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Machakos Water and Sanitation 'Design-and-Build' Project

Environmental and Social Impact Assessment of Machakos Town Water Supply Project

Athi Water Services Board

20 March 2018

Notice

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This document has 157 pages including the cover.

Document history

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Declaration

This ESIA Study Report for the Proposed **Machakos Town Water Supply Project** is prepared and submitted, on behalf of **Howard Humphreys (East Africa) Ltd** by**:**

Name	*Registration No.*	*Signature*	*Date*
Simon Wandeto	885	……..	20 March 2018

The Report is endorsed, on behalf of **Athi Water Services Board** by:

Name: ……..
Designation: ……
Date: ……

Abbreviations

AfDB	African Development Bank
AWSB	Athi Water Services Board
BOD	Biological Oxygen Demand
CEMMP	Construction Environmental Management and Monitoring Plan
CIDP	County Integrated Development Plan
COD	Chemical Oxygen Demand
EC	Electrical Conductivity
EMCA	Environmental Management and Coordination Act
EMMP	Environmental Management & Monitoring Plan
GWP	Global Warming Potential
HDPE	High-Density Polyethylene
HGV	Heavy Goods Vehicles
KIHBS	Kenya Integrated Household Budget Survey
MAWASCO	Machakos Water and Sewerage Company
MSDS	Materials Safety Data Sheets
NAC	No Additional Cost
NEMA	National Environment Management Authority
PPE	Personal Protective Equipment
PS	Pond Series
OD	Outside Diameter
OEMMP	Operational Environmental Management and Monitoring Plans
O&M	Operations and Maintenance
OS	Operational Safeguard
OSHA	Occupational Safety and Health Act
ROW	Right of Way
STDs	Sexually Transmitted Diseases
TAWSB	Tanathi Water Services Board
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
WRMA	Water Resources Management Authority
WRUA	Water Resource Users Association

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Project background

Athi Water Services Board (AWSB), on behalf of Tanathi Water Services Board (in whose area Machakos is located) has commissioned a feasibility study and conceptual design of the Machakos Water and Sanitation Project.

The objectives of the feasibility study are to, inter alia, investigate the current level of service, operations and adequacy of the existing water supply and sanitation infrastructure in terms of quality and quantity with a view to determining the feasibility, adequacy, efficiency, rehabilitation and augmentation potential within the framework of providing water and sanitation services to the target population in the most economical way.

The Proposed Project

The proposed project entails the design and construction of new water supply infrastructure comprised of a reservoir on Miwongoni River, treatment works, transmission lines, storage tanks and a distribution network for Machakos Town. The project also entails rehabilitation of the existing water supply infrastructure.

ESIA Rationale

The Environmental Management and Coordination Act (EMCA) 1999 and the Amendment Act of 2015 provides for the completion of an Environmental and Social Impact Assessment (ESIA) and the preparation and submission of a Study Report before undertaking a project of the proposed nature. Howard Humphreys was commissioned by AWSB to carry out an ESIA of the proposed project and submit an ESIA Report for review and approval by the National Environment Management Authority (NEMA).

The overall aim and purpose of the ESIA was to assess environmental and social impacts that are likely to arise from implementation of the proposed project. Specific objectives of the ESIA were to:

- Collect and analyze baseline environmental and socioeconomic data in the study area;
- Identify and assess potential environmental impacts in the design, construction and operation of the proposed project;
- Liaise with interested and affected parties in the area in order to seek their views on pertinent issues related to the proposed project;
- Identify mitigation measures for the actual and potential adverse impacts; and
- Develop environmental and social management plans suitable for the proposed works, activities and anticipated environmental impacts.

Study approach

The ESIA was carried out in line with the provisions of the Environmental Management and Coordination Act, 1999 and the Amendment Act of 2015, the Environmental (Impact Assessment and Audit) Regulations 2003, as well as international guidelines on environmental and social impact management.

A scoping exercise was carried out to identify gaps in information and determine the range of issues to be addressed in the ESIA. The key methods that were used to gather information in the ESIA study included desktop studies, field surveys and stakeholders' consultations. A systematic approach was used to identify and evaluate significant impacts of the proposed project based on project activity event magnitude and receptor sensitivity. Mitigation measures were then proposed to address the adverse impacts identified.

Stakeholder Consultations

Various methods were applied in stakeholder consultations including interviews, administration of questionnaires and stakeholder/community meetings. Outcomes of these consultations revealed that from the community's perspective, the project was a worthwhile investment that would solve the water supply problems

in Machakos. However, there were concerns on the potential displacement of people by project components such as the proposed Miwongoni dam, and environmental pollution by construction activities.

Prediction and evaluation of impacts and mitigation measures

Potential impacts of construction, operation and decommissioning the project were identified and their significance evaluated. In determination of impact significance, event magnitude (extent/scale, frequency, duration, and intensity) and receptor sensitivity (presence and resilience) were considered. Significance was either categorized as Negligible, Minor, Moderate or Major.

The ESIA established that significant beneficial impacts – key of which is the improved access to clean water for the population in the target area. Other benefits include creation of employment and business opportunities during construction and operations, and positive changes in the ecology within and around the reservoir following development of a lacustrine habitat.

Adverse impacts identified include displacement and/or disturbance of members of the community with potential loss of livelihoods, the potential increase in noise pollution, air pollution, soil and water resources pollution, and increased health and safety hazards during construction phase of the project. The risk of changes in river flow regime from impoundment, over abstraction and dam safety are some of the significant impacts during operations, with potential to adversely affect aquatic ecology, and downstream users of the river and surrounding communities.

The Table below summaries the impacts identified, their significance, and mitigation measures proposed.

Impact	Significance	Mitigation Measure
Air Quality		
Nuisance and health effects on humans from dust exhaust gases	Moderate	• Maintenance of equipment and machinery to by regular servicing to maintain efficiency in combustion and reduce carbon emissions; • Use environmentally friendly fuels such as low sulphur diesel; • minimize idling of machinery; • ensure no burning of waste on sites/non-designated areas; • Sprinkling of all active construction areas as and when necessary; • Control of construction vehicle speeds by imposition of speed limits; • Immediate backfilling of trenches and rehabilitation of disturbed areas once completed; • Use of tarpaulins to cover trucks carting away spoil using public roads; • Proper planning in transportation of spoil to ensure that the number of trips done or the number of vehicles used is as minimum as possible; and • Provision of appropriate Personnel Protective Equipment such as dust masks to site workers.
Stunted growth of crops and natural vegetation from dust deposition	Moderate	
Visual & landscape		
Visual disturbance effects on humans from disturbed sites, opened views and construction plant and machinery	Moderate	• Reinstatement in accordance with the project's reinstatement specification; • Avoidance of the removal of existing mature trees which form important visual focal points; and • Replacement of any removed trees during the reinstatement phase using indigenous species of local provenance.
Adverse impacts on natural vegetation from clearance and topsoil removal	Moderate	
Water environment		
Contamination of water resources by spillages	Moderate	• Develop and implement a site construction waste and wastewater management plan to minimize environmental damage from construction activities; • Install secondary containment measures in areas where fuels, oils, lubricants etc. are stored and loaded or unloaded, including filling points; • Implement soil erosion control measures at construction sites; • Design and implement an agreed seasonal compensation flow regime during operation; • Manage operations to avoid rapid fluctuations in downstream flow; • Undertake regular (preferably continuous) flow monitoring downstream; • Undertake regular water quality monitoring in reservoir, to include dissolved oxygen, nutrients (N & P), pesticides and nuisance plants; • Seek an abstraction license from WRMA and adhere to the conditions of the license; • Construction of silt check dams, traps and vegetation (capable of thriving in waterlogged conditions) at and upstream of the tail of the reservoir, along and across the valley
Sedimentation of Miwongoni River from construction activities	Major	
Contamination of water resources by direct discharge of wastes	Moderate	
Increased water demand	Moderate	
Siltation of the reservoir be upstream land uses	Major	
Changes in river flow regime	Major	
Deterioration of reservoir water quality	Moderate	
Eutrophication of the reservoir from upstream agricultural activities	Moderate	
Changes in the water table around the reservoir	Moderate	
Ecology and biodiversity		
Destruction of aquatic habitats and organisms by sediments	Moderate	• Minimize riverbed and shoreline disturbance (e.g. restricting access of construction activities and workers to susceptible areas that could contribute to sediment loading); • Implement education programmes for construction workers on, inter alia: respect for wildlife and vegetation, avoidance of fires and accidental damage, and generally minimizing the footprint of the construction camp and work areas; • Prohibit development of unnecessary spur roads off main access roads, to limit land degradation and habitat disturbance; • Develop "good construction environmental management" protocols to reduce effects on vegetation and wildlife; • Replant or take measure to encourage recolonization by native vegetation in disturbed or denuded areas immediately following construction.
Loss of terrestrial habitats and associated wildlife	Minor	
Changes in biological communities within the reservoir	Moderate	

