA processes, especially for projects located near water bodies. This engagement ensures that local communities' concerns are considered, traditional knowledge is incorporated, and potential water-related impacts are properly addressed.
- **Water Pollution Control:** WRA monitors and regulates water pollution from industrial, agricultural, and domestic sources. Projects that could contribute to water pollution must incorporate appropriate pollution control measures and technologies.

3.4.3 Directorate of Occupational Safety & Health Services (DOSHS)

The Directorate of Occupational Safety and Health Services (DOSHS) is a regulatory body in Kenya responsible for promoting and ensuring the health, safety, and well-being of workers in various industries and workplaces. DOSHS operates under the Ministry of Labour and Social Protection. Directorate of Occupational Safety and Health Services (DOSHS) plays a vital role in ensuring that workplaces in Kenya are safe, healthy, and conducive for workers. It establishes regulations, conducts inspections, and promotes best practices to prevent accidents, injuries, and occupational diseases, ultimately contributing to the overall well-being of the workforce. Overview of DOSHS's role and functions include:

- **Promotion of Occupational Safety and Health:** DOSHS is tasked with promoting a safe and healthy working environment for all workers in Kenya. This includes raising awareness about occupational hazards, risks, and best practices to prevent workplace accidents and occupational diseases.
- **Development of Regulations and Guidelines:** DOSHS develops and enforces regulations, guidelines, and standards related to occupational safety and health. These regulations cover various aspects, including workplace design, machinery safety, hazardous substances handling, and personal protective equipment (PPE).
- **Enforcement of Occupational Safety Laws:** DOSHS is responsible for enforcing occupational safety and health laws and regulations across different industries. This includes conducting inspections, investigations, and audits to ensure compliance with safety standards and proper working conditions.
- **Training and Capacity Building:** DOSHS offers training programs, workshops, and seminars to educate employers, employees, and stakeholders about occupational safety and health practices. This aims to enhance the capacity of individuals and organizations to create safer workplaces.

- **Accident and Incident Investigations:** In cases of workplace accidents, injuries, or fatalities, DOSHS conducts thorough investigations to determine the causes and contributing factors. This information is used to prevent similar incidents in the future.
- **Worker Welfare:** DOSHS works to protect workers' rights and well-being by ensuring fair working conditions, reasonable working hours, and adherence to health and safety standards. It also advocates for the provision of appropriate medical care in cases of work-related injuries.
- **Collaboration with Stakeholders:** DOSHS collaborates with employers, employees, trade unions, industry associations, and other relevant stakeholders to develop and implement effective safety and health measures in various workplaces.
- **Licensing and Certification:** Certain industries and activities require licenses or certifications from DOSHS to operate. These licenses often include compliance with specific safety and health requirements.
- **Response to Emergencies:** DOSHS may respond to emergencies related to workplace accidents, hazardous material releases, and other incidents that pose risks to workers' safety and health.

3.5 World Bank Environmental Framework

3.5.1 World Bank Environmental and Social standards (ESSs)

The World Bank's Environmental and Social Standards (ESS) are a set of principles and requirements that guide the assessment, management, and mitigation of environmental and social risks and impacts associated with projects funded by the World Bank Group. These standards are designed to ensure that projects align with global best practices, promote sustainable development, and safeguard the well-being of communities and the environment. The World Bank ESSs will help the Bank to manage the risks and impacts of the projects, and improve their environmental and social performance, through a risk and outcomes-based approach. This will ensure that proposed projects are environmentally and socially sustainable, and thus improve decision-making. As of 2022, the World Bank has 10 Environmental and Social Standards (ESS) that cover various aspects of project development. The ESSs relevant to the project are as outlined below:

i. ESS1: Assessment and Management of Environmental and Social Risks and Impacts: This standard outlines the process for identifying, assessing, and managing potential environmental and social risks and impacts associated with a project. It emphasizes early identification and integration of mitigation measures into project planning.
ii. ESS2: Labor and Working Conditions: This standard focuses on ensuring fair and safe labor practices, including worker rights, health and safety, and appropriate working conditions. It aims to protect workers' rights and promote positive working environments.
iii. ESS3: Resource Efficiency and Pollution Prevention: ESS3 emphasizes resource efficiency, pollution prevention, and waste management. It aims to minimize the use of natural resources, reduce pollution, and promote sustainable consumption and production patterns.
iv. ESS4: Community Health, Safety, and Security: This standard focuses on safeguarding the health, safety, and security of project-affected communities. It includes measures to prevent and mitigate potential health and safety risks arising from project activities.

v. ESS5: Land Acquisition, Restrictions on Land Use, and Involuntary Resettlement: ESS5 addresses land acquisition, restrictions on land use, and involuntary resettlement. It outlines principles for fair compensation, livelihood restoration, and meaningful consultation with affected communities.

vi. ESS6: Biodiversity Conservation and Sustainable Management of Living Natural Resources: This standard aims to conserve biodiversity and ensure the sustainable management of natural resources. It focuses on protecting ecosystems, habitats, and endangered species.

vii. ESS7: Indigenous Peoples: ESS7 focuses on the rights, cultural heritage, and livelihoods of indigenous peoples and local communities. It requires meaningful consultation, participation, and the protection of their rights.

viii. ESS8: Cultural Heritage: This standard addresses the preservation of cultural heritage sites and artifacts. It requires identifying, protecting, and preserving cultural heritage during project implementation.

ix. ESS9: Pest Management: ESS9 focuses on integrated pest management practices that minimize the use of hazardous chemicals and promote environmentally friendly pest control methods.

x. ESS10: Stakeholder Engagement and Information Disclosure: This standard emphasizes engaging stakeholders, providing relevant project information, and fostering open communication. It aims to ensure that affected communities and stakeholders are consulted, informed, and engaged throughout the project lifecycle.

3.5.2 EHS guidelines-Air Emissions and Ambient Air quality

The World Bank's Environmental, Health, and Safety (EHS) Guidelines for Air Emissions and Ambient Air Quality provide guidance for managing air quality in various industries and sectors. These guidelines aim to help industries and projects minimize air pollutant emissions and protect ambient air quality, thus reducing potential negative impacts on human health, ecosystems, and the environment. Some key aspects covered in the World Bank's EHS Guidelines for Air Emissions and Ambient Air Quality include:

- **Emission Assessment and Monitoring:** The guidelines emphasize the importance of assessing potential air emissions from project activities and monitoring these emissions over time. They provide methodologies for quantifying emissions and estimating their impacts on air quality.
- **Air Quality Standards:** The guidelines provide information on relevant air quality standards and guidelines established by international bodies and local regulatory agencies. They help ensure that project activities comply with acceptable levels of air pollutants.
- **Pollution Prevention and Control Technologies:** The guidelines outline various pollution prevention and control technologies that industries can adopt to minimize air emissions. These technologies include cleaner production processes, emission controls, and best practices.
- **Stack Emission Controls:** The guidelines address the design, installation, and operation of stack emission controls to reduce the release of harmful pollutants into the atmosphere.
- **Vehicle Emissions:** The guidelines offer strategies for managing vehicle emissions, including promoting cleaner vehicle technologies, implementing vehicle inspection and maintenance programs, and improving public transportation systems.

- **Industrial Processes:** The guidelines provide sector-specific guidance on managing air emissions from industrial processes, such as energy production, manufacturing, and waste incineration.
- **Ambient Air Quality Monitoring:** The guidelines emphasize the importance of monitoring ambient air quality to assess the impact of emissions on the local environment and public health.
- **Health and Safety:** The guidelines focus on protecting human health by addressing potential health risks associated with exposure to air pollutants. They recommend strategies for minimizing exposure, especially for vulnerable populations.
- **Community Engagement:** The guidelines highlight the importance of engaging local communities in decisions related to air quality management, as their well-being is directly affected by air pollution.
- **Continuous Improvement:** The guidelines encourage industries and projects to adopt a continuous improvement approach to air quality management, using monitoring data to make informed decisions and adjust practices as needed.

By providing comprehensive guidance on air emissions and ambient air quality, the World Bank's EHS Guidelines help industries and projects adopt practices that safeguard human health, improve air quality, and promote sustainable development. These guidelines contribute to global efforts to reduce air pollution, mitigate climate change impacts, and create healthier living environments for people around the world.

3.6 World Health Organization Guidelines for environmental health standards

The World Health Organization (WHO) has a broad mandate to establish and promote global environmental health standards across various parameters to safeguard public health. These standards provide guidance to member countries and stakeholders on acceptable levels of environmental pollutants and hazards. These standards and guidelines are based on scientific evidence and aim to prevent health risks associated with environmental pollutants and hazards. By providing member countries with evidence-based recommendations, WHO contributes to global efforts to protect public health and promote sustainable development.

Key areas where WHO sets environmental health standards include:

- **Air Quality:** WHO establishes guidelines for air quality that define safe levels of air pollutants such as particulate matter, nitrogen dioxide, sulfur dioxide, ozone, and carbon-monoxide. These guidelines help countries manage air pollution and its associated health impacts.
- **Water Quality:** WHO sets standards for the quality of drinking water and recreational water bodies. These standards cover parameters like microbial contaminants, chemical pollutants, and physical characteristics of water.
- **Noise Pollution:** WHO provides guidelines on acceptable noise levels in various settings, such as residential areas, workplaces, and recreational spaces. These guidelines aim to minimize the health impacts of noise pollution.
- **Chemical Exposure:** WHO establishes guidelines for exposure to various chemicals and pollutants, including heavy metals, pesticides, and hazardous substances? These guidelines help countries regulate chemical usage and minimize health risks.

- **Radiation:** WHO provides guidance on radiation exposure from sources such as nuclear facilities, medical procedures, and natural sources. The organization helps countries establish safe limits and protective measures.
- **Hydrogen Sulfide:** Hydrogen sulfide is a toxic gas found in various industrial processes. WHO sets guidelines for occupational exposure to hydrogen sulfide to protect workers' health and safety.
- **Waste Management:** WHO offers guidance on safe waste management practices to minimize health risks associated with improper waste disposal and pollution.
- **Indoor Air Quality:** WHO provides recommendations for indoor air quality to ensure safe living and working environments, especially relevant for pollutants like mold, tobacco smoke, and volatile organic compounds.
- **Climate Change and Health:** WHO addresses the health impacts of climate change and establishes guidelines for adapting to changing climate conditions to minimize health risks.
- **Food Safety:** While not exclusively environmental, WHO also plays a significant role in setting international food safety standards to protect public health from contaminants in the food supply.

3.7 International Conventions and Agreements

3.7.1 Introduction

International conventions and agreements are vital instruments for addressing global environmental challenges. They promote cooperation, standardization, accountability, and knowledge sharing among countries, leading to better environmental outcomes and a more sustainable future for all. They provide a rational and justified approach to addressing global environmental challenges that transcend national boundaries. The significance lies in their ability to foster global cooperation, establish consistent standards, enhance transparency, and enable the sharing of knowledge and resources. The rationale stems from the fact that many environmental issues have far-reaching consequences, demanding collective action. These agreements enhances environmental standards, preserve common resources, and ensure equity by supporting vulnerable nations. The justification lies in the cross-border impact of environmental problems, inadequacy of individual national efforts, and the need to address market failures. As a result, international conventions and agreements play a pivotal role in promoting sustainable development, safeguarding shared resources, and securing a healthier future for the planet and its inhabitants.

3.7.2 Paris Agreement

The Paris Agreement is an international treaty adopted in December 2015 during the 21st Conference of the Parties (COP 21) to the United Nations Framework Convention on Climate Change (UNFCCC). Its primary goal is to strengthen the global response to the threat of climate change by limiting global warming to well below 2 degrees Celsius above pre-industrial levels, with efforts to limit the temperature increase to 1.5 degrees Celsius.

Its salient features include

- Global Commitment: The agreement unites nearly all countries in a common cause to limit global warming to well below 2 degrees Celsius above pre-industrial levels, with efforts to limit it to 1.5 degrees Celsius. This collective commitment reflects the urgency of climate action.

- Nationally Determined Contributions (NDCs): Each country is required to submit its own climate action plan, known as an NDC. These plans outline the country's efforts to mitigate greenhouse gas emissions and adapt to the impacts of climate change. NDCs are expected to be progressively enhanced over time.
- Transparency and Accountability: The agreement establishes a transparency framework that requires countries to regularly report on their emissions, progress toward NDCs, and financial support provided or received. This transparency enhances accountability and trust among nations.
- Finance and Support: Developed countries pledge to provide financial resources to help developing countries in their mitigation and adaptation efforts. The agreement emphasizes the need for balance between adaptation and mitigation, and encourages the mobilization of financial resources from various sources.
- Loss and Damage: The agreement recognizes the importance of addressing loss and damage associated with the impacts of climate change, particularly in vulnerable and developing countries. While not creating liability or compensation, it establishes a framework for cooperation and support.
- Technology Transfer: The agreement promotes the development and transfer of environmentally sound technologies to assist developing countries in their climate action efforts.
- Capacity Building: Capacity building is recognized as a key component to enhance the ability of developing countries to effectively implement the agreement's provisions.
- Global Stocktake: The agreement includes a global stocktake process every five years to assess collective progress towards meeting the agreement's goals. This encourages countries to ramp up their efforts over time.
- Long-Term Goals: The long-term temperature goals of well below 2 degrees Celsius and efforts to limit to 1.5 degrees Celsius provide a clear direction for global climate action.
- Adaptation: The agreement places significant emphasis on adaptation, urging countries to enhance their adaptive capacity, foster resilience, and reduce vulnerability to climate impacts.
- Private Sector Engagement: The agreement recognizes the crucial role of the private sector, civil society, and other non-state actors in achieving its goals and encourages their active participation.

3.7.3 United Nations Framework Convention on Climate Change

The United Nations Framework Convention on Climate Change (UNFCCC) is an international treaty established in 1992 as a response to the growing concerns about global climate change. The UNFCCC serves as the foundational framework for international cooperation on climate change, providing a platform for dialogue, negotiations, and collaborative actions to mitigate greenhouse gas emissions and adapt to the impacts of a changing climate. The primary objective of the UNFCCC is to stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous human-induced interference with the climate system. The convention has near-universal participation, with 197 parties (196 countries and the European Union) as of September 2021. Its salient features include:

- Principle of Common But Differentiated Responsibilities (CBDR): The CBDR principle recognizes that all countries share a common responsibility for addressing climate change, but

acknowledges that developed countries should take the lead in mitigation efforts due to their historical contributions to greenhouse gas emissions and greater capacity.

- Climate Conferences (COPs): The UNFCCC holds annual Conferences of Parties (COPs) to review progress, negotiate agreements, and set the agenda for international climate action. COP 21 in 2015 led to the adoption of the Paris Agreement.
- Kyoto Protocol: An important outcome of the UNFCCC was the adoption of the Kyoto Protocol in 1997. This legally binding treaty established emission reduction targets for developed countries and introduced mechanisms like emissions trading and Clean Development Mechanism (CDM).
- Non-Binding Commitments for Developing Countries: Developing countries are encouraged to take voluntary actions to address climate change under the principle of "common but differentiated responsibilities."
- Financial and Technological Support: The UNFCCC recognizes the need for financial and technological assistance from developed to developing countries to support their mitigation and adaptation efforts.
- Capacity Building: The convention promotes capacity building in developing countries to enhance their ability to address climate change challenges.
- Adaptation: The UNFCCC emphasizes the importance of adaptation to climate change impacts, particularly for vulnerable countries and communities.
- Subsidiary Bodies: The UNFCCC has established subsidiary bodies to provide technical advice and facilitate negotiations, including the Subsidiary Body for Scientific and Technological Advice (SBSTA) and the Subsidiary Body for Implementation (SBI).
- Science-Based Approach: The UNFCCC relies on scientific assessments, such as those from the Intergovernmental Panel on Climate Change (IPCC), to guide policy decisions and negotiations.
- Global Partnerships: The UNFCCC encourages cooperation among countries, international organizations, civil society, and the private sector to collectively address climate change challenges.

3.7.4 The United Nations Convention to Combat Desertification (UNCCD)

The UNCCD is a treaty aimed at combating desertification, land degradation, and drought in arid, semi-arid, and dry sub-humid areas. The UNCCD plays a crucial role in addressing land degradation and desertification, which have wide-ranging impacts on food security, livelihoods, and ecosystems. The UNCCD has three main objectives: To combat desertification and restore degraded land and soil, to enhance the sustainable management of land resources and to mitigate the effects of drought and improve resilience in affected regions. Its salient features include:

- **Integrated Approach:** The convention emphasizes an integrated approach that takes into account environmental, social, and economic factors in addressing desertification.
- **Participatory Approach:** The UNCCD promotes the involvement of local communities, indigenous peoples, and stakeholders in planning and implementing land management strategies.

- **National Action Programs:** Parties develop National Action Programs (NAPs) that outline their strategies and actions to combat desertification, promote sustainable land management, and enhance resilience to drought.
- **Knowledge Sharing:** The convention encourages the exchange of scientific, technical, and traditional knowledge among parties to support effective land management practices.
- **Capacity Building:** The UNCCD supports capacity building and technical assistance to help parties implement sustainable land management initiatives.
- **Land Degradation Neutrality:** The convention promotes the goal of achieving land degradation neutrality, where the rate of land degradation is balanced by restoration and sustainable land management.
- **Adaptive Measures:** The UNCCD emphasizes adaptive measures to enhance the resilience of communities and ecosystems to the impacts of climate change and desertification.
- **Global Mechanism:** The convention operates in partnership with the Global Mechanism, which supports mobilization of financial resources, knowledge sharing, and implementation of projects.
- **Synergy with Other Conventions:** The UNCCD recognizes the interlinkages between desertification, climate change, and biodiversity, and promotes synergy with other relevant international agreements.
- **Reporting and Review:** Parties submit regular reports on their progress in implementing the convention's objectives, enabling monitoring and evaluation of their efforts.

4 CHAPTER FOUR: BASELINE INFORMATION OF THE STUDY AREA

4.1 Introduction

This chapter illustrates the description of the existing environmental status of the study area with reference to the prominent environmental attributes. The study area covers the location falling within 10 km radius around the proposed incinerator. The existing environmental setting is considered to adjudge the baseline environmental conditions, which are described with respect to climate, hydro- geological aspects, atmospheric conditions, water quality, soil quality, vegetation pattern, and ecology, socio-economic profiles of people, hydro-geological aspects, land use and archaeological importance. The primary baseline monitoring consists of meteorology, ambient air quality, noise levels, water quality, soil quality and ecology (aquatic and terrestrial). The land use, geology, demography, is based on the secondary data collected from various Government, semi-Government and public-sector organizations.