		• Provide for rescue of rare or distressed animals; • Selectively harvest tall trees within the inundation area prior to impoundment to force tree-dwelling wildlife to migrate from the area prior to flooding; • Begin reservoir inundation after the dry season once hibernating animals have emerged; • Reduce the biomass that will be flooded by selective vegetation clearing; • Implement 'nuisance' plant monitoring programme for the reservoir.
Soil Resources		
Soil loss resulting from erosion and carting to spoil	Major	• Back-fill material to be compacted to a similar value to the original surrounding soils to avoid subsidence as a consequence of rain water channeling; • Implementation of a project specific Reinstatement Plan which includes mitigation for impacts to soils; and • Implementation of spillage prevention and control measures for hazardous materials in use and storage at sites.
Soil contamination from pollution incidences	Major	
Waste		
Environmental pollution and creation of health and safety hazards from poor management of wastes during construction	Major	• Land-fill spoils as much as possible within the sites or identified fill areas; • Felled trees, shrubs and stumps can be isolated for collection by locals as firewood; • Organic wastes can be composted on site; • Provide pit latrines at the camp(s) and construction sites for use by workers; • Vehicle maintenance to be done off- site (at the construction camp's garage/workshop or commercial garage) and wastes (used oil, oily rugs, cans and used parts) disposed in a designated area; • Ensure that construction materials left over at the end of construction are used elsewhere rather than their disposal; • Washing of concrete coated vehicles or equipment to be done off-site or in a designated wash area, a minimum of 50 feet away from drainage channels; • Runoff from the on-site concrete wash area to be contained in a temporary pit where the concrete can set; • The temporary pit to be lined with plastic or clay to prevent seepage of the wash water into the ground. The wash water should be allowed to evaporate or collected along with all concrete debris in a concrete washout system bin; and • To the extent possible, hydraulic test water should be discharged into the next section of the pipeline to be tested.
Environmental pollution health and safety hazards from poor management of during operations	Moderate	• Disposal of the water treatment plant sludges could involve incineration, disposal into the existing sewer system for Machakos town, compositing, spreading on land as soil conditioner or fertilizer, or landfilling • The backwash wastewater from filter washing operations should be recycled into the system. • Sewerage generated from staff houses should be disposed in a septic tank with a soak pit
Noise and Vibrations		
Vibrations and noise nuisance to the community during construction work	Moderate	• Portable hoods to be installed to shield compressors and other small stationary equipment where necessary; • Pumps, generators and other mobile equipment to be sited as far as practicable from housing and other noise sensitive locations; • The contractor to endeavor to use equipment installed with noise abatement devices as much as practicable; • Idling time on trucks and other noisy equipment to be limited to a minimum; and • Personal protective equipment such as ear muffs will be provided to workers at the sites as necessary.
Occupational and public health, safety and security		
Exposure of workers and the general public to health and safety hazards during construction work	Major	• Provision of all workers on site with the necessary Personal Protective Equipment; • Ensuring a safe and healthy environment for the construction workers;

		• Workers accidents to be mitigated by enforcing adherence to safety procedures and preparing contingency plans for accident response; • The Contractor to have qualified first aid personnel among the workers and maintain fully stocked first aid kits at the sites; • Hazards and accidents involving the public to be minimized by controlling access to the construction sites; • Contractor to ensure that workers have access to sanitary facilities at the sites and provide potable water. • Inform local communities of major activities in advance; • Endeavour to lay pipes and backfill as soon as possible to reduce the time of hazards exposure to the public from open trenches; • Enforce and monitor road safety standards; • Follow best practice to prevent the creation of breeding areas for vermin; • Spray construction areas and roads regularly with water to suppress dust emissions; • Ensure that potentially disturbing construction noise is not produced outside of working hours; • Provide safety training, traffic management and place a high priority on public safety • Ensure that the workers camp(s) and construction areas are open only to formal employees; • Develop and enforce a strict code of conduct for workers to regulate behavior in the local communities; • Provide awareness training to the workforce regarding the transmission of STDs, and traffic safety awareness;
Exposure of staff to health and safety hazards	Moderate	• Develop and implement operating procedures cognizant of the health and safety hazards at the reservoir and treatment plant • Provide training to staff at the facilities and ensure they have appropriate PPE for work at the sites
Exposure of the surrounding and downstream communities to dam safety hazards	Major	• Structural dam integrity monitoring; • Establishment and implementation of emergency preparedness plans; • Maintenance of the perimeter fencing around the reservoir; and • Creation of awareness among the surrounding community on safety and coexistence with the dam
Land acquisition		
Loss of land and livelihoods for affected people	Major	• Cash compensation based on market value of land or provide with option of replacement land within the village if available of equivalent size and quality; • Cash compensation to be provided for lost agricultural productivity during the construction period; and • Reinstatement of land to a least the condition it was in prior to construction.

Conclusion

Although potential adverse impacts were identified in the construction and operation of the proposed project, various opportunities were also identified for the mitigation of these impacts. It is considered that with good environmental and social practices and procedures during construction, the project has potential to enhance benefits while avoiding environmental degradation. The requirements identified for the contractor(s) in this Report will ensure environmental protection, health and safety of the workers and the general public. Sound environmental management practices during operations will also enhance community benefits and social acceptance of the project.

An environmental audit of the project is recommended upon completion of the construction works to corroborate the implementation of the proposed mitigation measures. Any unforeseen project impacts shall be identified and addressed through annual environmental audits. The Consultant proposes that project approval and an Environmental Impact Assessment license be issued by NEMA based on the environmental management measures contained in this ESIA Study Report.

1. Introduction

1.1. Background

Athi Water Services Board (AWSB), on behalf of Tanathi Water Services Board (in whose area Machakos is located) has commissioned a feasibility study and conceptual design of the Machakos Water and Sanitation Project.

The objectives of the feasibility study are to, inter alia, investigate the current level of service, operations and adequacy of the existing water supply and sanitation infrastructure in terms of quality and quantity with a view to determining the feasibility, adequacy, efficiency, rehabilitation and augmentation potential within the framework of providing water and sanitation services to the target population in the most economical way.

Most of the existing water supply and sanitation infrastructure in Machakos is old and dilapidated and requires rehabilitation and augmentation to meet the present and future demands of the fast-growing population of Machakos Town.

1.2. Existing water supply system in Machakos

1.2.1. Water sources

The Town depends on three main sources for its water supply (i) Maruba dam, (ii) Nol-Turesh supply, and (iii) boreholes. However, these sources are unable to meet the current demand since the total production is far below the current estimated demand of 22,315m^3/d. As such, severe water shortages are experienced. The demand is expected to rise to approximately 32,208m^3/d in the year 2030 and 41,922m^3/d in the ultimate year (2040).

1.2.1.1. Maruba dam

Maruba Dam is located about 4km to the Southwest of Machakos Town. The dam was raised by 6m by the National Water Conservation and Pipeline Corporation (NWCPC) in 2010 and this increased its storage capacity to 2.45 x 10^6m^3. Other works carried out by the Corporation at the time included: rehabilitation of the dam spillway; rehabilitation and expansion of the water treatment works and staff houses; expansion of the water treatment plant to match the increased capacity of Maruba dam; and replacement of the treated water mains to Iveti tank.

Raw water abstracted from the dam is treated in a conventional water treatment plant (TP1) located about 300m from the dam on the downstream side. This treatment plant has a design capacity of 3,500m^3/d but is currently only producing about 1,500m^3/d. A composite treatment plant, (TP2) with a capacity of 600m^3/d, was later constructed adjacent to the old plant which currently produces 400m^3/d.

The treatment units for TP1 consist of six vertical flow sedimentation tanks and four rapid gravity sand filters. Treated water is stored in a clear water tank where it is chlorinated before being pumped to Iveti tank. There are 3 pumps (1 standby) which operate for 18-21 hours a day although they were originally designed for 24-hour operation. There is no standby generator.

In 2010, NWCPC constructed a treatment plant of capacity 5,000m^3/d (TP3) adjacent to TP2. Production from these plants however, was reported to be below the design capacity at only 3,500m^3/d.

The quality of the raw water is poor, with high turbidity due to siltation of the dam. As a result, large quantities of Alum are used for coagulation. In addition, there are no jar test facilities and the quantity of alum required is estimated.

The treated water is pumped via two rising mains from which there are consumer connections: one consisting of a 150mm diameter uPVC line and another one varying in diameter from 150mm to 250mm to the 1,140m^3 Iveti 'A' Tank. At the time another treatment plant was constructed in 2009 (see above), a 150mm diameter main was laid up to a new 225m^3 tank in Kiima-Kimwe adjacent to the existing one of similar capacity. This

new tank is located about 100m to the southeast of the 6,000m^3 tank that is designed to receive Nol-Turesh water as described below.

The Iveti 'A' tank is a circular, concrete tank located to the north of the town from which water is supplied to the town by gravity. Another tank, Iveti 'B', is located about 35m above Iveti 'A' which is not in use since, as reported by the operators, the pumps at Maruba treatment works cannot supply water to this tank.

1.2.1.2. Nol-Turesh water supply

Nol-Turesh water supply system was designed to supply 5,800m^3/d to Machakos Town. It was designed to draw water from a spring on the foot of Mount Kilimanjaro in Oloitokitok. The water is of good quality and the only treatment provided is chlorination at source. A 550mm diameter steel gravity main is laid up to Pumping Station No. 1 (PS1) at Kiima, about 125km away. PS1 is designed to lift the water for about 10km to a 500m^3 reservoir at Kiima-Kiu near Salama where there are booster chlorination facilities. From this reservoir, 400mm and 300mm diameter gravity mains of total length 35.3km, are laid to Machakos Town.

There are twin-3,000m^3 rectangular reservoirs adjacent to each other in Katoloni to the south of Machakos Town designed to store water from Nol-Turesh. These reservoirs, with a total capacity of 6,000m^3, were constructed in 1989 and are in good structural condition.

Due to high demand in the areas along the pipeline route from Mount Kilimanjaro, and frequent breakdown of the pumps at PS1, very little water is normally received in Machakos.

1.2.1.3. Boreholes

The total number of boreholes that had been drilled within Machakos Municipality by the year 2009 (including private ones) is shown on the Table below. A number of other boreholes have been developed since then. Some of the boreholes are owned by Machakos Water and Sanitation Company (MAWASCO) and these supply consumers through the existing distribution network.

At the moment, Machakos County Government has commissioned the drilling of approximately 70 boreholes at various locations around the County to alleviate the water problem.

Table 1-1 Boreholes within Machakos Municipality

	Locality	No of Boreholes	Depth Range (m)	Tested Yield Range (m^3/h)
1	Machakos Town	35	36 - 178	0.59 – 14.5
2	Katelembu	4	91 - 149	1.44 – 10.8
3	Mua Hills	6	90 - 136	Nil – 10.86
4	Katheka-Kai	3	91 - 153	8.16 – 20.7
5	Kyanguli	1	140	5.1
6	Kaumoni	1	84	3.4
7	Kitanga	1	47	Nil
8	Mathathani	2	92 - 134	Nil - 0.7
9	Kaani Market	1	167	0.3
10	Kyumbu	1	57	3.9
11	Ngelani	1	58	1.32
	Total	**56**		

Data from the existing boreholes suggests that the area has a moderate to low groundwater potential. The yield of a borehole in most areas is expected to be less than 10m^3/h depending on the subsurface conditions encountered, depth drilled and the construction and development of the borehole.

The rate of borehole failure in the County is also a high. Some of the boreholes after being constructed, fail to produce water or the water they produce is not viable. The failure is caused by several factors such as:

- Geology: this is one of the major factors since the dominant lithologies in the area are metamorphic and igneous rocks. These rocks are known to be compact and very dense and therefore they do not make good aquifers. A good aquifer is one that has a good network of joints, faults and fractures or is porous so as to allow water to flow. Metamorphic and igneous rocks have fewer joints, faults and fractures and they are not porous and this makes them poor aquifers. The few aquifers present in this region are found in those zones that are rich in joints or zones rich in weathering.

- Over-extraction: this is a significant problem especially around Machakos town. Over-extraction results in drops in the water table, which may drop to depths exceeding the depths of the boreholes in the area.
- Precipitation of minerals in the aquifer: the precipitation causes blockages leading to borehole failure. The conditions for precipitation of these minerals are optimum when the borehole is being pumped. Therefore, to solve this problem the time for pumping water in the borehole has to be reduced.
- Prolonged drought is the other climatic factor experienced by the County, and which leads to a fall in the water table.

1.2.1.4. Storage

There are various storage tanks within Machakos Municipality, some of which are not in use. These are as shown in the Table below:

Table 1-2 Existing storage tanks

Tank	Capacity (m^3)	Approx. Ground Elevation (m)	Remarks
Nol-Turesh (Katoloni)	6,000	1685	Twin 3000m^3; receives very little water
Iveti A	1,140	1664	
Iveti B	1,200	1699	Not in use, in poor condition
Kiima Kimwe 1	225	1710	In good condition
Kiima Kimwe 2	225	1710	Recently constructed; in good condition

The total storage, as shown in the Table above is 7,590m^3 excluding the Iveti B tank which would need replacement subject to a detailed investigation of its water-retaining ability.