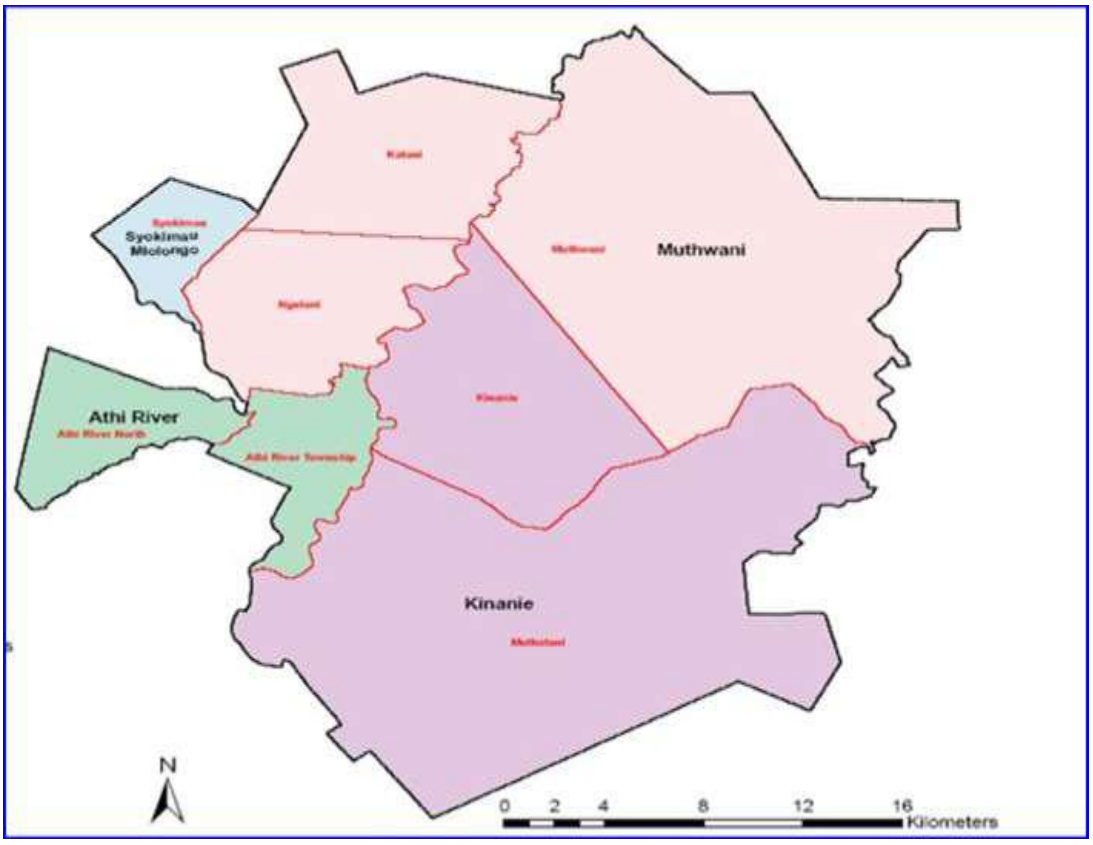


Figure 4-1: Administrative location of the proposed project

4.2 Location

The proposed project will be located in Kinanie Ward of Mavoko sub-county in Machakos County. Kinanie Ward is one of the four (4) wards of Mavoko Sub County. The Sub County covers an area of 843.2 sq.km stretching from KAPA/ Airport area where it borders with Nairobi County, and covers Katani, Ruai, Kangundo Road through Muthwani-Lukenya, Makutano(Kyumbi) to the east where it boarders Machakos Town. It covers Kapiti Plains to the south west towards Kitengela area where it borders with Kajiado County then to Embakasi in Nairobi County. The Sub County also borders Matungulu, Kathiani and Machakos Sub Counties.

4.3 Geology and Hydrology

4.3.1 Geology

Geologically, the Athi River area lies on Cenozoic volcanic material overlying Basement System rocks at a depth. The geology of the area is characterized by a succession of lava and pyroclastics overlying a foundation of pre-Cambrian schists and gneisses of Mozambique belt. This region forms the eastern border zone of the rift valley which was associated with volcanicity. The study area is covered by black cotton soils, Athi tuffs and lake beds and Kapiti Phonolites that are underlain by gneisses and schists of Pre-Cambrian age. The black cotton soils overly thin layers of sandy sediments and tuffs of Athi tuffs and lake beds which resulted from consolidation of fragmented volcanic material deposits. Wamwangi (2010) states that the Athi tuffs and lake beds were well developed from a very important Aquifer system (Athi Series) The volcanic rocks in this area are not particularly permeable to contribute to ground water, but fractures zones and weathered layers form zones for groundwater. The groundwater may be saline or hard with concentration of chloride, sulphate and fluoride. Athi River and its environs fall into Agro ecological zone VI. This is almost exclusively a ranching zone but with irrigation run-off catchment techniques, farming can be practiced.

4.3.2 Hydrology

Groundwater normally occurs in pores and interstices of various rock formations depending on the geological conditions and Physiography of the area, the permeability and porosity of the rock formations, the degree and depth of weathering, fracturing of the rock formation and the historical tectonic conditions of the area. The recharge conditions are also very important factors.

In general groundwater in volcanic rocks is limited to fractures and erosion levels within the volcanic succession. Fresh lavas are usually not water bearing because of their massive and impervious nature. The most significant aquifer system in the study area is the Upper Athi Series aquifer system. The groundwater potential in the Basement System towards the east is generally lower than that of the volcanic areas to the west.

4.3.3 Drainage System

The Kinanie site proposed for installation of the incineration treatment plant is situated within the drainage of the Mbagathi tributary of Athi River. Downstream of Kinanie, Mbagathi joins the Stony Athi to form the Athi River which is later on joined by the Nairobi River upstream of Donyo Sabuk and later receives the Kaiti/ Thwake System and the Tsavo River upon which it continues flow as the Galana and later enters the Indian Ocean North of Malindi as the Sabaki. Mbagathi tributary therefore, is among the major contributors of flow which sustains economic and ecological systems in downstream areas of Drainage Basin. Specifically, the Athi River downstream of Donyo Sabuk traverses semi-arid country in Machakos, Kitui, Makueni and Kilifi Counties where it provides a critical lifeline as a source of water for domestic and agricultural use in addition to supporting wildlife and tourism in the Tsavo National Park while the Baricho well field supplies the bulk of water consumed in Malindi, Kilifi and parts of North Coast Mombasa.

4.4 Topography

Kinanie in Athi River is located in a relatively flat escarpment area at the edge of rift valley, with a gentle slope and stands at 1532m above sea level. The terrain includes both plains and rolling hills, with occasional isolated hills, ridges and mountains projecting above the plains.

4.5 Built up Land

It is defined as an area of human habitat developed due to non-agriculture use. The built-up land in 10 km radius from project site comprises of Athi River town that include buildings, Industries, factories, transport, communications, utilities in association with water and vegetation. Athi River is an industrial town that has in the recent years witnessed increased development of middle income housing. It is located 26 KM South East of Nairobi. The town has grown rapidly due to a number of factors including: Its administrative role as it is the headquarters of Mavoko Division in Machakos County, improved infrastructural development with the Standard Gauge Railway (SGR) train station being based in the town, industrial activities that attract population to the area, the town hosts the Export Processing Zone (EPZ) and a number of factories in the cement and construction industry such as Bamburi Cement, ARM Cement, Blue Triangle Cement and Mabati Rolling Mills.

4.6 Waste

Waste generated from the industries/factories and hospitals are enormous in this area because of high population and industries. The need for a means of managing the hazardous waste triggered the proposal from the proponent.

4.7 Biological Environment

4.7.1 Introduction

Ecology is the study of surrounding environment wherein various living or biotic groups live together and form a system of existence where every component, whether small or big is interdependent and hence is an indispensable part of an Ecosystem. In an ecosystem, plants are important as primary producers of a food chain followed by small organisms that are food of the other organisms. An ecosystem gets disturbed even if a single member of it gets extinct. The various ecosystems constitute of the man and animals, plants, microorganisms, aquatic and desert animals and so on. Humans are dependent on their environment, as are all other organisms. Any change in the environment affects the living things and their behaviour. All organisms are dependent on each other in many ways. Destruction of one organism in the environment can lead to the destruction of other organisms. Technological advances have given humans the ability to exert great influence over the environment of all living things. However, the ability of ecosystems to sustain humans is becoming increasingly stunted. For this reason, it is necessary to understand ecology in order to survive. The EIA studies would be very much incomplete if proper attention is not provided towards project's impact foreseeable on flora and fauna of the study area. Accordingly, conducted the necessary survey of terrestrial flora, fauna and literature review of aquatic. Kinanie lies in the Athi-Kapiti plains which are dry savannah, open grassland with scattered scrubs and bushes. The vegetation in this area has great influence from the climate, fire, wildlife and human activities. The Ecology of Savannahs can be described as "Multiple Stable States" (Citation). Savannahs tend to grow as either open grassland with almost no trees or as dense woodland with many trees and less grass. Transitions between these states are rapid and that it was difficult to maintain a mixture of the two states. According to Sharam (citation), Savannahs generally do not undergo succession

after disturbance, but will switch back and forth between their multiple stable states without any intermediate stage.

4.7.2 Flora

4.7.2.1 Trees and scrubs

The majority of trees in these savannah plains are Acacias, Commiphoras, or Terminalias. All of these trees are drought resistant and share the same characteristics that protect them from fires that often ravage these plains. Some of the dominant trees identified in the area are;-

- Whistling thorn (Acacia drepanolobium) (Ant-galled Acacia). This tree has hard, hollow spheres at the base of its thorns, filled with biting ants. The tree actually encourages these ants by both providing homes and food in special flower-like structures called "extra-floral nectaries". These trees grow in abundance wherever the soil is saturated.
- Balanites (Balanites aegyptia) (Desert Date): The Balanites tree is often confused with Acacia trees, but can easily be identified by its green thorns. This tree produces date-like nuts which are fed on by some wild animals like the warthogs.
- Yellow Fever tree (Acacia xanthophloea); The Yellow Fever Tree is a common site in wet areas, such as along rivers.
- Umbrella tree (Acacia tortilis). The seedlings of this tree are cannot survive bush fires,
- Euphorbia tirucalli; Euphorbia tirucalli is an unarmed shrub or small tree 4-12 (-15) m high with brittle succulent branchlets 7 mm thick often produced in whorls, green and longitudinally finely striated, with white to yellowish latex. It appears to grow on almost any soil type. This plant is important for it;- Protects bare soil in dry areas from wind and water erosion; Can be used in land reclamation programmes since it is very drought resistant; Is widely planted for ornamental purposes and is an extensively used as boundary, barrier, support or hedge plant in rural areas of East Africa.

4.7.2.2 Grasses;

The Athi-Kapiti plains are covered with a huge variety of grasses all of them having the same traits that encourage and protect them from fire during the dry season. Grasses in this area include the Tetrapogon bidentatus and Chrysopogon anchieri species. These grasses form the basic food for the many herbivores inhabiting this area.

4.7.2.3 Forests

There are no gazetted forest reserves within the immediate area of influence of the Athi River to Kinanie project.

4.7.3 Animals (Fauna)

The Athi-Kapiti Plains is the dispersal area of a substantial number of wildlife migrating seasonally from and to Nairobi National Park. Some animals migrate from the Park even up to Amboseli. Many wild animals live permanently on the Plains but depend on the Park during droughts.

- Mammals; From the Nairobi national park, Herbivores, including wildebeest, hartebeest, giraffe, gazelle and zebra, use the Kitengela conservation area and migration corridor to the

south to reach the Athi-Kapiti plains. They disperse over the plains in the wet season and return to the park in the dry season. Many Predators and scavengers also inhabit the area.

- Birds: Many avian species inhabit the area. Ostrich, guinea fowls, ravens, and many other bird species inhabit the area. Migratory species of birds also visit the area.
- Reptiles; Many species of reptiles including various snakes and lizard species inhabit the Athi-Kapiti plains.
- Amphibians; Amphibian species are restricted mainly in the few rivers as well as seasonal wetlands.
- Insects; the area is rich in Insect life. Ants, termites, Bees and flies and many other species are found in the area.
- Ranching; this area has several large private ranches where cattle graze together with wild animals. There are often cases of conflict between human and wild animals reported in this area. The domestic animals in the study area mostly comprise of goats and Cows.
- Rare and endangered species; Cheetahs, hyenas and Wild dogs, highly endangered species, roam still the Athi-Kapiti Plains.

4.8 Land use and livelihoods

The project area lies in Kwa Mboo sub-location which is largely a rural setup with little urban interference. The area has large tracts of idle land with moderate human settlements. The main economic activities in the area are subsistence agriculture, sand harvesting in river beds and quarries, livestock keeping as well as small scale trade and commerce. Currently there are no industrial activities in the area and the proposed Leather industrial park in the area will revolutionize the land use pattern in the entire location.

4.9 Settlement

There are no human settlement at the site. However, within the wider span, Settlement patterns in is determined by two factors urbanization and agro-ecological (soil fertility and rainfall) potential. Specifically in the rural areas of the project road, settlement patterns have no defined sequence as one settles next to the fathers homestead, on inherited land or a distance on purchased/inherited land parcels. Naturally, the location is inhabited by the Kamba tribe. Even in the more cosmopolitan Athi River Town, the Kamba tribe is still the dominant community.

4.10 Public Health and Safety

The project area is in a rural set up and therefore has little social amenity facilities. Kwa Mboo sub-location with a population estimated at 5000 people has no any health facilities. The CGM is currently constructing Kwa Mboo dispensary. The residents rely on Kinanie health centre which is about 6 kilometers from the proposed project site. The area is also served by Athi River Police Station which is approximately 7 kilometers from the site. There is no fire station in the area. Residents in the area rely on borehole for potable water supply. Some residents downstream in Kangemi Village within Kwa Mboo sub-location use water from River Athi for domestic purposes. The river water is also used for livestock as well as for subsistence irrigation farming.

4.11 Road and Transport network

The project area can be accessed using an earth road approximately 19 kilometers from Mombasa Road turn-off near Athi River Township. The earth road is in a poor state of repair and is not easily motorable during rainy season. There are no public transport vehicles in the project area.

4.12 Geographical Location and Environmental Setting around Project Site

Table 4-1 Summary of physical and environmental factors

Sr. No	Particulars	Details
1.	Name of Project	Environmental impact assessment study for the proposed development (incinerator and auxiliary facilities) on LR number 23961 (part) portions 11, Kinanie Athi-River, Machakos County.
2.	Location Coordinates	**1°35'21.4"S and 37°06'20.5"E**
3.	Climatic condition (Köppen-Geiger classification: Cfb).	• On average, the warmest month is March. • On average, the coolest month is August. • The average annual maximum temperature is: 24.0°C (75.2° Fahrenheit) • The average annual minimum temperature is: 11.0°C (51.8° Fahrenheit)
4.	Predominant wind directions	North-East
5.	Present Land Use at the proposed site	EPZA ponds-Waste water treatment work
6.	General elevation above MSL	1614.00m/5295.28ft
7.	Transport Connectivity	Nairobi-Mombasa High way-14 Km away
8.	Protected areas as per Wildlife Protection Act, (Tiger reserve, Elephant reserve, Biospheres, National parks, Wildlife sanctuaries, community reserves and conservation reserves)	None within 10Km
9.	Nearest Waterbody	Nil
10.	Hills/Valleys	Lukenya
11.	Ecologically sensitive zones within 5-km distance	None
12.	Historical/Archaeological places	Nil

4.13 Climate and Rainfall

The study area experiences average rainfall of between 500mm and 1000mm annually. The rainfall is bimodal and the rainfall figures in Athi River are one major and one minor monsoon seasons. The major monsoon season is experienced in the months of March, April and May and is called the long rains. The minor monsoon seasons occur between October and December, referred as short rains (Mbegera, 2010).The climate has been changing over the years. On average, the warmest month is March.

- On average, the coolest month is August.
- The average annual maximum temperature is: 24.0° Celsius (75.2° Fahrenheit)
- The average annual minimum temperature is: 11.0° Celsius (51.8° Fahrenheit)

The mean monthly temperature ranges from 12°C on the coldest months (July-August) to 25°C on the hottest months (March and October) (Republic of Kenya, 2002a). Annual average temperatures are in the region of 30°C.

4.14 Infrastructure and Amenities

4.14.1 Energy Resources

Different types of energy sources are in use in the project area and include electricity, solar, firewood, charcoal, kerosene, gas and biogas. Electricity and gas are the most commonly utilized energy sources both for domestic and commercial purposes. The proposed project area is served by electricity and hence that will be one of the sources of energy for the project. The main energy source will be solar energy.

4.14.2 Water Resources

Water is a core strategic resource whose availability or otherwise dictates trends and pace of economic development. In the project area, Mbagathi River traverses the area. The river however, is seasonal on account of poor flood storage capacity and possible over abstraction which makes it a dry river bed with absolutely no potential to support large-scale investments heavy on water demand. The proposed site will obtain water from a borehole provided by EPZA.

4.14.3 Road and Transport Network

The project area can be accessed using an earth road approximately 19 kilometres from Mombasa Road turn-off near Athi River Township. The earth road is in a poor state of repair and is not easily passable during rainy season. There are no public transport vehicles in the project area.

4.14.4 Sewerage services

The dominant infrastructure at Kinanie is the sewerline and sewage treatment plant operated by the EPZA. The proposed project will be connected to the EPZA sewer line system.

4.14.5 Power Supply

Kinanie area is served by several three-phase electricity which serve the neighbourhoods including, homes, market, schools, boreholes and other facilities.

5 SECTION FIVE: CONSULTATIONS AND PUBLIC PARTICIPATION

5.1 Introduction

Consultations with various stakeholders and engaging the public throughout the Environmental Impact Assessment (EIA) process are fundamental aspects of ensuring a comprehensive and transparent evaluation of the proposed project's potential impacts. The requirement for such consultations and public participation is in accordance with the provisions outlined in Legal Notice No. 101, Kenya Gazette Supplement No. 56 of June 13th, 2003, specifically the Environmental (Impact Assessment and Audit) Regulations, 2003, revised in 2019. The consultation and public participation process was extensive, interactive, and thorough, with a focus on reaching as many stakeholders as possible and ensuring that the concerns and opinions of the public were considered. The immediate neighborhood received special attention during this process. Views, comments, concerns, and opinions of neighbors in relation to the proposed project were actively sought and integrated into the assessment. The Comprehensive Public Participation (CPP) approach adopted in this process holds several benefits:

- Local and Traditional Knowledge: It allowed for the collection of local and traditional knowledge that might not be captured through other means, contributing to a well-informed decision-making process.
- Alternatives and Mitigation: CPP facilitated the consideration of various alternatives and mitigation measures. Stakeholders' insights can aid in identifying creative solutions and trade-offs that might enhance the project's positive outcomes.
- Addressing Overlooked Impacts: Engaging stakeholders and the public helped ensure that no important impacts are overlooked and that the potential benefits of the project are maximized.
- Conflict Resolution: By identifying contentious issues early on, CPP helped to reduce conflicts and tensions, contributing to smoother project implementation.
- Positive Design Influence: Public input can positively influence the design of the project, incorporating valuable perspectives that might enhance its overall quality.
- Transparency and Accountability: By involving stakeholders and the public, the decision-making process becomes more transparent and accountable, fostering trust and confidence.
- Enhanced Public Confidence: A robust CPP process increases public confidence in the EIA process, making it more likely that the final project decisions will be respected and supported by the community.

In conclusion, the adoption of consultations with stakeholders and active public participation throughout the EIA process was crucial not only for regulatory compliance but also for making well-informed decisions, addressing concerns, and ultimately fostering a sense of ownership and positive engagement within the community.

5.2 Stakeholder analysis and stakeholder engagement plan

This followed the provisions of the Environmental (Impact Assessment and Audit) (Amendment) Regulations, 2003, Legal notice No. 31 of 2019.

NB: It is important to note that the proponent fully complied with section 17 part 1 of EMCA regulation which states that "During the process of conducting an Environmental impact assessment study under

these Regulations, the proponent shall in consultation with the Authority, seek the views of persons who may be affected by the project". During the ESIA study, the extensive consultations was done to ensure that all stakeholders are informed of the proposed project and are involved in it. The consultations was in form of: Community consultative meetings on site, lead agencies consultations, wider public reach through the mass media and site visits, interviews and discussions. For Kinanie community, the EIA stakeholder engagement provided enhanced knowledge about real impacts occurring in their neighbourhood, reduced uncertainties about (cumulative) impacts, and generated adequate management responses to complaints and concerns about nuisances, safety or health issues. A Stakeholder Engagement Plan (SEP) was developed.

A stakeholder is defined as any individual, organization or group which is potentially affected by the Project or which has an interest in the Project and its impacts. The objective of stakeholder identification is to establish which stakeholders may be directly or indirectly affected either positively or negatively ("affected parties"), or have an interest in the Project ("other interested parties"). It is important that particular effort will be made to identify any disadvantaged and vulnerable stakeholders who may be differentially or disproportionately affected by the proposed project or who may have difficulty participating in the engagement and development processes.

Table 5-1: SEP for the Proposed Development (Incinerator and auxiliary facilities)

Stakeholder group	Stakeholder type		Connections to the Project	Timeframe and mode
	Potentially Affected party	Other interested party		
Local Communities				
▪ **Kinanie Village** ▪ **Wider Athi-River community** ▪ **Users of local public amenities** ▪ **Employees of surrounding government institutions and public amenities like EPZ**	✓		Households and communities that will receive impacts (positive or negative) as a result of the Project e.g. positive employment opportunities, provision of infrastructure services or negative Impacts associated with installation and operation	Week 1
National, County Government and political offices				
▪ **CEC, Environment and Natural Resources-Machakos County** ▪ **Development control office-Machakos County** ▪ **Ward Administration** ▪ **Public Health office** ▪ **Area MCA** ▪ **NEMA Office, Machakos County**		✓	Oversee the procedures to contain conflict and ensure the ESIA process is coordinated smoothly for decision making.	Week 2
Ministry of Interior and Coordination of National Government				
▪ **Deputy County Commissioner** ▪ **Chief**		✓	Ministry of Interior and Coordination of national Government has primary importance to the Project with permitting meeting requirements that must be met by the Project and responsibilities for calling for public meetings at the project venue or any suitable venue.	Throughout the ESIA process
EPZ administration		✓	As a landlord	

5.3 Methodology used in Public Consultation

The exercise was conducted by a team of experienced registered environmental and social safeguard experts. Stakeholders' participation forms were distributed to the project neighbors as key stakeholders.

5.3.1 Questionnaire survey

A questionnaire survey was carried out targeting stakeholders and neighbours of the proposed project site. The stakeholders responded to the questionnaire and none had objection to the establishment.

5.3.2 Detailed Public Consultation

Consultation meetings were held with project neighbours and local stakeholders in order to gauge their perception regarding the proposed project. Two (2) consultative meetings were held including a courtesy call to the Chief's office. Detailed outcomes of each meeting are discussed in the next clauses.

5.3.3 Courtesy Call on the area Chief

This involved briefing the Chief on the purpose of the planned EIA exercise on the proposed project:

i. The need for conducting an ESIA as per NEMA requirements contained in the 2015 Environment Management and Co-ordination Act.
ii. Brief by the Chief on the administrative issues; boundaries within Kinanie, Athi-River.
iii. Environmental challenges facing the Kinanie, Athi-River especially waste management issues.
iv. The expectation of the community and ways in which the proponent can further work in harmony with community once the project kicks off.

5.4 Neighbors' Views about the Project

There were no objections from neighboring communities regarding the project. All community members supported the project citing the following.

5.4.1 Potential positive impacts:

- The project will contribute to improved health and at the same time promote economic growth to the company as well as the County and National governments through revenue and job creation.
- The project is a waste management facility hence will promote environmental conservation.
- The project will spur other similar projects which may come up in the County.
- The project will encourage other investors to consider investing in Machakos County.

5.4.2 Negative Issues

The public consulted also raised negative issues which they anticipate the project will create hence should be mitigated:

- Air pollution may occur during the operation phase.
- Increased demand for available social amenities and other services
- Noise pollution during installation and operation
- Ash waste generation by the project.

- Occupation safety and health concerns during operation phase.

5.4.3 Summary of concerns from one of the public meetings

1. **Philip Mutua:** In this regard posed the below questions to the consultants;
   i. Are there jobs reserved for the locals? Can they be subcontracted to supply building materials during construction?
   ii. What wastes will be incinerated in the proposed incinerator?
   iii. How are air quality standards be enforced bearing on mind that Athi River locality is Heavily Polluted and the proposed plants might led to further pollution?
   iv. Will the ash from the incineration process be used for any purpose? Is it contaminated? What is the commitment to CSR by this company?
2. **Josephine Mutuku:** Concerned about employment terms to the locals based on previous experience with other companies. The investor must obey labour laws in Kenya and pay for over time.
3. **Janet Kanini**: Sought questions related to tissue proper management of waste items contaminated with blood, body fluids, or other potentially infectious materials, such as used gloves, syringes, needles, and bandages including pathological waste: This category includes tissues, organs, body parts, and other biological materials removed during medical procedures or surgeries. Her inquiry was whether these items burn completely or not?
4. **Benard Mutisya**: Wanted to establish if the ongoing project by Green City Incinerator Ltd has employed locals as per promises in their previous public participation.
5. **Betty Mulei**: Raised concern on Equal Opportunities: Prevailed upon Plenser management to ensure that both men and women have equal access to job opportunities and are not discriminated against based on their gender. This includes fair hiring practices and equal pay for equal work. She requested to be employed in the construction work.
6. **Daniel Ndambuki**: Was concerned about safety of workers: The use of Personal Protective Equipment (PPE) in workplaces is crucial to ensure the safety and protection of workers from various occupational hazards and risks. Plenser Waste management Ltd should provide PPE designed to protect workers from physical, chemical, biological, and other workplace hazards that can cause injuries, illnesses, or even fatalities
7. **Musyoka**: Will the proponent undertake CSR to the community particularly beginning with rehabilitation of Assistant chief office that is almost crumbing?
8. **Muya Nzioka**: Are there specialized vehicles for transporting hazardous wastes?
9. **Mangeni**: Plenser to give long term contracts to workers and flexible work plans to the considered locals.
10. **Muthama Mbatha**: Requested to be considered for day or night guard job as he is currently jobless

5.5 Suggestions by respondents

- Community Social Responsibility (CSR) Plan: Plenser Waste Management Limited shall develop and implement a comprehensive CSR plan for the benefit of the local community. This plan shall include initiatives aimed at enhancing the socio-economic well-being of the community through education, health, employment opportunities, and infrastructure development.
- Environmental Management Practices: Plenser Waste Management Limited shall adhere to stringent environmental management practices throughout the project's lifecycle. These practices shall encompass waste disposal, emission control, and proper handling of hazardous materials to minimize any adverse environmental impacts.

- Proper Installation of the Incinerator and its components: Plenser Waste Management Limited shall ensure that the incinerator is installed following industry best practices. The design and installation shall be such that minimal to no particulate matter is released into the atmosphere during the operation of the incinerator.
- Local Employment Opportunities: During both the construction and operation phases of the project, the proponent shall prioritize the employment of casual workers from the local community. This approach aims to empower the host community by providing job opportunities and enhancing local economic growth.
- Noise Pollution Control: The proponent shall implement effective measures to control noise pollution during the installation and operation of the incinerator. Noise control measures shall be put in place to ensure that noise levels remain within permissible limits and do not adversely affect the surrounding community.

Plate 5-1: Area Chief moderating the proceedings during CPP

Plate 5-2: Participants following proceeding of the Baraza

Plate 5-3: Proponent representative explaining to the community the concept of the incineration process

6 SECTION SIX: ANTICIPATED IMPACTS AND MITIGATION MEASURES

6.1 Introduction

This section provides a brief indication of the significant potential positive and negative environmental impacts relating to the development of the proposed incinerator and auxiliary facilities for Plenser Waste Management Limited. Once a potential issue and/or potential impact has been identified it is necessary to identify which activity or aspect of the operation result in the impact. By considering the cause of the issue, the probability of the activity resulting in an impact can be determined. The associated impact can then be assessed to determine the significance and to define mitigation or management measures to address the impact. The potential environmental impacts associated with activities during operation may be significant and long lived and mitigated in an Environmental Management Plan (EMP). This chapter outlines the generic methodology that was followed when determining and evaluating impacts. This generic methodology was used when assessing the significance of the impacts related to the key issues and potential impacts raised. Human activities have a positive or negative, direct or indirect impact on the biological and physical environment. The nature and degree of impact however varies dependent on the location and the type of operation.

NB: Impacts were grouped into two categories based on their assessment of their significance as assessed:

a) Impacts for which there are published standard criteria, regulations or for which levels of acceptability have been determined. Few countries have published clear criteria for acceptable environmental impact (Environmental Quality Objectives - EQOs); research is urgently needed in most African situations to address this issue.

b) Impacts for which the assessment has to be based on the qualitative judgment of various stakeholders:

   i. Opinions of qualified decision makers in County Government of Machakos, or Sectoral departments based on the government's national and sectoral development policies;
   ii. Opinions of specialists (e.g. environmentalists, ecologists, sociologists, urban planners);
   iii. Past documented experience of similar projects;
   iv. Surveys of public opinion as to acceptability of impacts.

6.2 Criteria used to determine the Consequence of the Impact

Table 6-1: Criteria used to determine the Consequence of the Impact

Rating	Definition of Rating	Score
A. Extent – the area over which the impact will be experienced		
Local	Confined to project or study area or part thereof (e.g. site) Kinanie.	1
Regional	The region, which may be defined in various ways, e.g. cadastral, catchment, topographic	2
(Inter) national	Nationally or beyond	3
B. Intensity – the magnitude of the impact in relation to the sensitivity of the receiving environment, taking into account the degree to which the impact may cause irreplaceable loss of resources		
Low	Site-specific and wider natural and/or social functions and processes are negligibly altered	1
Medium	Site-specific and wider natural and/or social functions and processes continue albeit in a modified way	2
High	Site-specific and wider natural and/or social functions or processes are severely altered	3
C. Duration – the timeframe over which the impact will be experienced and its reversibility		
Short-term	Up to 2 years	1
Medium-term	2 to 15 years	2
Long-term	More than 15 years	3

The combined score of these three criteria corresponds to a Consequence Rating in Table 6-2 below

Table 6-2: Method used to determine the Consequence Score

Combined Score (A+B+C)	3-4	5	6	7	8-9
Consequence Rating	Very low	Low	Medium	High	Very high

Table 6-3: Probability Classification

Probability – The likelihood of the impact occurring	
Improbable	< 40% chance of occurring
Possible	40% - 70% chance of occurring
Probable	> 70% - 90% chance of occurring
Definite	> 90% chance of occurring

The overall significance of impacts was determined by considering consequence and probability using the rating system prescribed in Table 6-4.

Table 6-4: Impact significance ratings based on impact probability and consequence

		Consequence				
		Very High	High	Medium	Low	Very Low
Probability	Definite	Very High	High	Medium	Low	Very Low
	Probable	Very High	High	Medium	Low	Very Low
	Possible	High	Medium	Low	Very Low	Insignificant
	Improbable	High	Medium	Low	Very Low	Insignificant

The impact significance rating should be considered by authorities in their decision-making process based on the implications of ratings ascribed in Table 6-5 below

Table 6-5: Impact significance categories and definitions

Impact significance	Definition
Very High	The activity should only be approved under special circumstances.
High	The potential impact will affect the decision regarding the activity/development
Medium	The potential impact should influence the decision regarding the Activity/development.
Low	The potential impact may not have any meaningful influence on the decision regarding the proposed activity/development.
Very Low	The potential impact is very small and should not have any meaningful influence on the decision regarding the proposed activity/development
Insignificant	The potential impact is negligible and will not have an influence on the decision regarding the proposed activity/development.

Finally, the impacts were also considered in terms of their status (positive or negative impact) and the confidence in the ascribed impact significance rating. The prescribed system for considering impacts status and confidence (in assessment) is laid out in Table 6-6

Table 6-6: Impact status and confidence classification

Status of impact	
Indication whether the impact is adverse (negative) or beneficial (positive).	+ ve (positive – a 'benefit')
	– ve (negative – a 'cost')
Confidence of assessment	
	Low
	Medium
	High

The determination of 'significance' incorporates judgments of the above together with the potential magnitude of the impact. In addition, the frequency of impacts upon the receiving environment is a factor in determining the significance. An impact that is moderate in size but continuous can be more significant than one that is infrequent or rare.

Project impacts can also be considered direct or indirect:

- Direct: Effects directly attributable to the proposed project activities or actions; and
- Indirect: Effects not directly attributable to the operational activities.

The determination of significance is therefore dependent upon decisions of the below factors in section.

6.3 ESIA significance factors that were considered

Table 6-7: Impact status and confidence classification

Significance Factors	Description
Extent/Magnitude	Potential impact should be quantified with range limits wherever possible and relevant modeling may be undertaken in order to predict impacts for appropriate factors.

Reversibility	A reversible impact is one in which the condition which the impact effects can be returned to the baseline condition prior to the impact.
Duration	The length of time of an impact may be short, medium or long term. Typically, this is defined as <5 years, 5-15 years and >15 years respectively.
Standards	Complying with the national and international standards, which may exist for a particular impact, also helps define the potential significance of an issue. With regard to the proposed project, this would consist of both Kenyan and international guidelines.
Sensitivity of receptors	In many areas the sensitivity is further defined by consultation and baseline surveys, which help detail the existing environment. Areas designated nationally or internationally should be considered as sensitive areas and impacts minimized wherever possible

6.4 Anticipated Impacts of the proposed project

6.4.1 Anticipated (potential) positive Impacts

i. **Decreased quantities of waste:** The proposed development (Incinerator and auxiliary facilities) will be able to decrease the quantity of waste by 95% and reduce the solid quantity of the original waste by 80-85% depending on the components that will be in solid waste. Hence, even though incinerators do not completely get rid of dumping ground, they definitely decrease the quantity of land needed.

ii. **Reduced Pollution:** Research has shown that solid waste incinerators are less likely to pollute the environment than landfills do. One particular study done during a 1994 lawsuit in the US showed that a waste incinerator location was more environment-friendly compared to a landfill. The research discovered that the landfill was releasing higher quantities of greenhouse gases, nitrogen oxides, dioxin, hydrocarbons, and non-methane organic compounds. Landfills also leach poisonous chemicals into the water below thus contaminating underground water systems. The proposed incinerator using proper scrubber technology will reduce air pollution in the atmosphere as well as contribute to Climate change mitigation.

iii. **Trapping of pollutants that would have otherwise been released if open burning was adopted**: The main problem concerning the incineration of solid waste is the release of hazardous compounds, particularly dioxin. Nonetheless, the proposed modern incinerator plant will use a wet scrubber system to trap hazardous gases and particulate dioxin. The proposed incinerator will operate within the required pollution limits recommended by the NEMA and international protocols.

iv. **Saving on Transportation of Waste within Athi-River and neighbouring Counties**: The proposed incinerator will be in a reasonable distance from Machakos County and Nairobi city. This is advantageous since it means waste does not have to be driven for long distances for dumping. It significantly reduces the cost of transport; the money can then be spent on the wellbeing of the community and sustaining the growth of waste generators. Additionally, it reduces the harmful gases released by vehicles during transportation, thus drastically reducing the overall carbon footprint.

v. **Better control over odor and noise**: The proposed incinerator will be able to provide less bad smells because waste gets burnt, unlike landfills where waste is allowed to decay thereby emitting

unpleasant smells, which cause air pollution. The production of methane in landfills may also lead to explosions that cause noise pollution, which is unheard-of when it comes to the use of incinerators.

vi. **Prevention of the production of methane gas**: In landfills, when the waste is decaying methane gas is generated which if not controlled, may explode causing further global warming. Unlike landfills, incinerators do not produce methane, therefore making them safer.

vii. **Elimination of harmful germs and chemicals**: The proposed incinerator will function at very high temperatures of about 1,200 ºC that can destroy germs and chemicals that are harmful. Thus, it is a very effective method when it comes to eliminating clinical waste.

viii. **All weather operation**: The proposed incinerator can function in any type of weather. For instance, during a rainy season, waste cannot be dumped in a landfill because the rain will possibly wash down poisonous chemicals into the ground and consequently create leachate thus contaminating the underground water as well as the neighboring land. Waste can also not be dumped when it is windy since it will get blown into the surroundings. On the other hand, incinerator will not be limited to weather changes since it will burn waste without leakages. Incinerator also has the capacity to function 24 hours a day is more efficient in managing waste compared to landfills.

ix. **Effective for Metal Recycling:** When the proposed incinerator will be burning waste, the metals still remain whole because they have a high melting point. After the process of burning waste is done, it is expected that the workers remove the remaining metal and recycle it. This removes the need for separating out any metal before waste disposal. When garbage is taken to a landfill, it is usually not organized which results in wasting of resources that could have been recycled. Therefore, using an incinerator will makes it easier to remove and reuse metals.

x. **Computerized monitoring system:** The proposed modern incinerator has a provision for a computerized monitoring system device to allow for the troubleshooting of most problems. This will enable operators to discover a problem before it becomes more serious and much more expensive to repair.

xi. **Potential Uses of ash waste:** The ash that comes from the combustion of waste can be used in construction, get shipped or even landfilled.

xii. **Job creation:** The proposed incinerator plant will directly or indirectly create jobs for the locals.

xiii. **Generation of raw materials:** Through recycling, the proponent intends to generate some raw materials that can be used in other industries.

xiv. **Promoting research and training:** On current technologies on waste management.