1.2.1.5. Distribution network within Machakos Town

The existing distribution network within Machakos Town consists of Galvanized Iron (G.I), uPVC and asbestos cement (AC) pipes of varying sizes from 50mm to 150mm. Many of these pipes are in poor condition and bursts occur whenever the level of water in the storage tanks is high, leading to high levels of unaccounted-for water (UfW).

1.3. The proposed project

The proposed project entails the design and construction of new water supply infrastructure comprised of a reservoir on Miwongoni River, treatment works, transmission lines, storage tanks and a distribution network for Machakos Town. The project also entails rehabilitation of the existing infrastructure. A detailed description of the Project is provided in Chapter 2 of this Report.

1.4. ESIA rationale

The Environmental Management and Coordination Act (EMCA) 1999 and the Amendment Act of 2015 provide for the preparation and submission of an ESIA Study Report before undertaking a project of the proposed nature. This Study Report has been prepared to comply with Section 58 of the EMCA, 1999 and the Amendment Act 2015, Legal Notice No 150 on the Act, Part 2 Section 7 of the Environmental (Impact Assessment and Audit) Regulations, 2003, Legal Notice 101, and other relevant regulations.

1.5. Objectives of the ESIA

The overall aim and purpose of the study was to assess environmental and social impacts that are likely to arise from implementation of the proposed water supply project. Specific objectives of the ESIA study were to:

- Collect and analyse baseline environmental and socioeconomic data in the study area;
- Identify and assess potential environmental impacts in the design, construction and operation of the proposed project;
- Liaise with interested and affected parties in the area to seek their views on pertinent issues related to the proposed project;

- Identify mitigation measures for the actual and potential adverse impacts; and
- Develop environmental and social management plans suitable for the proposed works, activities and anticipated environmental impacts.

1.6. ESIA methodology

The ESIA was carried out in line with the provisions of the Environmental Management and Coordination Act, 1999, the Environmental (Impact Assessment and Audit) Regulations 2003, as well as international guidelines on environmental and social impact management.

1.6.1. Scoping

A scoping exercise was carried out to determine the range of issues to be addressed in the ESIA, the significant issues that would need detailed study and those that were not significant. Determination of the boundaries of the ESIA in terms of the geographical extent and timing was also done. A Terms of Reference for the ESIA study was thereafter prepared and was approved by NEMA on 28th July 2017.

1.6.2. Literature review

The Consultant reviewed literature related to the proposed project and the project area. These included feasibility studies and design reports for the project, and other studies on physiography, geology, hydrogeology, water resources and socio-economics of the project area. Both local and international legislation, policies and procedures in social and environmental management were also reviewed.

1.6.3. Baseline data collection

Baseline data was collected on the proposed project sites and the immediate neighborhood in the period between April and December 2017. The data collected was on aspects such as: topography; local flora and fauna; soils and geology; existing and past activities including human settlements; local surface and ground water resources; ambient air quality and noise levels (qualitative); waste management practices; and natural resources and cultural heritage aspects of the project areas.

1.6.4. Identification, prediction and determination of environmental impacts

A systematic approach was used to rank identified impacts according to their significance determined by consideration of project activity **event magnitude** and **receptor sensitivity**. The expected significance of environmental impacts was assessed considering:

Event Magnitude determined by the following parameters:

- **Extent** – the size of the area across which the effect of the activity extends;
- **Duration** – the length of time over which the effect of the activity occurs;
- **Frequency** – how often the activity occurs; and
- **Intensity** of the impact – concentration of an emission or discharge with respect to standards of acceptability that include applicable legislation and international guidance, its toxicity or potential for bioaccumulation, and its likely persistence in the environment, and degree and/or permanence of disturbance or physical impact

Receptor Sensitivity determined by:

- **Presence** – whether biological species present are unique, threatened, protected or not vulnerable and are present during a period of high sensitivity (e.g. breeding, spawning or nesting). For human receptors, whether they are permanently present to uncommon in the area of impact and for physical features whether those present are highly valued or of limited or no value. For physical receptors/features, whether they are national or international value (e.g. state protected monument), local or regional value and is sensitive to disturbance or none of the above; and
- **Resilience** – how vulnerable people and/or species and/or features are to the change or disturbance associated with the environmental interaction with reference to existing baseline conditions and trends (such as trends in ecological abundance/diversity/status, ambient air quality etc.) and their capacity to absorb or adapt to the change. For physical receptors/features, highly vulnerable, undergoes moderate

but sustainable change which stabilizes under constant presence of impact source or unaffected or marginally affected.

Socio-economic impacts were also assessed considering event magnitude and receptor sensitivity. However, a more qualitative approach was applied, which considers how significant the change would be on social, economic and cultural dynamics, the potential for governmental and stakeholder intervention, the value of the receptor (on a local, regional, national or international scale) and the resilience of the receptor to change or adapt to a given change.

Impact significance was assessed considering existing control measures that are incorporated into the project design.

Sets of criteria were defined for both impact magnitude and receptor sensitivity and these were then combined in an appraisal matrix to identify relative degrees of impact significance. The matrix was accompanied by ancillary definitions of the resulting final significance categories.

1.6.5. Stakeholder consultations

Stakeholder consultations were carried out to: inform project stakeholders of the proposed project; to explain the likely impacts (positive/negative) of implementing the project; and to obtain views, concerns, comments and suggestions from interested and affected parties regarding the proposed project.

Stakeholder identification and analysis was carried to determine who were the project affected people and the most appropriate means of engagement. The methods of engagement ranged from questionnaires, interviews and public meetings with the stakeholders.

1.6.6. The ESIA team

The Environmental and Social Impact Assessment was undertaken by a team of consultants from Howard Humphreys (EA) Limited that included the following:

- Simon N. Wandeto – Environmental Lead Expert;
- Lydia Njeru – Sociologist and Associate Environmental Expert

As required under Regulation 14 of the Environmental (Impact Assessment and Audit) Regulations 2003, Howard Humphreys (East Africa) Limited is registered by the National Environment Management Authority (NEMA) as a Firm of Experts. The above named environmental experts are registered and licensed by NEMA as Environmental Impact Assessment and Audit Experts. Registration certificates and licenses for the Firm of Experts and Lead Expert are attached in **Appendix A** of this Report. The ESIA team was also supported by other experts who included:

- Eng. Anthony Bichii – Water Engineer;
- Eng. Walter Muira – Water Engineer;
- Peter Mugo – Surveyor; and
- Wilberforce Oundo - Valuer

2. Project description

2.1. Project location

The proposed project is located in Machakos County and will mainly target the population in Machakos Central Division comprised of the town and surrounding areas. The Figure below shows the location of Machakos County, and Machakos Central Constituency.

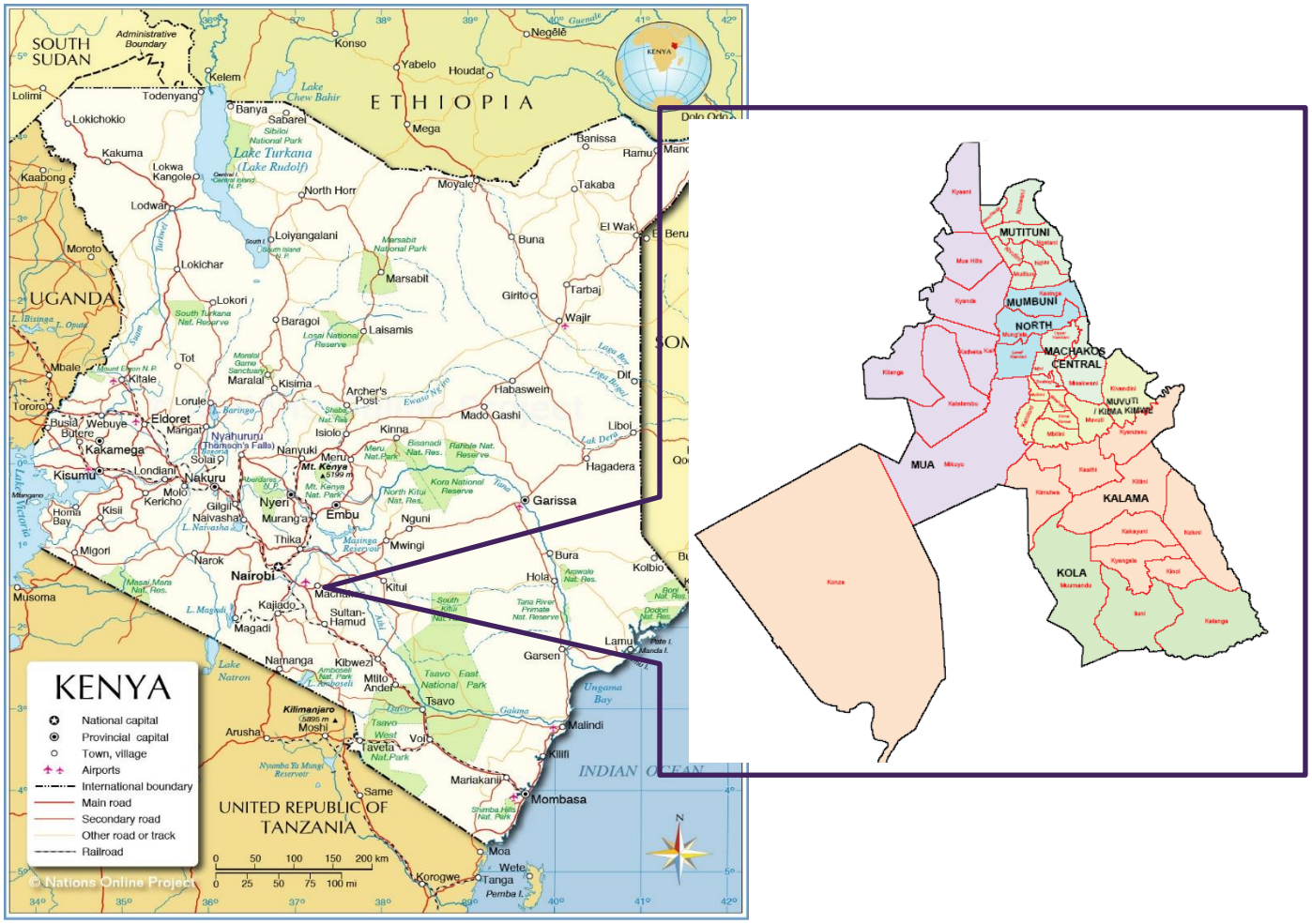


Figure 2-1 Map of the project location

2.2. Project baselines

2.2.1. General

The proposed scheme has been designed for the ultimate (year 2040) demand.

2.2.2. Water demand

The water demand for the entire Machakos Municipality is shown in the Table below:

Table 2-1 Water Demand Projections for Machakos Municipality

Location	Water Demand (m^3/d)			
	Present (2017)	Initial (2020)	Future (2030)	Ultimate (2040)
Machakos Town	12,847	14,164	18,450	23,917
Rural areas	9,468	10,468	13,758	18,005
Total	**22,315**	**24,632**	**32,208**	**41,922**

2.3. Proposed works

It is proposed that raw water be abstracted from an intake on Miwongoni River and transmitted by gravity to a full conventional treatment works located near the confluence of Maruba and Miwongoni Rivers, about 650m from the intake. The treated water will then be pumped to a new storage tank at the offices of Katelembu Co-operative Society. From this tank, water will flow by gravity to Machakos Town to connect to the existing distribution network. The works to be constructed are as follows:

- A 15m high Reinforced Concrete (RC) weir on Miwongoni River;
- Filling of a 1.6 x $10^6 m^3$ reservoir on Miwongoni River;
- A 650m, 600mm diameter steel gravity Raw Water Main from the weir on Miwongoni River to a new Miwongoni treatment works;
- New Miwongoni treatment works of capacity 10,000m^3/d about 300m to the Southwest of the existing Maruba Treatment Works including pumps, staff houses, laboratory, admin block;
- New pumping mains and tanks as follows:
  - 5km long pipe, 450mm diameter steel rising main from the new treatment works to a new storage tank of capacity 6,000m^3 at Katelembu;
  - A new 7.2km, 450mm diameter steel rising main from the new treatment works to Iveti storage tank of capacity 4,000m^3,
  - A new 5.8km, 450mm diameter steel rising main from the new treatment works to Kilima storage tank of capacity 3,000m^3,
- Gravity mains (uPVC) from the proposed Katelembu tank to Machakos Town. This main is 315mm in diameter and has a total length of 6,920m, plus a DN100 uPVC line that will serve the Kyumvi area of length 8.9km (this line is from Katelembu tank via a booster pump of capacity 30m^3/hr head 30m;
- Gravity main of 315mm in diameter, 3.6km that will distribute water from the proposed new Kilima tank of 3,000m^3 capacity. This line joins the Kimutwa system and the Nol Turesh rehabilitated line that will act as a distribution (previously Nol Turesh was a rising main from Kilimanjaro source)
- Machakos Town distribution network consisting of 14,020m of new uPVC pipelines and 3,995m of existing pipelines, uPVC and G.I, to be rehabilitated.
- Rehabilitation of 5No. existing boreholes (includes 1nr borehole at Ngomali area);
- Development of 10No. new boreholes (mostly at Kimutwa and Mua areas);
- Rehabilitation of existing Maruba dam (de-silting using a dredging machine, planting trees around the dam, check dams upstream/silt traps etc.);
- Rehabilitation of existing treatment works at Maruba;
- Replacement of the existing booster pumps to Mutituni;
- Rehabilitation of Kimutwa, Mutituni Market, Kiseveni/Kivandini, Mwanyani/Kyeni, Kenya Israel/Katelembu and Kathemboni water supply networks (to include disposal of existing asbestos pipes)
- Rehabilitation of Emali/Nguu-Masimba water supply scheme;
- Rehabilitation of Nzai water supply scheme;
- Construction of MAWASCO office Block;

Figure 2-2 Proposed site for Miwongoni dam

Figure 2-3 Proposed site for Miwongoni treatment works

Figure 2-4 Proposed route for the transmission line from Miwongoni treatment works