6.4.2 Potential negative impacts

i. **Degradation of the air quality and the environment: Incinerator produce smoke during the burning process that can pollute the environment if proper** filter or scrubber is not installed. The smoke produced includes acid gases, carcinogen dioxin, particulates, heavy metals, and nitrogen oxide. These gases are poisonous to the environment. This is a potential impact that forms the whole basis for this assessment.

The pollutants of concern including dioxins and furans, heavy metals (in particular, cadmium, mercury, and lead), acid gases, and particulate matter, either are formed during waste incineration or are present in the waste stream fed to the incineration facility. Emissions of dioxins and furans

result, in part, by the processes in the combustion chamber that lead to the escape of products of incomplete combustion (PICs) that react in the flue gas to form the dioxins. PICs are formed when combustion reactions are quenched or incompletely mixed. The combustion chamber for incineration must therefore be designed to provide complete mixing of the gases evolved from burning of wastes in the presence of air and to provide adequate residence time of the gases at high temperatures to ensure complete reactions. The operation of the combustion chamber also affects the emission of pollutants, such as heavy metals, that are present in the waste feed stream. Such compounds are conserved during combustion and are partitioned among the bottom ash, fly ash, and gases in proportions that depend on the compounds' volatility and the combustion conditions. Mercury and its salts, for example, are volatile, so most of the mercury in the waste feed is vaporized in the combustion chamber. In the cases of lead and cadmium, the partitioning between the bottom ash and fly ash will depend on operating conditions. More of the metals appear in the fly ash as the combustion-chamber temperature is increased. In general, there is a need for the combustion conditions to maximize the destruction of PICs and to minimize the vaporization of heavy metals. It is also important to minimize the formation of NO_x (which is favored by high temperatures or the presence of nitrogen-containing fuels). In addition to the composition of the waste feed stream and the design and operation of the combustion chamber, a major influence on the emissions from waste-incineration facilities is their air-pollution control devices. Particulate matter can be controlled with electrostatic precipitators, fabric filters, or wet inertial scrubbers. Hydrochloric acid (HCl) and sulfur dioxide (SO_2) can be controlled with wet scrubbers, spray dryer absorbers, or (to a lesser extent) dry-sorbent injection and downstream bag filters. NO_x can be controlled, in part, with combustion-process modification and with ammonia or urea injection through selective or nonselective catalytic reduction. Concentrations of dioxins and mercury can be reduced substantially by injecting activated carbon into the flue gas, or by passing the flue gas through a carbon sorbent bed, which adsorbs the trace gaseous constituents and mercury. The application of improved combustor designs, operating practices, and air-pollution control equipment and changes in waste feed stream composition have resulted in a dramatic decrease in the emissions that used to characterize uncontrolled incineration facilities. For example, emission of dioxins from uncontrolled incinerators exceeded 200 nanograms/TEQ per dry standard cubic meter (200 ng/TEQ-dscm) in a number of commercial units. It has been reduced to below 0.1 ng/TEQ-dscm in many modern units. Rates of emission of mercury have decreased, at least in part, as a consequence of changes in the waste feed streams resulting from the elimination of mercury in some waste stream components, such as alkaline batteries. To maximize combustion efficiency, it is necessary to maintain the appropriate temperature, residence time, and turbulence in the incineration process. Optimal combustion conditions in a furnace ideally are maintained in such a manner that the gases rising from the grate mix thoroughly and continuously with injected air; the optimal temperature range is maintained by burning of auxiliary fuel in an auxiliary burner during startup, shutdown, and upsets; and the furnace is designed for adequate turbulence and residence time for the combustion gases at these conditions.

Note: The proposed incinerator is fitted with APCDs designed to remove the respective air pollutants.

ii. **Ash waste risk:** Even though the ash that remains from the process can be comparatively small in quantity, it contains a number of poisons and heavy metals which requires further treatment. If not disposed correctly, it can cause serious harm to the public and the environment. The proponent has proposed measures in place for ash management.

iii. **Impact on Climate:** The proposed incinerator takes place within the industrial land already possessed by the proponent and it does not involve any vegetation land which clearly indicates that, impact on the climatic conditions from the proposed civil works and incinerator installation will be insignificant.

iv. **Identified Impacts on Air Environment**. The potential of air pollution from the installation and operation of the incinerator are emissions from vehicular/ equipment engine exhaust emissions during construction, particulate matter (dust) generated by grading, excavation and the movement of construction vehicles and point sources of particulate matter (chemical residuals, smoke and dust) and gaseous emissions during operation. Holding areas for the hazardous waste materials as received will likely be sources of dust, particularly from the transfer process to the sorting areas and into the incinerator. The incineration process will also involve burning of hazardous materials at very high temperatures (between 800ºC –1,200ºC). Particulate matter will comprise of ashes and flue gases from the burning process and smoke as a combustion product. Other emissions from this point is hydrocarbon residuals, carbon dioxide, carbon oxide, nitrogen oxides and sulphur oxides from fuels and related combustion processes. However, the incinerator is fitted with a scrubber and as seen in the incinerator descriptions these will be reduced to the minimum.

Table 6-8: Potential negative impacts and mitigation measures

CONCERN	POTENTIAL NEGATIVE IMPACTS	PROPOSED MITIGATION MEASURES
SITE PREPARATION AND INSTALLATION PHASE		
Dust disturbances	▪ Eye irritation; ▪ Skin irritation; ▪ Impairment of normal sweating of the skin as it blocks pores on the skin; ▪ Chocking of the throat; ▪ Respiratory difficulties; ▪ Difficulty in breathing; ▪ Potential cause of chest complication and ailment	▪ Employees involved in the site preparation and installation work to be provided with dust masks; ▪ Project management and contractor to enforce strict use of personal protective clothing; ▪ Complaints of dust related ailments among employees given access to medical attention; ▪ Screen off the area to reduce dust in the neighbourhood; ▪ Vehicle speeds in the construction area will be limited to minimize dust in the area; ▪ The construction contractor will water the site with exposed soil surfaces twice each day during dry weather.
Exhaust emissions	▪ Vehicular/equipment engine exhaust emissions are a potential source of impacts to air quality.	▪ Discourage idling of vehicles i.e., vehicle and equipment will be turned off when not in direct use to reduce exhaust emissions; ▪ Discourage idling of vehicles i.e. vehicle and equipment engines will be turned off when not in direct use to reduce exhaust emissions; ▪ Regular maintenance of construction plant and equipment.
Noise disturbances	▪ Reduced concentration of people ▪ Shouting during conversation among workers on site ▪ Noise induced hearing loss among workers who are continuously exposed to high noise levels ▪ Reduction in productivity and efficiency of the workers at the workplace ▪ Stressing the worker and thus reduced concentration.	▪ All installation works to be limited to daytime only; ▪ All employees likely to be exposed to ear noise to be provided with ear protectors; ▪ Contractor to ensure strict enforcement on user of ear protectors; ▪ Where applicable and possible exceptionally noisy machines to be fitted with noise reduction devices; ▪ Any employee who may complain about ear related pain and or complication while at work to access medical attention at the expense of the contractor or project proponent; ▪ Regular maintenance of construction plants and equipment; ▪ There should not be unnecessary horning of the involved machinery; ▪ Provision of billboards at the construction site notifying of the construction activity and timings; ▪ Sensitize drivers of construction machinery on effects of noise;

		▪ Provide barriers such as walls around site boundaries to provide some buffer against noise propagation; ▪ The proponent should comply with the Environmental Management and Coordination (Noise and Excessive Vibration Pollution) (Control) Regulations, 2009.
Soil erosion	▪ During site clearing and excavation	▪ Avoid unnecessary movement of soil materials from the site; ▪ Provide soil conservation structures on the areas prone to soil erosion mostly to reduce impact by the run-off; ▪ Control construction activities especially during rainy conditions; ▪ Re-surface open areas after completion of the project and introduce appropriate vegetation; ▪ Provide suitable storm water drainage channels to effectively discharge water to safe areas; ▪ Channels need to be regularly maintained and repaired to avoid point discharge in case of breakages or blockages; ▪ Conduct landscaping after the project completion to maximally control any possible chance of soil movement.
Storm water drainage	▪ Poor drainage causes dampness to building structures as well as water stagnation. ▪ Dampness is influenced by poor drainage, in the presence of warmth and darkness, breeding grounds for malarial and other diseases can be directly traced from it. ▪ Drainage of the general property/premise comes in handy to enhance effective flow of the much anticipated surface run-off emanating from the roof catchments and other areas within the site	▪ The design of the drainage system should ensure that surface flow is drained suitably into the public drains provided to control flooding within the site; ▪ Drainage channels should be installed in all areas that generate or receive surface water such as car parking, drive ways and along the building block-edges of the roofs; ▪ Channels should be covered by approved materials to prevent occurrence of accidents and entry of dirt that would compromise flow of run-off; ▪ Drainage channels should ensure safe disposal of run-off/surface water and should be self-cleaning; ▪ Paving of the sideways, driveways and other open area should be done using pervious materials to encourage recharge and thus reducing water runoff volume.
Solid waste	▪ Cause visual pollution making such areas unsightly.	▪ Solid waste to be handled, managed and disposed according to the waste management regulations;

	▪ Poorly managed and disposed waste can attract disease vectors ▪ Can be injurious to those working at the project	▪ Waste handling bins to be provided for workers onsite, each bin should have a lid which should always be covered; ▪ Colour code to be used to distinguish waste bins of different waste; ▪ Solid waste to be disposed only at licensed disposal sites; ▪ In a case of cement bagging, they can be stored recycled or put into different usage; ▪ It is recommended that land clearance, excavation and construction waste be recycled or reused to ensure that materials that would be disposed of as waste are diverted for productive use; ▪ Oils and grease from moving machine parts and other sources should be handled as hazardous wastes in accordance with the waste regulations.
Occupational injuries	▪ Complete incapacitation of the affected employee ▪ Loss of life ▪ Increase in Costs of litigation and compensation ▪ Exposure to Environmental hazards	▪ Appropriate personal protective equipment such as safety belts for workers working at height to be provided; ▪ Proper use of PPE provided; ▪ Appropriate training of workers of ways of working safely; ▪ Appropriate supervision at workplace; ▪ Rest times to be strictly observed to reduce stress; ▪ Noise and dust and other factors can result in reduced concentration to a level of causing an accident to be appropriately mitigated; ▪ Construction crew at the site will be sensitized on social issues such as drugs, alcohol, diseases; ▪ A first aid kit should be provided within the site. This should be fully equipped at all times and should be managed by qualified person; ▪ The contractor should have workmen's compensation cover. It should comply with workmen's compensation Act, as well as ordinances, regulations and union agreements; ▪ All moving machine parts and high temperature areas should be fitted with guard rails and restrict access; ▪ Adequate sanitary facilities should be provided and standard cleanliness maintained; ▪ Food handlers preparing food for the workers at the site should be controlled and monitored to ensure that food is hygienically prepared; ▪ Regular maintenance of machinery on site;

			▪ Workers should be provided with evacuation procedures in case of fire Safe operation procedures/ clear instruction provided to the workers to ensure that safety is maintained; ▪ Conducting risk assessments before the work commences to ensure that hazards are identified and eliminated before the work commences;
Increased demand on water and energy resources	▪ Water is a major concern especially in construction sites ▪ There will also be high power consumption during construction ▪ The construction will cause strain to the existing water supply as well as the energy supply which will have a direct impact to the water and energy supply.		▪ Avoid wasting the water supplied to the site; ▪ Encourage water reuse/recycling during both construction; ▪ Encourage proper water management systems; ▪ All Plant equipment and electrical appliances should be switched off when not in use. ▪ Explore the use of solar and wind energy especially for site security lighting during the night; ▪ Create awareness among workers by use of stickers on the need to conserve energy.
Effluent Disposal	▪ Provision for disposal of sanitary waste should be done for construction workers.		▪ All liquid wastes to be disposed of properly by connecting to the EPZ sewer line system; ▪ Construction of the drainage system to be under the supervision of the structural engineer; ▪ Provide mobile toilets to construction workforce.
OPERATIONAL PHASE			
Local Air quality degradation	▪ Air quality health hazards such mainly bronchial infections, skin problems, visibility, etc. for employees and public are likely effects from uncontrolled air pollution.	▪ CO_2, water vapor, and ash, which are respectively oxidation-reaction products of carbon, and hydrogen, and non-combustible materials in the fuel. ▪ Particulate Matter (retained	▪ Installation of electrostatic precipitators, fabric filters, or wet inertial scrubbers for particulate matter control; ▪ Limiting the ash content of the waste feed via source control or selection; ▪ Optimize voltage and other electric conditions of an ESP (to maximize capture of particles); ▪ Designing and operating the primary combustion chamber to minimize fly-ash carryover; ▪ Choosing advanced combustion designs and emission-control technologies for the pollutant of concern; ▪ Having well-trained and certified employees that ensure that the combustor is operated to maximize combustion efficiency and that the emission control devices are operated to optimize conditions for pollutant capture or neutralization; ▪ Installation of well-designed and well-operated fine-particle of Air pollution Control device (APCD) such as filtration collectors, including primary fabric filters (baghouses); electrostatic collectors, including dry and wet electrostatic precipitators (ESPs) and

	▪ Concentrations of dioxins in air water and soil in the food chain to levels dangerous to human health	noncombustible matter in the flue gas, and the products of incomplete combustion existing in solid or aerosol form), inorganic ash present in the waste and carbonaceous soot formed in the combustion process.	ionizing wet scrubbers; and wet inertial-impaction collectors, including venturi scrubbers and advanced designs that use flux-force condensation-enhancement techniques; ▪ Optimize furnace operation, including temperature, oxygen concentration, and carbon monoxide concentration by optimizing grate speeds; under-fire and over-fire air-injection rates, locations, and directions; and operating auxiliary burners; ▪ Maintain a maximum gas flow-rate limit to ensure adequate residence time in the combustion chamber and proper operation of the air pollution control equipment; ▪ Optimize baghouse pressure drop, bag-break detection, wet-scrubber pressure drop, pH, and liquid-to-gas ratio; ▪ Quarterly stack emission assessment of the incinerator.
		▪ Acid Gases (flue-gas constituents that form acids when they combine with water vapor, condense, or dissolve in water. Acid gases include NO_x, SO_x, HCl, hydrogen bromide, hydrogen fluoride, and hydrogen iodide.	▪ Installation of acid gas scrubbers such as packed-bed absorber. The scrubbing liquid can be water or an alkaline solution, which reacts with the acid-gas constituents to form neutral salts; ▪ Furnace design and combustion process changes; ▪ Optimize flue-gas temperature in control devices (to minimize dioxin formation and to maximize condensation and capture of pollutants while avoiding gas dewpoint problems; ▪ Installation of stack-gas monitors.

		HCl and SO_2 are often present in uncontrolled flue-gas streams in concentrations ranging from several hundred to several thousand parts-per-million-by-volume)	
		▪ NOx	▪ Combustion-furnace designs, combustion-process modifications, or add-on controls such as ammonia or urea injection through selective or nonselective catalytic reduction.
		▪ Hydrochloric acid (HCl) and sulfur dioxide (SO_2), hydrogen bromide, hydrogen fluoride, and hydrogen iodide	▪ Installation of wet scrubbers, spray dryer absorbers, or (to a lesser extent) dry-sorbent injection and downstream bag filters.
		▪ Mercury	▪ Injecting activated carbon into the flue gas, or by passing the flue gas through a carbon sorbent bed, which adsorbs the trace gaseous constituents and mercury.
		▪ Lead (Pb) emissions	▪ Limiting the Pb content of the waste feed via source control (**Highly recommended**); ▪ Designing and operating the combustion process to minimize Pb vaporization; ▪ Designing and operating the primary combustion chamber to minimize fly-ash carryover; ▪ Using well-designed and properly operated APCDs,
		▪ Products of Incomplete Combustion	▪ The combustion chamber for incineration be designed to provide complete mixing of the gases evolved from burning of wastes in the presence of air and to provide adequate residence time of the gases;

		(PICs); free-radicals (molecular species possessing an unpaired electron) in the combustion unit sometimes do not combine with oxygen or hydroxyl radicals and instead combine among themselves to form many organic compounds (e.g., methane, ethane, acetylene, and benzene), dioxins and furans, partially oxidized organic compounds (e.g., acids and aldehydes), and polycyclic aromatic Shydrocarbons.	▪ Carbon removal through of finely divided activated carbon particles into the flue gas stream ahead of the particulate APCD; ▪ Systematic injection of granular or powdered activated carbon upstream in the incinerator to remove dioxins and furans. In general: ▪ Ensure that the incinerator is functioning properly, and the chimney is clear of excessive soot; ▪ Ensure that the incinerator is preheated adequately and that supplementary fuel is added whenever necessary to maintain the burning temperature above; ▪ Load the incinerator according to the recommended "Best Practices"; ▪ Adopt rigid quality control measures.