Figure 2-5 Proposed site for Kilima water storage tank

Figure 2-6 Proposed site for Katelembu water storage tank

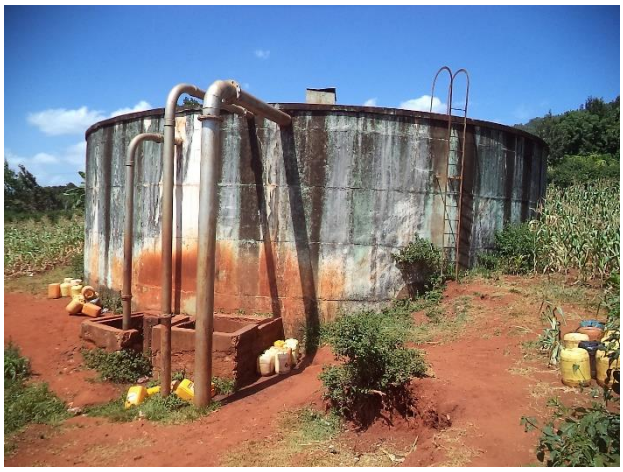


Figure 2-7 The existing Iveti tank to receive additional supplies of water

2.3.1. Hydrology of Miwongoni River

Abstraction from Miwongoni River is proposed, and a hydrological study of the river was carried out at feasibility stage and the safe yield at 95% (Q95), 80% (Q80) and 50% (Q80) reliability was determined to be 3,456m^3/d, 6,912m^3/d and 15,552m^3/d respectively. The Hydrological Study Report is included in **Appendix D** if this Report.

A run-of-the-river abstraction from Miwongoni River, based on Q_{95}, is not sufficient even for the initial (year 2020) demand of 14,164m^3/d for Machakos Town. Storage is therefore required, whereby a 15m-high reinforced concrete (RC) weir is proposed which will have a storage capacity of 1.6million m^3 of water.

2.4. Conceptual design criteria

2.4.1. Criteria for design of the Intake Works

The proposed intake works will consist of a 15m high reinforced concrete weir across Miwongoni River with an intake chamber. A suitable river cross section for construction of the weir has been taken into consideration, that is, good geological formation and shape of valley that allows the shortest length of weir.

2.4.2. Criteria for design of pipelines

As recommended by the Practice Manual for Water Supply Services in Kenya, the velocity of flow in the pipeline has been limited to 0.5 - 2m/s and the minimum pressure to about 10m.

2.4.3. Criteria for design of storage tanks

Storage tanks have been sized to provide ½ day storage as recommended by the Practice Manual for Water Supply Services in Kenya. The tanks will provide storage required to even out fluctuations in demand and supply and for emergency storage when there is no flow from the treatment works. They will also act as balancing tanks to reduce peak flows in the distribution mains.

2.4.4. Criteria for design of the distribution network

The network has been sized to deliver the total daily demand at the various nodes and also to maintain a minimum residual pressure of 1bar (10m water head) as recommended by the Practice Manual for Water Supply Services in Kenya.

The Hazen-Williams formula, with a friction factor, C, of 130 for new steel pipes, 140 for new uPVC pipes and 110 for existing pipes, has been used for conceptual designs. A comparison has been made with the Darcy-Wiesbach formula, with a friction factor of 0.05mm for new pipes. This factor includes normal friction losses in bends and fittings along the pipelines.

The sections below describe each component of the proposed works.

2.5. Intake Works

The proposed intake on Miwongoni River is at an approximate elevation of 1,572.5m asl in order to facilitate gravity flow to the Treatment Works, some 650m downstream at an elevation of about 1,563m asl. The site is approximately 500m to the North-West of the existing Maruba Treatment Works. The proposed site has been chosen where the river valley is relatively steep and therefore the length of the proposed weir is as short as possible. The approximate UTM co-ordinates of the proposed intake are: 37M 302640mE, 9828995mS.

The intake consists of a concrete weir, 15m high, with wing-walls and an intake chamber at the side. Scour and compensation flow pipes are provided which can be operated from a bridge directly above the weir.

The suitability of the weir site as the dam axis, as well as the use of the weir as dam core of the proposed 40m high earth dam (under a separate consultancy) will however need to be confirmed during design of the dam.

2.6. Raw water main

The raw water gravity main is a DN600 steel from the proposed weir on Miwongoni River to a new treatment works (Miwongoni treatment works). The approximate length of the raw water main is 650m.

A 600mm diameter pipe is adequate to transmit the full 25,000m^3/d that will be available from Miwongoni Dam which is to be constructed later in Phase 2.

2.7. Treatment works

At the proposed intake, the quality of the raw water is poor as the catchment is heavily settled and has little vegetation cover. Full conventional treatment (comprising chemical dosing using alum followed by coagulation/flocculation, horizontal flow sedimentation, rapid sand filtration and disinfection using chlorine) is therefore proposed. Horizontal flow sedimentation tanks are proposed due to the consistency of the quality of the treated water produced (they are not significantly affected by variations in raw water quality) and their ease of operation, although they require a larger area compared to vertical flow tanks of the same capacity.

The proposed Miwongoni treatment works is located near the confluence of Maruba and Miwongoni Rivers, about 300m to the Southwest of the existing Maruba treatment works.

2.7.1. Treatment works units

The dimensions of the main 20,000m^3/d treatment works units are as follows:

- Flocculation Basins (horizontal sinuous flow) - 4No. 10m x 9.75m
- Sedimentation Tanks (horizontal flow) - 4No. 37m x 10m
- Filters (Rapid Gravity Sand) - 8No. 6m x 5m
- Clear Water Tank (circular, reinforced concrete) - 1No. 1,000m^3 capacity

The treatment works is also provided with an administration building, chemical/chlorine building and store as well as staff houses.

2.7.2. Pumps

Pumping will be required from the Clear Water Tank to the proposed Katelembu Tank and to the backwash tank for use within the treatment work site. 2 sets of pumps are provided in the pump house i.e. backwash pumps and main pumps to Katelembu Tank. These pumps are located in the same pump house with similar suction and delivery pipework.

2.7.2.1. Backwash water pumps

2 No. electrically driven centrifugal pumps, 1 No. duty, 1 No. standby, are proposed together with suction and delivery pipework. Each will be capable of delivering 80m^3/hr against a total head of 25m. The pumps will be sited so as to provide a positive suction. Treated water will be pumped via a 300mm diameter rising main to a 250m^3 elevated steel tank. This tank will also supply treated water to the Staff Housing, Administration Building and for mixing of chemicals.

2.7.2.2. Pumps for supply to storage tanks

Treated water will be pumped to the storage tanks using 4 pumps (3 duty + 1 standby). The capacity of each pump is 139m^3/hr against a total head of 159m.

A summary of the pumps (which are all centrifugal, end-suction pumps) is given in the Table below.

Table 2-2 Pumps at treatment works site

Description of Pumps	Duty Pumps	Standby Pumps	Discharge (m^3/h)	Total Head (m)	Power (kW)
Main pumps to storage tanks	3	1	139	159	90
Backwash Pumps	1	1	80	25	10

2.8. Treated water rising main

The rising mains have been designed to transfer 10,000m^3/d to Katelembu Tank, and 10,000m^3/d to Iveti Tank. The rising main to Kilima Tank is designed to transfer a similar amount while rationing supply on either of the two other tanks until construction of Miwongoni Dam and expansion of the treatment works. Due to high pressures expected on the lines, steel pipelines are proposed.