Impacts of solid waste including bottom ash, fly ash, scrubber water, and various miscellaneous waste streams and other residues such as lime and activated carbon, themselves with condensed or absorbed contaminants	▪ PotenStial impact on public health and safety	▪ Initial sorting of municipal-solid to remove stream of large items unsuitable for burning (such as whole refrigerators, gas stoves, and auto batteries); ▪ Knowledge of the intrinsic properties of the material, including the physical, chemical, and leaching properties by the incinerator operator; ▪ Solid waste to be handled managed and disposed according to the Environmental Management and Coordination (Waste Management) Regulations 2006; ▪ Proponent to contract a NEMA licensed waste collection company to be collecting all solid waste to and from the Incinerator; ▪ Only NEMA licensed vehicles to be used to collect and transport waste from the facility; ▪ Waste to be sorted at source; ▪ There should be no scattering of waste during transportation to the site.
Ash handling at the site	▪ Health risks including exposing the workers to a wide range of chemical poisoning, toxicity or long term health complications ▪ Safety of workers and the general public and the possibility that fugitive ash will escape into the environment during handling or removal of the ash for disposal	▪ The ash be contained at all times both inside and outside the facility; ▪ Use of water to quench the ash, simultaneously reducing dust generation and minimizing the possibility of ash-dust inhalation or ingestion by workers; ▪ Enclosed ash-handling systems throughout the incinerator.
Ash disposal	▪ Soil quality degradation that may result from deposition of pollutants from the plant operations or carried to other areas through surface runoff, ▪ Pollution of water sources through direct deposition, surface runoff and/or infiltration into groundwater aquifers	▪ Fly ash residues are to be transported and disposed of only after it has been solidified in the incinerator; ▪ Ash be handled and disposed in a secure hazardous-waste landfill that is designed to ensure that there will be no groundwater pollution; ▪ Regular testing of ash to determine its toxicity.

	▪ Health risks including exposing the workers to a wide range of chemical poisoning, toxicity or long term health complications ▪ Safety of workers and the general public and the possibility that fugitive ash will escape into the environment during handling or removal of the ash for disposal	
Scrubber waste disposal	▪ Soil quality degradation that may result from deposition of pollutants from the plant operations or carried to other areas through surface runoff, ▪ Pollution of water sources through direct deposition, surface runoff and/or infiltration into groundwater aquifers ▪ Health risks including exposing the workers to a wide range of chemical poisoning, toxicity or long term health complications	▪ Wet-scrubber wastewater be discharged to on-site wastewater-treatment system
Operational inefficiency leading to GHG emissions	▪ Altered natural concentrations of gases leading or contributing to unnatural warming of the earth. ▪ Dilution of Climate change mitigation and adaptation effort	▪ Screening incoming wastes at the plant to reduce incineration of wastes (such as batteries) that are non-combustible and are likely to produce pollutants when burned; ▪ Certification procedure for incinerator control-room operators; ▪ Emissions be reduced by modifying operating characteristics such as furnace temperature, air-injection rate, flue-gas temperature, reagent type, and injection rate, and by selecting optimal combustor designs and emission-control technologies;. ▪ Use and continued calibration and maintenance of continuous monitors of emissions and process characteristics provide real-time feedback and facilitate maintenance of optimal operating conditions at all times by incineration operators; ▪ Computerized continuous emission monitors (CEMs) for CO, O2, SOx, NOx, and HCl;

		▪ Survey furnace emission-control devices and related equipment regularly to ensure that they continue to be operative and properly sealed and insulated; ▪ Congregation from the heat exchange system.
Occupational hazards or injuries to works, visitors and general public	▪ Complete incapacitation of the affected employee or persons ▪ loss of life ▪ Increase in Costs of litigation and compensation ▪ Disruption of the plant operational activities	▪ Plant operators and worker training in hazardous-material management and annual refresher courses; ▪ All workers should be provided with protective gear. These include working safety boots, overalls, helmets, goggles, earmuffs, respirators/masks and gloves; ▪ A first aid kit should be provided within the site. This should be fully equipped at all times and should be managed by qualified person; ▪ Ensure qualified first aiders are in place and trained; ▪ The proponent should have workmen's compensation cover (WIBA). It should comply with workmen's compensation; ▪ Adequate sanitary facilities should be provided and standard cleanliness maintained; ▪ Safe operation procedures/ clear instruction provided to the workers and general public to ensure that safety is maintained; ▪ Workers operating within the high temperature zones should not exceed 2hrs continuous presence or/as may be directed by the Occupational Health and Safety Experts; ▪ Mounting of safety signage's within and outside the incinerator plant; ▪ Conducting risk assessments before the work commences to ensure that hazards are identified and eliminated before the work commences; ▪ Ensuring the workplace is registered under DOSHS; ▪ Undertaking statutory audits including health and safety and fire safety audits; ▪ Documenting the facility's Environmental Safety and Health policy, OHS and fire safety policies; ▪ Adequate sanitary facilities should be provided and standard cleanliness maintained.
Storm water generation and flooding at the site from precipitation	▪ Possible transportation of bottom ash, fly ash, scrubber water, and various miscellaneous waste streams and other residues such as lime and activated carbon, themselves with condensed or	▪ Appropriate site landscaping to be employed; ▪ Vegetation cover of all open area to reduce surface run off; ▪ Re-vegetation of all open areas to reduce surface run off; ▪ Have a proper drainage to channel the surface run off.

	absorbed contaminants to unintended natural environment. ▪ Disruption of the plant operational activities leading to economic losses	
Increased vehicular traffic	▪ Possible traffic congestion of local road causing occasional experience of delays; ▪ Pedestrians and cyclists using local roads will have to exercise more care with increase of vehicular traffic on the said roads; and ▪ There will be an increase of exhaust emission from vehicles delivering the combustible waste which will pollute local atmospheric air.	▪ All users of said roads to always observe traffic rules this will give pedestrians and cyclist their space and safety while using the road; ▪ Speed limits to be strictly observed; ▪ Motorist to be sensitised to use unleaded fuel as opposed to leaded fuel.
Social impacts	▪ Behavioural change such as alcoholism ▪ Emergence of new cultures ▪ STD and HIV AIDs ▪ Drug and substance abuse	▪ Awareness creation on topical issues among residents such as STD and AIDS, drug and substance abuse.
Conflict with the Community	▪ Stalled operation and losses to the proponent	▪ Continuous public participation and engagement for improving the environmental impact assessment and increasing total welfare of different interest groups in Kinanie and beyond; ▪ Pursuing economic achievements with regard to social, public health and environmental issues that are of concern to the locals; ▪ Independent Audits and strict supervision by NEMA, County Governments and other stakeholders.
Noise generation	▪ Deliveries of hazardous wastes, movement of hazardous materials from one point to another within the plant	▪ Machinery should be maintained regularly to reduce noise resulting from friction; ▪ There should not be unnecessary horning of the involved machinery; ▪ Maintain plant equipment; ▪ Audiometric tests to be carried out to workers exposed to noise by designated medical practitioner;

	and operations of the incineration equipment components.	▪ Workers in the vicinity of high-level noise to wear safety and protective gears.
Fire hazards	▪ Given that the facility will be disposing wastes by combustion, it should have the right category of firefighting equipment such as carbon and powder fire extinguishers as well as buckets of dry sand inside the facility too to help fight electric fires. ▪ Adequate fire safety measures to be provided.	▪ Provide adequate and standard firefighting equipment; ▪ The management should also ensure that contacts for emergency service providers are well displayed in and around the facility; ▪ Provide an emergency alarm system; ▪ The incinerator attendants should be trained by reputable firms; ▪ Undertake annual fire drills; ▪ Emergency fire evacuation procedures should be documented; ▪ Constitute and train a fire safety team; ▪ A dedicated emergency response team should be in place; ▪ Adhere to the fire risk reduction rules 2007.
DECOMMISSIONING PHASE		
Noise	▪ Reduced concentration of people in the neighbourhood ▪ Shouting during conversation among workers on site ▪ Noise induced hearing loss among workers who are continuously exposed to high noise levels ▪ reduction in productivity and efficiency of the workers at the workplace ▪ stressing the worker and thus reduced concentration	▪ Demolition works and other decommissioning activities to be limited to day time; ▪ Appropriate ear protective devices to be provided to workers working in noisy environment; ▪ Engineering controls on plant and equipment used in decommissioning to reduce noise; ▪ Noise control and hearing conservation programme to be developed; ▪ Audiometric tests to be carried out to workers exposed to noise by designated medical practitioner; ▪ Post notices and signs in noisy areas; ▪ Education and training for workers on importance and proper use of PPE; ▪ Appropriate acoustic barriers around areas generating noise to be provided; ▪ Noise attenuators such as trees on site to be preserved.
Dust	▪ skin irritation, chocking including coughing	▪ Appropriate personal protective equipment to be provided to all workers; ▪ Appropriate use of PPE provided to be enforced; ▪ The site to be secured with dust screens; ▪ Water sprinkling on dusty grounds to be done.
Occupational injuries	▪ Complete incapacitation of the affected employee	▪ Appropriate personal protective equipment such as safety belts for workers working at height to be provided;

	▪ loss of life ▪ Increase in Costs of litigation and compensation	▪ Proper use of PPE provided; ▪ Appropriate training of workers of ways of working safely; ▪ Appropriate supervision at workplace; ▪ Rest times to be strictly observed to reduce stress; ▪ Noise and dust and other factors can result in reduced concentration to a level of causing and accident to be appropriately mitigated.

6.5 Impact Matrix

The matrix was designed for the assessment of impacts associated with almost any type of project. It is a method of a checklist that incorporates qualitative information on cause-and-effect relationships but it is also useful for communicating results. Matrix method incorporates a list of impacting activities and their likely environmental impacts, presented in a matrix format. Combining these lists as horizontal and vertical axes in the matrix allows the identification of cause effect relationships, if any, between specific activities and impacts. The impact matrix for the actions is identified in Table 6.8 along with various environmental parameters. A rating scale has been devised to give severity of impacts in the following manner:

A. **Beneficial (positive) impact – Long term**
B. **Low beneficial impact – Short term**
C. **Strong adverse (negative) impact – Long term**
D. **Low adverse impact (localized in nature) – Short term**
E. **No impacts on environment**

Table 6-9: Summary of risk analysis of project's impacts

SN.	Activity	Positive Impact		Negative Impact		No impact
		Short term	Long term	Short term	Long term	
Pre-Project Activity						
1	Displacement and resettlement of local people					√
2	Employment for local people	√				
3	Change in land use				√	
4	Loss of trees/vegetation				√	
5	Shifting of equipment		√			
Civil works and installation Phase						
1	Pressure on infrastructure and social amenities			√		
2	Transportation system dust generation			√		
3	Noise Pollution			√		
4	Traffic					√
5	Impact on the land/soil/environment			√		
6	Impact on groundwater					√
7	Stacking and disposal of construction/installation material			√		
8	Impact on water quality			√		
9	Health and safety conditions of people			√		
10	Social impact	√				
11	Economic impact	√				
Operation Phase						
1	Increase in air pollution and noise levels				√	
2	Water harvesting and recharge		√			
3	Disposal of ash waste				√	
4	Quality of life		√			
5	Handling operations for hazardous waste transfer				√	
6	Community/workplace transmission			√		

6.6 Summary of Environment Impacts and Mitigation Measures

Table 6-10: Summary Environmental Impacts and their mitigation measures

Activity	Environmental Attributes	Causes	Impact Characteristics			
			Nature	**Duration**	**Reversibility**	**Significance & Mitigation measures**
Transportation of incinerator installation equipment and materials	Air quality	Transportation of construction material in trucks & exhaust emission from vehicles	Direct Negative	Short term	Reversible	Medium, Regular emission checks will be performed.
	Noise levels Noise generation	Noise generation from vehicles	Direct Negative	Short term	Reversible	Insignificant, if regular vehicle maintenance is done.
	Risk	Risk of accidents during transit	Direct Negative	Short term	Irreversible	Insignificant, if safety measures are taken to prevent accidents
Civil works	Air quality (SPM & RPM)	Operation of installation machinery, welding & others	Direct Negative	Short term	Reversible	Insignificant, if regular water sprinkling can be done
	Noise levels Noise generation	Operation of installation Construction machinery, welding & others	Direct Negative	Short term	Reversible	Insignificant, if properly maintained equipment can be used and PPEs to be provided to workers
	Land use	Setting up of project	Direct Negative	Short term	Reversible	Excavated material be stored for future use
	Ecology	Loss of vegetation	Direct Negative	Short term	Reversible	Insignificant, No cutting of trees and green belt Development is envisaged
Handling & Transportation	Air	Transportation of raw materials to the Site (Dust Emission)	Direct Negative	Short term	Irreversible	The covered dumper and trained transporter /driver will be engaged for the transportation of the incinerator materials.

of incinerator materials	Air	The raw material is emptied to the Raw material storage yard. While unloading there is dust emission released into the atmosphere (Dust Emission).	Direct Negative	Long term	Reversible	The unloading will be done in covered area. More over there will be water sprinkling system. So that minimum dust emission will occur. The Impact will be insignificant. Besides, the management will also ensure proper usage of the personal protective equipment by the workers to avoid any exposure to dust.
Operation of the incinerator and associated two chambers	Air quality	Dust emission from Stack, Fugitive emission	Direct Negative	Long term	Reversible	Stack will be provided with appropriate APC system so, the impact will be insignificant. If no APC system is installed there will be high impact.
Waste water discharge	water	Only Domestic waste water	Direct Negative	Long term	Reversible	There will be discharge of domestic waste water which will be connected to the EPZ Sewerline so this will not cause any impact on the water environment of the area.
Green Belt	Air	Dispersion of Air emission from stationary sources along with Fugitive emission	Positive	Long term	Reversible	Very High positive Impact due to development of a proper green belt along the periphery of the premises
Rain Water Harvesting from the office structures within premise	Water	Minimization of fresh water	positive	Long term	Reversible	Because of the RWH system, requirement if fresh water can be minimized
Employment	Socio Economic	Direct & Indirect Employment	Direct positive	Long term	Reversible	Positive Impact due to hiring of manpower from the Kinanie area. Substantial benefits in the form of contracts to local agencies for different services. Employment generation in transport sector as several local conveyance trips and trucks loadings will be handled every day.

Table 6-11: Overall matrix

Environmental Impact	No effect	Positive effect	Negative effect	Beneficial	Adverse	Problematic	Short term	Long term	Reversible	Irreversible
Environmental Area	√									
Soil characteristics									√	
Natural drainage	√									
Conformity to regional plans	√									
Air quality			√					√	√	
Ground water	√									
Surface water									√	
Noise			√					√	√	
Wild life	√									
Endangered species	√									
Natural vegetation		√						√		
Exotic vegetation		√						√		
Demography	√									
Recreation	√									
Health and safety		√		√				√		
Regional economy		√						√		
National economy		√						√		
Public facility				√						
Public services		√						√		
Transportation			√				√		√	

7 CHAPTER SEVEN: PROJECT ALTERNATIVES AND PROPOSED ACTION

7.1 Analysis of Alternative Sites

In compliance with the requirements of the Environmental Management and Coordination Act, Cap 387, and the Environmental (Impact Assessment and Audit) Regulations, 2003, as revised in 2019, this Environmental Impact Assessment (EIA) study report examines the proposed development involving the establishment of an incinerator and associated auxiliary facilities. A critical component of the EIA process involves the analysis of project alternatives. This section outlines the considerations, evaluations, and conclusions pertaining to viable alternative options to the proposed development. Selection of suitable site for a project is as important as selecting a technology. Factors which are taken into account for selection of site are proximity to raw materials or market and availability of manpower, water, infrastructure and ease of transportation.

However a new dimension has also raised concerns in selection of site and that is environment. Factors taken into consideration while selecting the site:

- Availability of land
- Proximity to the nearest settlement
- Connectivity
- Overall impact on environment
- Availability of water and power
- Other infrastructure

7.2 Purpose of Analyzing Project Alternatives:

The objective of evaluating project alternatives is to explore various feasible options for achieving the project's intended objectives while minimizing adverse environmental and social impacts. This analysis is essential for informed decision-making, ensuring that the most suitable and environmentally responsible approach is selected.

7.3 Methodology

The analysis of project alternatives was carried out through a comprehensive and systematic process that involved the following steps:

i. **Identification of Alternatives:** A range of feasible alternatives to the proposed incinerator development was identified. These alternatives encompassed different technologies, siting options, waste management methods, and associated facilities.

ii. **Criteria for Evaluation:** A set of criteria were established to evaluate the alternatives. These criteria included environmental impact, social implications, technical feasibility, economic viability, and alignment with national and regional waste management policies.

iii. **Qualitative and Quantitative Assessment:** Each alternative was subjected to qualitative and, where applicable, quantitative assessment. This involved considering potential benefits, risks, environmental outcomes, public health considerations, and overall project feasibility.

7.4 Analysis of Project Alternatives Statements:

i. **Status Quo (No-Action Alternative):** The "no-action" alternative involves maintaining the current waste management practices without establishing the proposed incinerator. While this option avoids potential new impacts, it does not address the need for efficient and environmentally sound hazardous waste management. Consequently, it fails to meet the goals of sustainable waste management.

ii. **Location:** The project is proposed within an EPZ, which is an industrial zone. Hence, sufficient infrastructure exists and lesser resources are required to be deployed for modernization as infrastructure. Since, installation and operation of the incinerator infrastructure does not affect the people in any way or other types of industries, no other site was considered.

iii. **Landfill Expansion:** Expanding existing landfill facilities emerged as an alternative option. However, this approach poses significant environmental and public health risks, including potential groundwater contamination, greenhouse gas emissions, and land use conflicts.

iv. **Exporting Waste:** Exporting hazardous waste to neighboring regions or countries was examined. This approach poses logistical challenges, increased transportation emissions, and potential social and ethical concerns related to waste export.

v. **Advanced Treatment Technologies:** Exploring cutting-edge waste treatment technologies, such as plasma gasification, was considered. While these technologies offer potential benefits, their high costs, technical complexities, and unproven effectiveness for certain waste types rendered them less viable.

7.5 Zero option

Under this alternative, there would be no incinerator project to be implemented on this site; this would mean that there would be no positive impacts to be achieved from the project and at the same time, no negative impacts to be noted.

Advantages:

- No possible emission of flue gases, fly ash, bottom ash, PIC etc. from the facility.
- There would be no strain on the existing infrastructures and facilities.

Disadvantages:

- Loss of revenue to the proponent: The installation of an incinerator is an expensive process.
- The existing poor disposal of biomedical waste will not improve in the area thus more health complications
- The land would remain un-utilized thus no economic value would be achieved.