2.9. Storage

Proposals include 6000m^3, 4000m^3 and 3000m^3 storage tanks at Katelembu, Iveti and Kilima. The tanks will provide storage required to even out fluctuations in demand and supply and to provide emergency storage when there is a breakdown in pumping equipment. The Practice Manual for Water Supply Services in Kenya recommends that the storage capacity required for balancing should be 18 hours when the reservoir is served by pumping, and 8 hours if there is more than one independent system. After construction of the proposed tanks, Machakos, which will be served by more than one pumping system (including the existing Maruba Dam system) will have about 12-hour storage in the initial year 2020.

2.10. Distribution mains

The distribution pipelines to be constructed include:

- The pipeline from Katelembu Tank to Machakos Town and the distribution network in Machakos town;
- The pipeline from Katelembu Tank to Kyumvi area (towards Mombasa road junction) via a booster pump;
- The pipeline from Machakos town distribution network towards Kaseve existing tank;
- The pipeline from Kilima tank towards Kimutwa where it joins the existing Nol Turesh pipeline

2.10.1. Distribution main from storage tanks

The distribution main from Katelembu storage tank to Machakos Town is a gravity main to be laid along the road from Mombasa Road Turn-off to Machakos Town. The pipeline route will pass near areas of heavy settlements or where settlements are currently being established (e.g. Kenya-Israel area).

For all the major distribution mains, Class C uPVC pipes are proposed due to their light weight and low cost, good hydraulic performance (low frictional resistance to flow) and resistance to corrosion. A total of 27,613m of new distribution mains are proposed to be laid. The Table below shows a schedule of the proposed new distribution mains described above.

Table 2-3 Proposed new distribution mains

Description	Pipeline Size (mm)	Pipe Material	Approx. Length (m)
Katelembu Tank to Nairobi-Machakos Road Junction	315	uPVC	1,220
Katelembu Junction to Machakos Town	315	uPVC	5,700
Katelembu Junction to Kyumvi area	110	uPVC	8,900
Kilima Tank to Kimutwa area	315	uPVC	3,593
Machakos Town to Kaseve	160	uPVC	3,900
Machakos Town to Kaseve	110	uPVC	4,300
Total			**27,613**

2.10.2. Distribution network within Machakos Town

A schedule of new pipe sizes for the distribution network in Machakos town is given in the Table below.

Table 2-4 Proposed new distribution network in Machakos Town

Pipeline Size (mm)	Pipe Material	Approx. Length (m)
110	uPVC	6,155
200	uPVC	4,055
250	uPVC	3,810
		14,020

Where there are existing AC (Asbestos Cement) pipes, they will be replaced with new uPVC pipes as they contain asbestos which has negative impacts on human health. New mains are also proposed to cover areas within the town that are currently not served. Where the existing pipes (G.I and uPVC) are found to be adequate, it is proposed that they be rehabilitated and re-used.

Only pipes of diameter 110mm or greater are considered. It is assumed that pipes smaller than 110mm diameter will be laid by the water company as they connect new consumers. A schedule of these existing pipes to be rehabilitated is shown in the Table below.

Table 2-5 Existing distribution mains in Machakos Town to be rehabilitated

Pipeline Size (mm)	Pipe Material	Approx. Length (m)
150	GI	1,120
160	uPVC	2,610
200	uPVC	265
		3,995

2.11. Description of expected project activities

2.11.1. Construction overview

Construction of the bulk water supply and distribution infrastructure is expected to be undertaken by contractor experienced in the type of work, who would be contractually obliged to complete the works in accordance with approved construction programs, project specifications, applicable government regulations and requirements, project permits and authorizations.

The Contractor is expected to develop construction programs which would consider factors such as critical habitat protection, ground conditions, topography, hydrology, presence of pre-existing infrastructure and weather conditions.

Within the regulatory framework, the selection of detailed construction methodologies and plant for the works would be the responsibility of the contractor. As such, a detailed approach in terms of the construction methodology cannot be defined at this stage. The sequencing of the construction activities and the direction of construction would also be at the contractors' discretion.

Prior to the commencement of the construction program, the construction contractor would develop method statements for the works to be performed. These documents would incorporate the reasonable requirements of landowners/occupiers and agencies such as NEMA, WRMA and other regulatory authorities in Kenya, and the mitigation measures outlined in this ESIA.

2.11.2. Pre-construction works

All construction activities would be undertaken within demarcated areas based on the design and the construction contractor's method statements. Dam construction would take place on the demarcated areas for the weir and reservoir. Transmission and distribution pipelines construction and rehabilitation would also be on a strip of land known as the 'working width', which would generally be 5m wide within the residential areas/farmlands and 3m in developed areas of Machakos.

Before construction begins on the pipelines, the routes would be surveyed and marked to establish the precise alignment. The pipeline routes would be expected, as far as practicable, to avoid and/or minimize direct impacts on private property and on known resources.

2.11.2.1. Access roads

Access to work areas around Machakos town is not expected to be a problem as these are mostly along existing roads. However, a new access road to the Miwongoni reservoir site and treatment works site would have to be created to give adequate and safe access for equipment, materials and personnel to the construction site and permanent works.

There are existing tracks to project sites which would, to the extent possible, be used and upgraded to the bare minimum required, to minimize the creation of new accesses.

2.11.2.2. Materials and equipment transport

An important aspect of the construction process is the transport of rock, aggregate, sand, cement, steel, pipe sections, plant and other equipment to the construction areas, dedicated storage areas and construction camps. Transportation would be accomplished through the use of the existing and new road infrastructure in the project areas. Materials for the RC weir, treatment works, and pipe delivery would represent the majority of movements associated with the construction phase.

Although some of the pipe sections can be transported directly to the ROW, it is likely that most would be stored initially in pipe yards. From the pipe yards, pipe sections would then be transported to the ROW on trucks that would travel along approved access routes.

2.11.2.3. Temporary construction facilities

Temporary facilities comprise storage yards, project offices and construction camps. The location and number of sites would be determined by the construction contractor and agreed with the Project Management Team. The construction contractor would be required to assess the environmental/social sensitivity of the site(s) prior to their approval for adoption.

Potential sites for construction camp and storage yards would be identified based upon but not limited to the following criteria:

- Sufficient ground for pipe storage to meet anticipated quantities;
- Reasonable road access/egress; and
- Proximity and access to construction sites.

2.11.3. Construction procedures

2.11.3.1. Setting out/staking of the facilities and pipeline route

The initial activity associated with construction is the final surveying and setting out or staking of the plinth areas, pipeline Right of Way (ROW) and any additional temporary workspaces. This may include flagging to indicate the construction workspace boundaries. Environmental compliance personnel would participate in the pre-construction identification (e.g. flagging) of environmental resources to be protected during the construction process. Examples of such resources include:

- Identified ecological resources (e.g., tree or plant specimens to be protected); and
- Watercourses, setbacks/buffer zones, and wetlands.

Environmental activities may also comprise additional data collection, rare plant translocation, and pre-construction surveys for rare or protected wildlife. Other activities such as the location and exposure of existing pipelines and other services would also be conducted at this time.

Broadly, the following are the expected construction procedures in advancing the project. These procedures also include best practices for environmental, health and safety management in construction activities:

2.11.3.2. Weir construction

The area to be covered by the 15m RC weir would be pegged out prior to commencement of any works. It would then be cleared and grubbed before excavation.

Construction would begin by de-watering the part of the river valley where the weir would be placed. This would be achieved by diverting the river through a tunnel/channel built through one side of the valley around the planned construction area.