7.6 Alternative option for biomedical/hazardous waste Management

Under this alternative, adoption of incinerator was compared to landfill and the following is concluded

- Incinerator will be able to decrease the quantity of waste by 95% and reduce the solid quantity of the original waste by 80-85% depending on the components that were in solid waste. Hence, even though incinerator will not completely get rid of dumping ground, it definitely decrease the quantity of land needed.
- Research has shown that solid waste incinerators are less likely to pollute the environment than landfills do. One particular study done during a 1994 lawsuit in the US showed that a waste incinerator location was more environment-friendly compared to a landfill. The research

discovered that the landfill was releasing higher quantities of greenhouse gases, nitrogen oxides, dioxin, hydrocarbons, and non-methane organic compounds. Landfills also leach poisonous chemicals into the water below thus contaminating underground water systems.

- Incinerator will function at very high temperatures that can destroy germs and chemicals that are harmful. Thus, it is a very effective method when it comes to eliminating clinical waste.
- Incinerator is able to provide less bad smells because waste gets burnt, unlike landfills where waste is allowed to decay thereby emitting unpleasant smells, which cause air pollution. The production of methane in landfills may also lead to explosions that cause noise pollution, which is unheard-of when it comes to the use of incinerator.
- In landfills, when the waste is decaying methane gas is generated which if not controlled, may explode causing further global warming. Unlike landfills, incinerator will not produce methane, therefore making it safer.
- Another advantage of incinerator is it can function in any type of weather. For instance, during a rainy season, waste cannot be dumped in a landfill because the rain will possibly wash down poisonous chemicals into the ground and consequently create leachate thus contaminating the underground water as well as the neighboring land. Waste can also not be dumped when it is windy since it will get blown into the surroundings. On the other hand, incinerators are not limited to weather changes since they burn waste without leakages. Incinerator will also function 24 hours a day and are more efficient in managing waste compared to landfills.

7.7 Conclusions

Upon thorough evaluation, it is evident that the proposed development of the incinerator and auxiliary facilities represents the most suitable and environmentally responsible approach. The alternative options either failed to adequately address hazardous waste management needs or presented significant drawbacks in terms of environmental impact, feasibility, and long-term sustainability.

The analysis of project alternatives reaffirms that the proposed incinerator project is aligned with the principles of efficient waste management, environmental conservation, and public health protection. This alternative was selected based on its potential to significantly reduce waste volume, minimize hazardous emissions through advanced scrubber technology, and contribute to sustainable waste management practices in line with national goals.

In summary, after careful consideration and rigorous evaluation, the proposed incinerator and associated auxiliary facilities emerge as the optimal choice among the alternatives examined. This conclusion is founded on the project's potential to effectively address biomedical/hazardous waste management while mitigating adverse environmental and social impacts. The option was best as compared to other options like co-location, open dumping or burning. Advantages of this option:

- Minimal disputes: Since the site would be solely operated by the proponent; there would be few or no disputes as in case with other options like co-location.
- The company can have more additional installation on the same site.
- The combustion capacity of the incinerator will be higher than in any other option.

Disadvantages

Cost and Time frame: The process is slightly longer and costly since there are many phases involved from site acquisition, construction to operation.

8 CHAPTER EIGHT: OCCUPATIONAL SAFETY AND HEALTH

8.1 Introduction

Occupational Safety and Health (OSH) is of paramount importance in any industrial project. The occupational environment directly affects employees, neighbourhood, visitors, contractors, sub-contractors and the general public. Plenser Waste Management Limited is therefore responsible for the following: -

- Implementation of appropriate national and internal recognized OSH standards, codes and guidelines;
- Inclusion of meaningful participation of employees in implementation and maintenance of procedures and processes;
- Implementation of a programme to change employee culture and altitudes regarding health and safety;
- Planning, implementing and monitoring programs and systems required to ensure OHS at the workplace;
- Provide and maintain workplaces, plant, equipment, tools and machinery and organize work so as to eliminate or control hazardous ambient work factors;
- Provide appropriate occupational health and safety training for all employees;
- Provide adequate personal protective gear/ clothing to all employees at no cost to employees;
- Record and report occupational injuries and illness;
- Ensure contract specifications include demands for service providers, contractors, and sub-contractors to have or establish systems enabling them to meet the OHS requirements of the employer.

8.2 Occupational Health and Safety Management System

An Occupational Health and Safety Management System (OHSMS) must be established, managed and operated for the project. The system must contain the following features:

i. Occupational health and safety policy;
ii. Organizational framework of the OHSMS;
    - Staffing of OHSMS
    - Competence requirements;
    - Operating procedures;
    - Training programs;
    - System documentation;
    - Communication
iii. OHSMS objective (documentation)
iv. Hazard prevention
    - Risk assessment;
    - Prevention and control measures (active and negative);
    - Management of changes;
    - Emergency preparedness and response;
    - Procurement (tools, equipment, plant, services, contractors).

v. Performance monitoring and measurements
   - Hazard prevention measures;
   - Ambient working environment;
   - Work related injuries, ill health, disease and injuries;

vi. Evaluation
   - Feedback;
   - Corrective measures;
   - Action plan.

8.3 Physical factors in the work place

Five physical factors in the work place are of importance. These are; -

- Installations, equipment, tools and substance;
- Access;
- Signage;
- First-aid;
- Personal protective equipment; and

8.3.1 Installations, equipment, tools and substances

The following must be ensured:

a) Installations, equipment, tools and substances selected to be suitable for the intended incinerator operation should be selected to minimize dangers to safety and health when appropriately used;
b) Equipment to be provided with adequate noise and vibration dumpers;
c) Ergonomic risks and hazards shall be minimized by selecting appropriate tools and equipment for use.

8.3.2 Access

a) Equipment and installations requiring recurrent servicing and cleaning should have permanent means of access;
b) Hand, knee and foot railings must be installed on stairs, fixed ladders, platforms, permanent and interim floor openings, loading bays ramps;
c) Measures to prevent access to unauthorized areas must be in place.

8.3.3 Signage

i. Hazardous and risky areas, installations materials, safety measures, emergency exits shall be properly marked;
ii. Signage shall be according to national and international standards, well known to, and easily understood by workers, visitors and general public.

8.3.4 First-Aid

- Employer to ensure qualified first aid is provided to employees at all times;

- Eye-wash stations and/or emergency showers shall be provided close to the site where the recommended first-aid response is immediate flushing with water;
- First Aid stations to be equipped with gloves, gowns and masks for protection against direct contact with blood and other body fluids;
- Written emergency procedure to be in place.

8.3.5 Personal protective equipment

- Plenser Waste Management Limited to identify and provide appropriate Personal Protective Equipment (PPE) that will offer adequate protection to the worker, co-workers, and occasional visitors without incurring unnecessary inconveniences;
- Plenser Waste Management Limited td to actively enforce use of PPE and ensure PPE is cleaned when dirty, properly maintained and replaced when damaged or worn out;
- Proper use of PPE to be part of recurrent training programmes for employees;

9 CHAPTER NINE: ENVIRONMENTAL AND SOCIAL MANAGEMENT MONITORING PLAN (ESMMP)

9.1 Introduction

This section presents a basic guideline in form of Environmental and Social Management Monitoring Plan (ESMP) that includes the set of institutional and mitigation measures and monitoring targets to: a) prevent, mitigate, repair and/or compensate adverse environmental and social impacts caused by civil works, installation and operation of the incinerator and associated equipment; and b) improve and strengthen the quality of the incinerator operation under environmental risk.

The implementation of the ESMMP is fundamental to assure the protection of the environment, including both the aspects that have to do with the integrity of the natural environment and those that assure a suitable quality of life for the potentially affected persons. The ESMMP includes the actions necessary to put these measures into practice. The activities are scheduled for the work's lifespan, reason why the programs required for the good management of the environmental and social system will be incorporated, both in the installation stage and in operation and maintenance. The ESMMP also includes a summary of criteria and environmental measures that must be included in the design of the works, whose function is to prevent and reduce potential adverse impacts on natural and anthropic ecosystems. On the other hand, it is possible to indicate that the plan and measures offered for the operation and maintenance phase of these works, will be implemented within the framework of the Environmental and Social Management Plan developed. Adequate environmental and social management contributes to the works performance and the reduction of carbon footprints, minimizing unexpected events, attenuating future conflicts and concurring to the articulation of the work and the environment and social, within the framework of a comprehensive use (integrated management).

The ESMMP contains information about i) the institutional framework and general guidelines for environmental and social management of the work; ii) the measures proposed to prevent, mitigate, remedy and compensate adverse impacts for complementary works; iii) monitoring plans; iv) programming and costs. In addition, it has presented a series of basic recommendations. The ESMMP is generally prepared to ensure that the components of the proposed development are operated in accordance with the approved environmental design. If the environmental management strategies discussed in the ESMMP are fully implemented, the adverse impacts of the project would be reduced, and there will be an overall improvement in physical, chemical, biological and socio-economic environment of the project and Kinanie area.

9.2 Environmental Inspection and monitoring

9.2.1 Inspections

Inspections typically are conducted to determine whether the project operations and related activities are being directed in compliance with applicable regulations, project commitments and specifications, disposal plans and/or permit conditions. For such a high risk project, a formalized environmental inspection program may be mandated by conditions attached to permits or governmental agencies including:

- Air quality management and pollution control;
- Hazardous Solid Waste Management Plan for protection of soil, surface and underground water;
- Occupational Hazards Management Plan;
- Storm water management plan
- Social impacts.

9.2.2 Source of inspection requirements

Inspections are conducted to verify that a project is being constructed in compliance with applicable regulatory requirements and contract/subcontract specifications. Sources of environmental inspection requirements include project permits and other regulatory agency approvals, environmental regulations and other project plans.

All sources of environmental compliance requirements must be reviewed to identify inspection requirements that will be included in the EIA license. Examples of project activities that may require inspection include, but are not limited to:

- Transportation, Storage and handling of hazardous/waste
- Stack emissions standards.
- Installation and maintenance of flood control structures within site.
- Risk mitigation implementation.

9.2.3 Documentation and record keeping

Environmental inspections will be documented and records retained in project files. Examples of documentation are telephone conversation logs, written correspondence, inspection logs and inspection reports. The inspector must develop an appropriate field inspection checklists, forms or other documentation. Checklists and forms generally will contain the following:

- Date and time
- Location
- Activity being inspected
- Inspector's observations and relevant data
- Need, if any, for corrective action
- Name, title and signature of inspector

Monitoring requirements are often identified in project permits or approvals, or as a component of environmental mitigation and resource protection plans that a project is required to prepare and agencies must approve.

9.2.4 Sources of monitoring requirements and parameters

Monitoring requirements are typically specified in environmental analysis documents and project permits and approvals. Agency required resource protection plans or mitigation plans could also be a source of monitoring requirements. Monitoring of resources is often required where specific development plans or resource information was not available during the permitting process, and therefore, impacts to a resource could not be determined. All sources of environmental compliance requirements must be

reviewed to identify any monitoring requirements and incorporated into the EIA license. Examples of parameters that will require monitoring activity include, but are not limited to:

- Air quality or air emissions
- Ash handling and disposal
- Biological resources
- Site flooding control structures

9.2.5 Management tools

Data management tools will be developed by the proponent to address project-specific monitoring and documentation requirements. The project's monitoring requirements, such management tools will include matrices or computerized databases, schedules and maps annotated with monitoring requirements and information.

Matrices and databases-Development of a matrix that identifies all agency-specified monitoring requirements will be helpful in planning, executing, documenting and reporting monitoring activities. Identification of monitoring requirements by resource, the nature of each requirement, special technical expertise required, waste incineration activity, monitoring location, and type of documentation will provide adequate record of compliance and any agency reporting requirements can be incorporated.

9.2.6 Regulatory reporting requirements

Plenser Waste Management Limited will undertake routine regulatory reporting to NEMA, Public Health, Machakos County Government, Kinanie and Athi-River Community leaders etc. on the progress and monitoring parameters within specified timeframes and so that appropriate documentation and information can be collected to satisfy requirements.

9.3 Significance of an ESMMP

ESMMP for the proposed development is to provide a logical framework within which identified negative environmental impacts can be mitigated and monitored. In addition, the ESMMP assigns responsibilities of actions of various actors and provides a timeframe within which mitigation measures and monitoring can be done. The ESMMP is a vital output of an Environmental Impact Assessment as it provides a checklist for project monitoring and evaluation for sound environmental planning at entire life of the project.

There will be a need to entrench within the working operations of the proposed project a sound ESMMP that will ensure no significant environmental pollution occurs as a result of the proposed activity. To achieve this, the following will need to be done: -

- Plenser Waste Management Limited centre to develop and document Environmental Management Policies that will guide incinerator operation activities. The policies should address environmental conservation measures to be put in place, occupational and safety matters of all users;
- Availing of necessary finance for implementation of ESMMP; and

- Plenser Waste Management Limited and its contractors to ensure that they carry out their work within Environmental and Occupational, Health and Safety requirements.

9.4 Monitoring Plans

This ESMMP covers the following key management (monitoring) plans which will need to be implemented and are covered in the ESMMP. The Management covers the following component: -

- Air quality management
- Solid Waste Management Plan including ash waste;
- Risk Management Plan;
- Occupational Hazards Management Plan;
- Site flooding management plan

9.5 ESMMP Implementation

This ESMMP implementation will be overseen by Plenser Waste Management Limited. However other institutions like NEMA, may undertake their own environmental management actions.

9.5.1 NEMA

NEMA is the oversight institution over the environment in Kenya. Its role will be of monitoring compliance to the environmental indicators as identified in this ESMMP. The role of NEMA will be:

- Oversight Monitoring; as the lead agency responsible for the protection of environment in Kenya; NEMA will play the leading oversight role of monitoring the activities of the project according to the EMCA 2015 and the EIA/EA Regulations.
- Site Inspection Visits; NEMA will undertake site visits to inspect and verify for themselves the nature and extent of the impacts and if the mitigation measures proposed in this EMMP are being complied with or vice versa.

9.5.2 Plenser Waste Management Limited as a licensed operator

Plenser Waste Management Limited will undertake monitoring of the activities to ensure internal compliance is achieved. The inspection and monitoring will be undertaken by the project management team under proponent and will occur during incineration process. The team will endeavour to ensure that all the mitigation measures highlighted in the ESMMP are being followed. They will produce an internal compliance inspection report that will be shared with NEMA if required.

Table 9-1: Summary of Environmental and Social Management Monitoring Plan

SITE PREPARATION, CONSTRUCTION AND INSTALLATION PHASE					
CONCERN	**POTENTIAL NEGATIVE IMPACTS**	**PROPOSED MITIGATION MEASURES**	**MONITORING ASPECT**	**RESPONSIBILITY**	**COST (KSHS)**
Dust disturbances	▪ Eye irritation; ▪ Skin irritation; ▪ Impairment of normal sweating of the skin as it blocks pores on the skin; ▪ Chocking of the throat; ▪ Respiratory difficulties; ▪ Difficulty in breathing; ▪ Potential course of chest complication and ailment	▪ Employees involved in the construction/installation work to be provided with dust masks; ▪ Project management and contractor to enforce strict use of personal protective clothing; ▪ Complains of dust related aliments among employees given access to medical attention. ▪ Sprinkle water on site.	▪ Complete PPE for workers ▪ Medical examination report ▪ Audiometric tests for noise impacts	▪ Proponent ▪ NEMA Inspectors ▪ DOSHS	20,000 for PPE
Noise disturbances	▪ Reduced concentration of people ▪ Shouting during conversation among workers on site ▪ Noise induced hearing loss among workers who are continuously exposed to high noise levels ▪ reduction in productivity and efficiency of the workers at the workplace ▪ Stressing the worker and thus reduced concentration.	▪ Contractor to ensure strict enforcement on user of ear protectors; ▪ Where applicable and possible exceptionally noisy machines to be fitted with noise reduction devices; ▪ Any employee who may complain about ear related pain and or complication while at work to access medical attention at the expense of the contractor or project proponent; ▪ Regular maintenance of construction plants and equipment; ▪ There should not be unnecessary horning of the involved machinery; ▪ Provision of billboards at the construction site notifying of the construction activity and timings; ▪ Sensitize drivers of construction machinery on effects of noise; ▪ Provide barriers such as walls around site boundaries to provide some buffer against noise propagation;			20,000 for PPE and Audiometric tests

		▪ The proponent should comply with the Environmental Management and Coordination (Noise and Excessive Vibration Pollution) (Control) Regulations, 2009.			
Solid waste	▪ Cause visual pollution making such areas unsightly. ▪ Poorly managed and disposed cement bagging waste can attract dieses vectors	▪ Solid waste to be handled, managed and disposed according to the waste management regulations; ▪ Waste handling bins to be provided for workers onsite, each bin should have a lid which should always be covered; ▪ Colour code to be used to distinguish waste bins of different waste; ▪ Solid waste to be disposed only at licensed disposal sites; ▪ In a case of cement bagging, they can be stored recycled or put into different usage.	▪ Records of collection and disposal ▪ Waste collection equipment such as bins	▪ Proponent ▪ NEMA ▪ Employees	▪ 50,000 for solid waste management during construction and installation of the plant
Occupational injuries	▪ Complete incapacitation of the affected employee ▪ Loss of life ▪ Increase in Costs of litigation and compensation	▪ Appropriate personal protective equipment such as safety belts for workers working at height to be provided. ▪ Proper use of PPE provided. ▪ Appropriate training of workers of ways of working safely. ▪ Appropriate supervision at workplace. ▪ Rest times to be strictly observed to reduce stress. ▪ Noise and dust and other factors can result in reduced concentration to a level of causing and accident to be appropriately mitigated.	Safety methods and procedures instituted Incidents report Staff welfare programs like WIBA OSHA Audit reports Safety committee instituted	NEMA inspectors NEMA Inspectors DOSHS	100,000 for staff occupation training 100,000 for OSHA Audits
Generation of wastewater	Pollution of underground and surface water	▪ Provision of means for handling sewage generated by construction workers such as mobile toilets. ▪ Conduct regular checks for sewage pipe blockages or damages since such vices can lead to release of the effluent into the land and water bodies ▪ Monitor effluent quality regularly to ensure that the stipulated discharge rules and standards are not violated	Regular monitoring	Mechanical Engineer & Project Manager	50,000 per quarter for management of waste waster

Increased demand on water and energy resources	Strain on existing infrastructure	▪ Avoid wasting the water supplied to the site; ▪ Encourage water reuse/recycling during both construction; ▪ Encourage proper water management systems; ▪ All Plant equipment and electrical appliances should be switched off when not in use. ▪ Explore the use of solar and wind energy especially for site security lighting during the night; ▪ Create awareness among workers by use of stickers on the need to conserve energy.	Regular monitoring	Contractor & Project Manager Employees	Internal Cost
Exhaust emissions	Vehicular/equipment engine exhaust emissions are a potential source of impacts to air quality.	▪ Discourage idling of vehicles i.e., vehicle and equipment will be turned off when not in direct use to reduce exhaust emissions; ▪ Discourage idling of vehicles i.e. vehicle and equipment engines will be turned off when not in direct use to reduce exhaust emissions; ▪ Regular maintenance of construction plant and equipment.	Equipment maintenance records	Project contractor and Drivers	100,000 for equipment maintenance per month
Soil erosion	During site clearing and excavation	▪ Avoid unnecessary movement of soil materials from the site; ▪ Provide soil conservation structures on the areas prone to soil erosion mostly to reduce impact by the run-off; ▪ Control construction activities especially during rainy conditions; ▪ Re-surface open areas after completion of the project and introduce appropriate vegetation; ▪ Provide suitable storm water drainage channels to effectively discharge water to safe areas;	Regular monitoring	Contractor and Proponent	200,000 per quarter

		▪ Channels need to be regularly maintained and repaired to avoid point discharge in case of breakages or blockages; ▪ Conduct landscaping after the project completion to maximally control any possible chance of soil movement.			
Storm water drainage	Poor design of drainage channels	▪ The design of the drainage system should ensure that surface flow is drained suitably into the public drains provided to control flooding within the site; ▪ Drainage channels should be installed in all areas that generate or receive surface water such as car parking, drive ways and along the building block-edges of the roofs; ▪ Channels should be covered by approved materials to prevent occurrence of accidents and entry of dirt that would compromise flow of run-off; ▪ Drainage channels should ensure safe disposal of run-off/surface water and should be self-cleaning; ▪ Paving of the sideways, driveways and other open area should be done using pervious materials to encourage recharge and thus reducing water runoff volume.	Regular Monitoring	Contractor	250,000 one off

OPERATIONAL PHASE						
ENVIRONMENTAL CONCERN	**POTENTIAL NEGATIVE IMPACTS**		**PROPOSED MITIGATION MEASURES**	**MONITORING ASPECT**	**RESPONSIBILITY**	**COST (KSHS)**
Air pollution (emission of toxic pollutants, heavy metals, and combustion products) **S**	▪ Health hazards such as bronchial infections, skin problems, etc. for employees and public ▪ Leads to concentrations of dioxins in air water and soil in the food chain to levels dangerous to human health	CO_2, water vapor, and ash, which are respectively oxidation-reaction products of carbon, and hydrogen, and non-combustible materials in the fuel. Particulate Matter (entrained noncombustible matter in the flue gas, and the products of incomplete combustion existing in solid or aerosol form), inorganic ash present in the waste and carbonaceous soot formed in the combustion process.	▪ Screening incoming wastes at the plant to reduce incineration of wastes (such as batteries) that are non-combustible and are likely to produce pollutants when burned. ▪ Installation of electrostatic precipitators, fabric filters, or wet inertial scrubbers for particulate matter control. ▪ Limiting the ash content of the waste feed via source control or selection. ▪ Optimize voltage and other electric conditions of an ESP (to maximize capture of particles) ▪ Designing and operating the primary combustion chamber to minimize fly-ash carryover. ▪ Choosing advanced combustion designs and emission-control technologies for the pollutant of concern ▪ Having well-trained and certified employees that ensure that the combustor is operated to maximize combustion efficiency and that the emission control devices are operated to optimize conditions for pollutant capture or neutralization ▪ Installation of well-designed and well-operated fine-particle of Air pollution Control device (APCD) such as filtration collectors, including primary fabric filters (baghouses); electrostatic collectors, including dry and wet electrostatic precipitators (ESPs) and ionizing wet scrubbers; and wet inertial-impaction collectors, including	▪ Stack emission assessment reports ▪ Kinanie community feedbacks ▪ Presence of pollution control devices. ▪ Direct observation of particulate matter.	NEMA inspectors NEMA Experts DOSHS DOSHS advisors Kinanie Community Combustion Experts	1,000,000 for investment in proper air quality device 50,000 quarterly for stack emission report 250,000 for combustion design experts

			venturi scrubbers and advanced designs that use flux-force condensation-enhancement techniques. ▪ Optimize furnace operation, including temperature, oxygen concentration, and carbon monoxide concentration by optimizing grate speeds; under-fire and over-fire air-injection rates, locations, and directions; and operating auxiliary burners. ▪ Maintain a maximum gas flow-rate limit to ensure adequate residence time in the combustion chamber and proper operation of the air pollution control equipment. ▪ Optimize baghouse pressure drop, bag-break detection, wet-scrubber pressure drop, pH, and liquid-to-gas ratio.			
		Acid Gases (flue-gas constituents that form acids when they combine with water vapor, condense, or dissolve in water. Acid gases include NO_x, SO_x, HCl, hydrogen bromide, hydrogen fluoride, and hydrogen iodide. HCl and SO_2 are often present in uncontrolled flue-gas streams in	▪ Installation acid gas scrubbers such as packed-bed absorber. The scrubbing liquid can be water or an alkaline solution, which reacts with the acid-gas constituents to form neutral salts. ▪ Furnace design and combustion process changes ▪ Optimize flue-gas temperature in control devices (to minimize dioxin formation and to maximize condensation and capture of pollutants while avoiding gas dewpoint problems. ▪ Installation of stack-gas monitors	▪ Stack emission assessment reports ▪ Kinanie community feedbacks ▪ Presence of pollution control devices	NEMA inspectors DOSHS Kinanie Community Combustion Experts	1,000,000 for investment in proper air quality device 50,000 quarterly for stack emission report 250,000 for combustion design experts

		concentrations ranging from several hundred to several thousand parts-per-million-by-volume)				
		NOx	▪ Combustion-furnace designs, combustion-process modifications, or add-on controls such as ammonia or urea injection through selective or nonselective catalytic reduction.			
		Hydrochloric acid (HCl) and sulfur dioxide (SO_2), hydrogen bromide, hydrogen fluoride, and hydrogen iodide	▪ Installation of wet scrubbers, spray dryer absorbers, or (to a lesser extent) dry-sorbent injection and downstream bag filters.			
		Mercury	▪ Injecting activated carbon into the flue gas, or by passing the flue gas through a carbon sorbent bed, which adsorbs the trace gaseous constituents and mercury.			
		Lead (Pb) emissions	▪ Limiting the Pb content of the waste feed via source control (**Highly recommended**) ▪ Designing and operating the combustion process to minimize Pb vaporization. ▪ Designing and operating the primary combustion chamber to minimize fly-ash carryover. ▪ Using well-designed and properly operated APCDs			
		Products of Incomplete Combustion (PICs); free-radicals	▪ The combustion chamber for incineration be designed to provide complete mixing of the gases evolved from burning of wastes in the presence of air and to provide adequate residence time of the gases			

		(molecular species possessing an unpaired electron) in the combustion unit sometimes do not combine with oxygen or hydroxyl radicals and instead combine among themselves to form many organic compounds (e.g., methane, ethane, acetylene, and benzene), dioxins and furans, partially oxidized organic compounds (e.g., acids and aldehydes), and polycyclic aromatic hydrocarbons.	▪ Carbon removal through of finely divided activated carbon particles into the flue gas stream ahead of the particulate APCD. ▪ Systematic injection of granular or powdered activated carbon upstream in the incinerator to remove dioxins and furans.			
Hazardous/infectious solid wastes	▪ Potential impact on employees, public health and safety		▪ Use of hazardous bags/ liners in handling the waste ▪ Hazardous waste to be handled managed and disposed according to the Environmental Management and Coordination (Waste Management) Regulations 2006.	▪ Solid waste tracking reports ▪ Kinanie community feedbacks ▪ NEMA registration	NEMA inspectors County Government of Machakos Kinanie Community The proponent	1,000,000 annually for sustainable waste management

		▪ Use of NEMA licensed waste dealer to be the collecting all waste from the points of generation; ▪ Only NEMA licensed vehicles to be used to collect and transport waste to the facility. ▪ There should be no scattering of waste during transportation to and from disposal site;	for waste handlers		
Ash handling at the site (bottom ash, fly ash, miscellaneous waste streams and other residues like such as lime and activated carbon) and disposal	▪ Health risks including exposing the workers and general public to a wide range of chemical poisoning, toxicity or long term health complications ▪ Soil quality degradation that may result from deposition of pollutants from the plant operations or carried to other areas through surface runoff, ▪ Pollution of water sources through direct deposition, surface runoff and/or infiltration into groundwater aquifers ▪ Health risks including exposing the workers to a wide range of chemical poisoning, toxicity or long term health complications.	▪ The ash be contained at all times both inside and outside the facility. ▪ Use of water to quench the ash, simultaneously reducing dust generation and minimizing the possibility of ash-dust inhalation or ingestion by workers. ▪ Enclosed ash-handling systems throughout the incinerator ▪ Fly ash residues to be disposed off only after it has been solidified in the incineration plant. ▪ Ash be handled and disposed in a secure hazardous-waste landfill that is designed to ensure that there will be no groundwater pollution. ▪ Regular testing of ash to determine its toxicity	▪ Ash waste tracking reports ▪ NEMA registration for waste handlers ▪ Presence of ash handling system	• NEMA inspectors • County Government of Machakos • Kinanie Community feedback • The proponent	1,000,000 annually for sustainable ash handling/ management
Greenhouse gases emissions	▪ Altered natural concentrations of gases leading or contributing to unnatural warming of the earth. ▪ Global warming and Climate change	▪ Quarterly stack emission assessment of the incinerator. ▪ Certification procedure for incinerator control-room operators. ▪ GHG Emissions be reduced by modifying operating characteristics reagent type, and injection rate, and by selecting optimal combustor designs and emission-control technologies. ▪ Use and continued calibration and maintenance of continuous monitors of emissions and process characteristics provide real-time feedback and	▪ Certification certificates for incinerators operators ▪ Emission assessment reports ▪ Number of refresher courses for	NEMA inspectors County Government of Machakos Kinanie Community The proponent	1,000,000 annually for monitoring, technology upgrade and maintenance

		facilitate maintenance of optimal operating conditions at all times by incineration operators. ▪ Computerized continuous emission monitors (CEMs) for CO, O2, SOx, NOx, and HCl.	plant operators on GHC gas management		
Scrubber waste management	▪ Soil quality degradation /pollution ▪ Pollution of water sources through direct deposition, surface runoff and/or infiltration into groundwater aquifers ▪ Health risks including exposing the workers to a wide range of chemical poisoning, toxicity or long term health complications	▪ Wet-scrubber wastewater be discharged to on-site wastewater-treatment system	▪ Scrubber waste tracking reports ▪ NEMA inspection reports ▪ Presence of an onsite waste water treatment system	NEMA inspectors County Government of Machakos Kinanie Community The proponent	2,000,000 annually for onsite waste-treatment system
Occupational hazards or injuries to works, visitors and general public	▪ Health hazards such as bronchial infections, skin problems, etc. for employees and public ▪ Complete incapacitation of the affected employee or persons ▪ loss of life ▪ Disruption of the plant operational activities	▪ Plant operators and worker training in hazardous-material management and annual refresher courses. ▪ All workers should be provided with protective gear. These include working safety boots, overalls, helmets, goggles, earmuffs, respirators/masks and gloves. ▪ A first aid kit should be provided within the site. This should be fully equipped at all times and should be managed by qualified person. ▪ The proponent should have workmen's compensation cover (WIBA). It should comply with workmen's compensation ▪ Adequate sanitary facilities should be provided and standard cleanliness maintained. ▪ Safe operation procedures/ clear instruction provided to the workers and general public to ensure that safety is maintained. ▪ Workers operating within the high temperature zones should not exceed 2hrs continuous	▪ Complete PPE ▪ Medical examination and respiratory tests reports ▪ Signage mounted	▪ Proponent ▪ NEMA Inspectors ▪ DOSHS	500,000 annually for PPE supply, medical examination for workers as well as signage. 150,000 annually for OSHA audits

		presence or/as may be directed by the Occupational Health and Safety Experts. ▪ Mounting of safety signage's within and outside the incinerator plant			
Site flooding from storm water generation	▪ Water pollution from leachate and run off ▪ Possible transportation of bottom ash, fly ash, scrubber water, and various miscellaneous waste streams and other residues like such as lime and activated carbon, themselves with condensed or absorbed contaminants to unintended natural environment. ▪ Disruption of the plant operational activities leading to economic losses	▪ Rainwater from the constructed roofs within the within the site to be harvested and collected and stored in underground collected tanks for later use ▪ Appropriate site landscaping to be employed ▪ Vegetation cover of all open area to reduce surface run off ▪ Revegetation of all open areas to reduce surface run off	▪ Number of rainwater harvesting and ▪ Storm water management drains constructed.	▪ Site Civil and landscape Engineers ▪ NEMA ▪ Proponent	300,000 for storm water management
Increased vehicular traffic	▪ Dust, road and traffic problems ▪ Possible traffic congestion of local road especially at junction connecting to Kinanie. ▪ Possible of occasional experience of delays on the said local road; ▪ Pedestrians and cyclists using local roads will have to exercise more care with increase of vehicular traffic on the said roads; and ▪ There will be an increase of exhaust emission from vehicles delivering the combustible waste which will pollute local atmospheric air.	▪ All users of said roads to always observe traffic rules this will give pedestrians and cyclist their space and safety while using the road; ▪ Speed limits to be strictly observed ▪ Motorist to be sensitised to use unleaded fuel as opposed to leaded fuel	▪ Drivers training report ▪ Records on type of fuel used	▪ NEMA ▪ Proponent	100,000 annually for traffic management and drivers training
Oil spill	▪ Pollution of soil and water bodies	▪ Spill containment measures and oil water separator	▪ Reports from spill containment inspection		20,000 one of for constructions of oil water separator.

Odor	▪ Compromised air quality around the project site and Kinanie community	▪ Implement effective odor control systems to prevent unpleasant smells from affecting the surrounding area. ▪ Regularly inspect and maintain the incinerator to prevent any leaks that could contribute to odors.	▪ Inspections records	▪ Proponent	Routine cost
Emergency Preparedness	▪ Potential fire incidents	▪ Develop and implement an emergency response plan to address any incidents or accidents promptly and effectively. ▪ Provide training to workers and local authorities on emergency procedures.	▪ Presence of ERP and fire maps	▪ Proponent	Routine cost
Social issues Conflict with Kinanie Community	▪ Stalled operation and losses to the proponent	▪ Continuous public participation and engagement for improving the environmental impact assessment and increasing total welfare of different interest groups in Kinanie and beyond as far as the incinerator operation is concerned ▪ Pursuing economic achievements with regard to social, public health and environmental issues that of concern to the locals	▪ Number of public participation held with Kinanie community	▪ Proponent ▪ Kinanie community ▪ Office of the Deputy County Commissioner Mavoko	▪ 40,000 per stakeholder meeting and engagement
DECOMMISSIONING PHASE					
CONCERN	**POTENTIAL NEGATIVE IMPACTS**	**PROPOSED MITIGATION MEASURES**	**MONITORING ASPECT**	**RESPONSIBILITY**	**COST (KSHS)**
Noise	▪ Reduced concentration of people in the neighbourhood ▪ Shouting during conversation among workers on site ▪ Noise induced hearing loss among workers who are continuously exposed to high noise levels ▪ reduction in productivity and efficiency of the workers at the workplace ▪ stressing the worker and thus reduced concentration	▪ Demolition works and other decommissioning activities to be limited to day time. ▪ Appropriate ear protective devices to be provided to workers working in noisy environment. ▪ Education and training for workers on importance and proper use of PPE. ▪ Appropriate acoustic barriers around areas generating noise to be provided. ▪ Noise attenuators such as trees on site to be preserved.	▪ Complete PPE for workers ▪ Medical examination report ▪ Audiometric tests for noise impacts ▪ Signage mounted	▪ Proponent ▪ NEMA Inspectors ▪ DOSHS	200,000 for PPE supply, medical examination for workers as well as decommissioning report.
Dust	▪ skin irritation, chocking including coughing	▪ Appropriate personal protective equipment to be provided to all workers. ▪ Appropriate use of PPE provided to be enforced.			

		▪ The decommissioned site to be secured with dust screens. ▪ Water sprinkling on dusty grounds to be done.			
Occupational injuries	▪ Complete incapacitation of the affected employee ▪ loss of life ▪ Increase in Costs of litigation and compensation	▪ Appropriate personal protective equipment such as safety belts for workers working at height to be provided. ▪ Proper use of PPE provided. ▪ Appropriate training of workers of ways of working safely. ▪ Appropriate supervision at workplace. ▪ Rest times to be strictly observed to reduce stress.			
Solid waste	▪ May contain endocrine disrupting compounds, toxic pollutants, heavy metals, combustion products heavy metals, pathogenic microorganisms ▪ Potential for human injuries and health risk	▪ Un-recyclable material to be transported by licensed waste transporters and disposed on NEMA approved dump sites ▪ Ensure safety precautions have been observed at decommissioning especially in regard to sharp debris, heavy metals etc. ▪ Careful removal lined ash pit on site ▪ Use of NEMA approved waste handlers	▪ Number of material recycled ▪ Records of hazardous materials disposed	▪ Proponent ▪ NEMA	▪
Site restoration and rehabilitation	▪ Introduction of incompatible procedures and methodologies	▪ Notify NEMA and other relevant authorities on intension to stop operations at least 3 months in advance. ▪ Carry out a decommissioning report and submit report to NEMA for review six months in advance, ▪ Re-vegetate the project site with as much indigenous trees as possible ▪ Monitor the site for one year.	▪ Observation	▪ Proponent	▪ 100,000

9.6 General EMP for the operation phase of the project

Table 9-2: General EMP for the operation phase

Area of concern	Recommended measures	Responsible party	Priority level	Approximate cost (Ksh.)
Collected raw materials wastes and other Solid wastes				
• Pollution and nuisance • Creation of breeding grounds for vectors, rodents and other disease causing and/or transmitting organisms	Use of an integrated solid waste management system (recycling and re-use)	Proponent	High	To be determined
	Collect and recycle wastes to the processing site within a week	Proponent	High	
	Cover the collection area to minimize invasion by pests and rodents or other animals	Proponent	High	
	Use of NEMA approved waste collection/ transportation companies	Proponent	High	
Dust and exhaust emissions				
• Health hazard • Visual obscurity • Degradation of air quality	Water all dust-active areas by sprinkling with water to suppress dust	Proponent	High	500 per day
	Minimize vehicle idling time	All vehicle users	Low	–
	Provide adequate ventilation in all working and accommodation areas by opening windows	Proponent	High	–
	Ensure taps are not running when not in use	All users	High	–
Wastewater and sewerage				
• Health hazard • Degradation of water resources • Pollution	Put in place measures to ensure proper use and daily cleaning of the sanitary facilities	Proponent	High	-
	Conduct regular checks to detect and correct sewage pipe blockages, damages and leakages	Proponent	High	2,000 per maintenance
Energy consumption				
• Increased demand on energy resources	Use energy-saving lights such as LED tubes and bulbs	Proponent	High	10,000 per bulb
	Switch off lighting fluorescent tubes during the day and all other electrical appliances when they are not in use	All users	High	–
Fires				
• Injuries and deaths • Destruction of property	Prominently display 'NO SMOKING' FIRE ASSEMBLY and EXIT signs at respective places.	Proponent	High	1,000
	Maintain first aid kits in the workshop	Proponent	Medium	1,500 per kit
	Conduct regular inspection of the firefighting equipment (every three months)	Proponent	Medium	5,000 per service
Record keeping and documentation				
Environmental degradation	Develop procedures for documentation of records keeping of all environmental and health concerns	Proponent	High	500 per month

9.7 Proposed occupational safety and health EMP for the incinerator construction and operation

Table 9-3: Proposed OHS EMP

Area of concern	Management	Responsibility	Time frame	Approximate cost (Ksh.)
General register	Keep a general register within the facility as stipulated in Section 62 (1) of OSHA, 2007	Plenser Waste Management Limited	Continuous	500 per month
Incidents and accidents	Report any incidents and accidents using prescribed forms obtainable from the Occupational Health and Safety Office		Continuous	500/month
	Conduct regular safety education and training		Quarterly	5,000 per trainee
	Prepare a contingency plan for emergency response		-off	10,000
Insurance	Insure the premises as per statutory requirements (third party and workman's compensation)		Annually	5,000 per year
Safety healthy environment (SHE) policy	Develop, document and display prominently an appropriate Safety and Healthy Environment policy		-off	1,000
Sanitary conveniences	Provide suitable, efficient, clean, well-lit and adequate sanitary amenities at the site taking care of gender division		-off	50,000
Ventilation	Provide adequate space within the premises to allow for adequate natural ventilation through circulation of fresh air		-off	_
Storage of wastes	Ensure that materials are stored or stacked in such manner as to ensure their stability and prevent any fall or collapse		Continuous	_
Safe means of access and safe place of employment	Floors, steps and passages of the premises must be of sound construction and be properly maintained		Continuous	_
First aid	Have on site a stocked first aid box which is easily available and accessible		-off	1,500 per kit
	Have on-site persons trained in first aid and issued with a certificate by a recognized body		-off	5,000 per trainee
Emergency preparedness and evacuation	Design suitable documented emergency preparedness and evacuation procedures for emergencies		-off	1,000
Fire protection	Regularly inspect and service fire-fighting equipment by a reputable service provider and maintain inspection records		Every 3 months	5,000
	Prominently display signs such as "NO SMOKING" at the site		-off	500
Lighting	Provide adequate artificial or natural lighting in all parts of the premises where persons are working or passing		-off	_
Disease incidences and spread	Provide sanitizers, masks, handwashing station and ensure a complete refuse collection and handling service		Continuous	5,000

9.8 Thematic parameters for environmental auditing during operation

Theme		1	2	3	4	5	Score
Solid Waste management and record keeping	Collection system in the generation site (i.e. segregation system, type of containers/bags);						
	Gather waste on a designated point/ location/ waste transfer station/Central storage conditions						
	Keep proper records of amount of waste taken away						
	Transport requirements e.g. use of covered trucks						
	Use of NEMA registered waste handlers						
	Approved disposal method						
	Reduce, reuse, recycling strategies implemented within Plenser Waste Management Limited						
Oil Spillage management	Oil water separator in all oil usage areas and storage tanks						
	Spill containment in place						
Air quality management	Regular sampling at the Plenser Waste Management Ltd premises/ ambient air quality monitoring including Particulate matter by NEMA accredited laboratory and DOSHS						
	Emissions inventorying						
	Simulation modelling; used to assess current and potential future air quality in order to enable informed policy decisions to be made. Current emissions and monitoring data can be used to validate an emission and dispersion model, which can then be used to forecast future changes based upon a range of 'what if' scenarios.						
	Standards and Guidelines						
	Public Information and its Dissemination; Clear information is needed about how the public can complain about air quality. In this way, public information will help in allowing the public to become involved in identifying problems and implementing solutions.						
	Air Quality Alert; establishment of a set of procedures to deal with the occasional acute occurrence of very poor air quality. Various agencies/department decide and agree upon a number of threshold concentrations at which an alert system would be triggered and the nature and priority of the procedures to be carried out in response to it.						
Energy supply, utilization and management	Roles and responsibility. Energy policy. Energy objectives and energy targets. Energy efficiency improvement plan.						

	Monitoring, measurement and analysis						
Pollution, disorders control; standard precautions and additional (precautions.	Education and training						
	Surveillance of Pollution						
	Policies, procedures, and guidelines						
	Audit processes for hand washing and antisepsis (hand hygiene). Use of personnel protective equipment when working.						
	Monitoring of the mills hygiene						
	Airborne precautions, droplet precaution and Contact precautions						
Safety concerns	Formulation of a strict policy to ensure adherence to using the PPE's provided when required.						
	Replacing ear muffs, masks, gloves &other protective clothing if worn out						
Fire concerns	Train employees on firefighting skills						
	Service fire extinguishers regularly						
	Housekeeping						
Policies	Environment, Health Safety policies exists						
	Fire Action Plan exists						
Records	Maintain waste management records						
	Electricity consumption records are maintained						
Warning signs	Available: Visual signs are clear and hence a presumption of adherence						
First aid box	There is a first aid box in the premises						
Occupational, Health and Safety training	Occupational, Health and Safety training conducted regularly and proposal/ recommendations implemented						
Health and Safety policy	Available						
Health and Safety audit	Annually conducted and recommendations implemented						
Fire Emergency Action Plan	Availability						
Inspection of electrical wiring in the Plenser Waste Management Ltd premises	Done regularly						
Overall rating for the Plenser Waste Management Limited Operation							

10 CHAPTER TEN: CONCLUSION AND RECOMMENDATION

10.1 Anticipated (potential) positive Impacts

i. **Decreased quantities of waste:** The proposed incineration plant will be able to decrease the quantity of waste by 95% and reduce the solid quantity of the original waste by 80-85% depending on the components that will be in solid waste. Though incinerator do not completely get rid of dumping ground, they definitely decrease the quantity of land needed.

ii. **Reduced Pollution:** Research has shown that solid waste incinerators are less likely to pollute the environment than landfills do. One particular study done during a 1994 lawsuit in the US showed that a waste incinerator location was more environment-friendly compared to a landfill. The research discovered that the landfill was releasing higher quantities of greenhouse gases, nitrogen oxides, dioxin, hydrocarbons, and non-methane organic compounds. Landfills also leach poisonous chemicals into the water below thus contaminating underground water systems. The proposed incinerator using proper scrubber technology will reduce air pollution in the atmosphere as well as contribute to Climate change mitigation.

iii. **Trapping of pollutants that would have otherwise been released if open burning was adopted**: The main problem concerning the incineration of solid waste is the release of hazardous compounds, particularly dioxin. Nonetheless, the proposed modern incinerator plant will use filters to trap hazardous gases and particulate dioxin. The proposed incinerator will operate within the required pollution limits recommended by the NEMA and international protocols.

iv. **Saving on Transportation of Waste within Athi-River and neighbouring Counties**: The proposed incinerator will be in reasonable distance from Machakos County and Nairobi city. This is advantageous since it means waste does not have to be driven for long distances for dumping. It significantly reduces the cost of transport; the money can then be spent on the wellbeing of the community and sustaining the growth waste generators. Additionally, it reduces the harmful gases released by vehicles during transportation, thus drastically reducing the overall carbon footprint.

v. **Better control over odor and noise**: The proposed incinerator will be able to provide less bad smells because waste gets burnt, unlike landfills where waste is allowed to decay thereby emitting unpleasant smells, which cause air pollution. The production of methane in landfills may also lead to explosions that cause noise pollution, which is unheard-of when it comes to the use of incinerators.

vi. **Prevention of the production of methane gas**: In landfills, when the waste is decaying methane gas is generated which if not controlled, may explode causing further global warming. Unlike landfills, incinerators do not produce methane, therefore making them safer.

vii. **Elimination of harmful germs and chemicals**: The proposed incinerator will function at very high temperatures of about 1,200 ºC that can destroy germs and chemicals that are harmful. Thus, it is a very effective method when it comes to eliminating clinical waste.

viii. **All weather operation**: The proposed incinerator can function in any type of weather. For instance, during a rainy season, waste cannot be dumped in a landfill because the rain will possibly wash down poisonous chemicals into the ground and consequently create leachate thus contaminating the underground water as well as the neighboring land. Waste can also not be

dumped when it is windy since it will get blown into the surroundings. On the other hand, incinerator will not be limited to weather changes since it will burn waste without leakages. Incinerator also has the capacity to function 24 hours a day is more efficient in managing waste compared to landfills.

ix. **Effective for Metal Recycling:** When the proposed incinerator will be burning waste, the metals still remain whole because they have a high melting point. After the process of burning waste is done, it is expected that the workers remove the remaining metal and recycle it. This removes the need for separating out any metal before waste disposal. When garbage is taken to a landfill, it is usually not organized which results in wasting of resources that could have been recycled. Therefore, using an incinerator will makes it easier to remove and reuse metals.

x. **Computerized monitoring system:** The proposed modern incinerator has a provision for a computerized monitoring system device to allow for the troubleshooting of most problems. This will enable operators to discover a problem before it becomes more serious and much more expensive to repair.

xi. **Potential Uses of ash waste:** The ash that comes from the combustion of waste can be used in construction, get shipped or even landfilled.

xii. **Job creation:** The proposed incinerator plant will directly or indirectly create jobs for the locals.

10.2 Potential negative impacts

i. **Degradation of the air quality and the environment: Incinerator produce smoke during the burning process that can pollute the environment if proper** filter or scrubber is not installed. The smoke produced includes acid gases, carcinogen dioxin, particulates, heavy metals, and nitrogen oxide. These gases are poisonous to the environment. This is a potential impact that forms the whole basis for this assessment.

Note: The proposed incinerator is fitted with APCDs designed to remove the respective air pollutants.

ii. **Ash waste risk:** Even though the ash that remains from the process can be comparatively small in quantity, it contains a number of poisons and heavy metals which requires further treatment. If not disposed correctly, it can cause serious harm to the public and the environment. The proponent has proposed measures in place for ash management.

10.3 Environmental and Social Management and Monitoring Plan (ESMMP)

The ESMMP outlined in section eight of this report has identified issues of concern (potential negative impacts) and mitigation measures as well as responsibilities, costs and measurable indicators that can help to determine the effectiveness of actions to maintain and upgrade the quality of environment; as regards the proposed project. This monitoring is done in relation to the baseline environment. Regular monitoring is therefore necessary to monitor the change in parameters. The ESMMP was considered for all phases; installation, operational and decommissioning.

10.3.1 Environmental statement

From the assessment, the EIA experts conclude that the proposed development in Kinanie, Athi-River is appropriate. This conclusion has been made in terms of environmental impact, site selection, public health and public participation responses/outcomes. By using a multi-criterion assessment model for

economic, social, public health and environmental effects, this study indicates the proposed project has taken much consideration of the public health and environment. A location analysis is also applied and some influences of waste incinerators are illustrated. This study finally offers some corresponding recommendations for improving the environmental impact assessment and enhancing the benefits of the proposed waste incineration project.

The ESIA report for the proposed incinerator has revealed that only **potential significant** issues maybe from;

i. Pollutant emissions, disposal (management) of fly and bottom ash, which causes serious pollution to the environment and is a threat to public interests and public health;
ii. Technology used in incinerators, the older generations of incinerators are often much more dangerous to public health. More advanced incinerators as proposed have flue gas and dust parameters cleaning systems to reduce the air pollution.
iii. Waste incineration deflects attention from more sustainable solutions, such as redesigning products for recyclability or eliminating toxic, hard-to-recycle plastics which is a holistic issue beyond the proponent of this project.

10.4 Recommendations

i. In terms of protecting the public health, improving the relevant techniques and standards of the incinerator is a necessity. The proposed project is expected to meet dioxins emission standard as the introduction and development of more eco-friendly waste-incinerating techniques that promotes the efficiency of incinerators and plays a vital role in reducing fly ash.
ii. The ESMMP should be implemented fully at all stages along the project cycle to maximize related positive environmental, economic, social, and public health influences of the proposed waste incinerator.
iii. Plenser Waste Management Limited should explore the opportunities for co-generation as indicated in the design. Co-incineration offers new markets for waste-derived fuels using existing infrastructure. It is hard to measure how many facilities are currently using co-incineration in Kenya, since there is no law compelling incinerator operators to report it.
iv. The proposed incinerator should have a provision for a computerized monitoring system device to allow for the troubleshooting of most problems related to APCD (wet scrubber system). A computerized monitoring will also make operators work easily as they will be able to track the environmental and operational efficiency of the incinerator plant.
v. Social inclusion: Waste management system relies heavily on informal workers, who collect, sort, and even manage generated waste. The project proponent should address waste picker livelihoods through strategies such as integration into the formal system, as well as the provision of safe working conditions, social safety nets, child labor restrictions, and education.
vi. Climate change and the environment: The project should continuously strive to promote environmentally sound waste disposal. It should support greenhouse gas mitigation through adoption of scrubber technology that capture Greenhouse gases. The value chain should also support resilience by reducing waste disposal in waterways and safeguarding infrastructure against flooding. In this regard, Stack emission assessment should be conducted on quarterly basis.

vii. Corporate Social Responsibility: Plenser Waste Management Limited should work closely with the local community in identifying projects whose implementation may address community needs. This will in the long run promote a culture of appreciation and trust between the community and the proponent. Local people should also be considered for job opportunities for which they have skills and especially casual jobs during project implementation period. This will in the long run make them feel part of the project.

viii. Annual environmental audits should be carried out on the project in order to ensure compliance of the project with the mitigation measures outlined in the Environmental and Social Management Monioring Plan (ESMMP). To ensure that the impacts on the environment are completely minimized, a monitoring and training activity should be carried out by Plenser Waste Management Ltd.

11 APPENDICES

Appendix 1: TOR Approval

Appendix 2: Summary of Climate Risk Assessment

Appendix 3: Land documentation

Appendix 4: KRA Pin and Certificate of incorporation for the Proponent

Appendix 5: EIA/EA expert Practicing license for consultants

Appendix 6: Minutes of the CPP and duly filled Public participation forms for Public consultation.

Appendix 7: Incinerator specification and layout plan.

APPENDIX 1

Climate Risk Assessment Report for Proposed Incinerator in Kinanie, Athi River, Mavoko Sub County by Plenser Waste Management Ltd

Executive Summary

This Climate Risk Assessment Report evaluates the potential climate-related risks associated with the construction and operation of the proposed incinerator in Kinanie, Athi River, Mavoko Sub County. The assessment aims to identify vulnerabilities and propose adaptive measures to ensure the project's resilience in the face of changing climate conditions.

1. Introduction

The proposed project is designed to address waste management challenges in the local area. However, the impacts of climate change must be considered to ensure the project's long-term effectiveness and sustainability.

2. Climate Context

Kinanie, Athi River, Mavoko Sub county experiences a subtropical climate with distinct wet and dry seasons. Recent climate trends indicate increasing temperatures and altered rainfall patterns, posing potential risks to the project's infrastructure and operations.

3. Climate-Related Risks

3.1 Extreme Weather Events: The project may be exposed to increased frequency and intensity of extreme weather events, such as heavy rainfall and storms, which could damage project infrastructure and disrupt operations.

3.2 Flooding: Altered rainfall patterns may lead to flash floods, potentially affecting project accessibility, safety, and equipment integrity.

3.3 Temperature Extremes: Rising temperatures might impact incinerator efficiency, altering waste combustion rates and emissions.

3.4 Air Quality: Climate change could exacerbate air quality concerns due to stagnant air conditions and temperature inversions, affecting compliance with air quality standards.

4. Vulnerabilities:

4.1 Infrastructure Vulnerability: Inadequate design to withstand extreme weather events may result in infrastructure damage or operational downtime.

4.2 Health and Safety Vulnerability: Climate-related impacts on waste management might compromise public health and safety due to potential pollution and contamination risks.

4.3 Economic Vulnerability: Climate-induced disruptions could lead to project downtime, repair costs, and potential revenue loss.

5. Mitigation and Adaptation Strategies

5.1 Resilient Infrastructure: Incorporating climate-resilient design principles into project infrastructure, considering flood-resistant features and reinforced structures.

5.2 Emergency Response Plan: Developing a comprehensive emergency response plan to effectively manage weather-related disruptions and ensure a prompt recovery process.

5.3 Temperature Regulation: Implementing measures to manage temperature variations, such as cooling systems or operational adjustments.

5.4 Air Quality Monitoring: Establishing a robust air quality monitoring system to detect deviations from air quality standards promptly.

5.5 Stakeholder Engagement: Engaging with local communities to raise awareness about climate risks, waste management practices, and safety protocols.

6. Conclusion

This Climate Risk Assessment Report underscores the significance of understanding climate-related risks associated with the proposed incinerator project in Kinanie, Athi River, Mavoko Sub County. By proactively integrating appropriate mitigation and adaptation strategies, Plenser Waste Management Limited can enhance the project's resilience, contribute to sustainable waste management, and foster the well-being of the Kinanie community.

7. Recommendations

Plenser Waste Management Limited is encouraged to collaborate with climate experts, County Government of Machakos and NEMA to implement the recommended mitigation and adaptation measures. Regular monitoring and updates of the climate risk assessment will ensure the project's ongoing preparedness for evolving climate conditions.