A cofferdam would be built upstream of the main construction area to act as a barrier to the river and cause it to flow through the diversion tunnel. Another cofferdam would be built downstream to prevent water flowing back into the construction area. Pumps would be used to remove any water that seeps through the cofferdams.

Topsoil would be heaped in areas outside of the area to be covered by the weir and all trees, scrub and roots removed. Topsoil would be placed in layers not exceeding 2 meters and planted with grass if it is to be left for a considerable time (more than 6 months). This would conserve the integrity of the topsoil.

While keeping construction site dry, the river bed of the construction site would be excavated until all the organic materials deposited therein have been removed and to the depth where hard foundation is found. The foundation of the weir would be further excavated to reach solid bedrock.

Reinforcement bars would be assembled for the base concrete and weir wall after which the framework (shuttering) would be assembled to enable placing of concrete. Concrete would be poured into the framework layer by layer to the design height.

2.11.3.3. Treatment works, transmission and distribution lines

2.11.3.3.1. Surface preparation and grading

The proposed new Miwongoni treatment works site would require clearing, cutting and filling to obtain the necessary levels for the facility. The pipeline routes would also need to be cleared and graded in some areas to permit the safe installation of the pipelines. This process would include the levelling and stripping of the top cover and the removal of scrub, trees and shrubs. Clearance work would be undertaken using hand tools and earth-moving equipment.

To ensure that the pipeline ROW can be properly reinstated and to allow the re-growth of vegetation, the topsoil and subsoil would be removed as required and stored separately. Areas such as roads that are subject to open trench crossings would be prepared by removing material only directly over the width of the pipe trench. This material would be kept separate from other stripped or excavated material.

2.11.3.3.2. Trenching

The first step of trenching is the staking and marking of the trench centerline. Where possible, existing third-party services (e.g., underground cables or pipelines) would also be located and marked prior to the commencement of excavation work.

The trench would be dug to a depth that allows pipeline installation with a minimum of 1m of cover from the top of the pipe to the pre-existing ground surface. The presence of sub-surface structures (such as other pipelines) and surface features (such as hills, rivers) may require deeper installation of the pipeline in some areas.

The trenching operation would be undertaken using methods to suit the local terrain and ground conditions. It is expected that trenching equipment would include hand tools, backhoes and/or excavators. In confined areas, such as areas adjacent to existing pipes, a combination of backhoes and hand tools would be used to open and reinstate the trench.

Where the ROW is near settlements, measures would be taken to limit public access to the ROW or excavated trench. At locations where it is necessary to provide public access across the trench, safe trench crossings would be constructed. Warning signs and barricades would be erected around the trench, and adequate warning lights/reflective material would be provided during the hours of darkness.

2.11.3.3.3. Pipeline crossings

Crossings are defined as the intersection between the proposed pipeline route and pre-existing features such as rivers/watercourses, public roads/ tracks, and underground services.

The construction technique chosen for watercourse crossings would be subject to ground conditions i.e. topography and size of the watercourse. This could range from open-cut crossings where the construction methodology would assume assume flowing water, or the immediate potential for flowing water during construction. To avoid interruption of the flow of the watercourse, wet-trenching or flumed water crossing techniques would be used. Where appropriate and advantageous, seasonal constraints on construction activities could be imposed to ensure that crossings are built during low flow conditions. Watercourse bank and bed material would be stored separately and would not be placed where flow or drainage will be obstructed. The disturbed portion of the watercourse bed and banks associated with any open cut crossings would be returned to pre-construction conditions, where possible. The trenching of the watercourse banks and

bed would be undertaken immediately prior to installing the pipeline and the trench would then be back-filled as soon as possible following pipeline installation.

Where the size of the watercourse is such that an open cut crossing is impractical, or will result in too much environmental disruption, trenchless techniques could be used. These would include spanned crossings, horizontal directional drilling, micro-tunneling and auger boring. Spanned crossing can be through a single span structure or span structure with in-stream support.

Minor road crossings would be accomplished by open trenching of one-half of the road at a time, maintaining one lane of through traffic at all times. Smaller rural roads could be closed to through traffic, following consultation with local officials and residents. Appropriate signs, barricades, and other traffic management measures would be used to minimize road user inconvenience and promote safety during temporary closure of roads.

2.11.3.3.4. Construction of the water treatment plant

The sequence of the construction program for the WTP is likely to be as follows:

- Site surveying to determine the geotechnical, geophysical and topographical features of the site;
- Perimeter demarcation and setting out;
- Establishment of temporary fences and gates;
- Site clearance and preliminary grading;
- Establishment of construction facilities (e.g., materials stores, laydown areas, offices etc);
- Site excavation and placement to achieve the required cut and fill profile for the facility;
- Installation of underground piping, drainage systems, utility lines and chambers;
- Construction of buildings and other structures;
- Connection of the facility to the raw water and treated water mains;
- Installation of all above ground utilities and services;
- Placing of granular surfacing to all unpaved areas;
- Landscaping (as necessary) including the supply, planting and establishment trees and other appropriate plant species; and
- Reinstatement of temporary and permanent roads, services and other items that have been damaged because of the work.

2.11.3.3.5. Pipeline testing and commissioning

The pipelines would be subjected to hydrostatic pressure testing to prove the strength and integrity of the pipeline system. Hydrostatic testing of the pipeline would involve filling sections with water and raising the pressure to a minimum of 1.5 times the maximum allowable operating pressure. The pipeline would be tested in sections to:

- Limit the volume of test water needed at one time;
- Limit elevation changes, allowing the test pressure to be maintained between the minimum required test pressure and maximum pressure which the pipeline will safely withstand; and
- Accommodate the maximum stress criteria for each wall thickness.

Hydrostatic testing activities would be carried out in sequence and would include the following:

- plugging each end of the pipeline test section;
- Controlled filling of pipeline sections with water;
- Pressurization of the pipeline test section;
- A test pressure hold period (i.e., commencement of up to 24-hour strength and leak test);
- De-pressurization of the pipeline test section;
- Controlled dewatering of the pipeline test section; and
- Removal of test ends.

The displaced hydrostatic test water could be transferred to another section of pipe or discharged at a suitable location. Discharge locations and rates would be agreed in advance with the relevant authorities.

2.11.3.4. Drilling and commissioning of boreholes

2.11.3.4.1. Borehole depth and diameter

The Contractor shall drill to such depth and diameter as will be instructed by the Engineer. The borehole will not be acceptable if drilled to such depth and diameter other than that instructed by the Engineer.

2.11.3.4.2. Drilling methods

The drilling method shall be any of the following four methods:

- Down-the-hole hammer with air or foam;
- Direct rotary with air and foam (light or boosted);
- Direct rotary flush using a water-based fluid;
- Reverse-circulation rotary

2.11.3.4.3. Sampling and cutting

Geological samples of dry weight 500g shall be collected at 2m intervals, and at prominent lithological boundaries. These will be sun- or oven-dried, packed in polythene bags of appropriate size, and clearly marked with tie-on labels indicating date of collection, depth interval and the borehole name and number. These shall eventually be logged on site by the Supervisor.

2.11.3.4.4. Temporary casing

Installation and diameter of any temporary casing required for the construction of each borehole shall be left to the Contractor so long as the finished product meets the borehole specifications.

2.11.3.4.5. Plain and screen casing

Well casing shall be mild steel manufactured in accordance with applicable parts of ASTM A 139 Grade B, with the following additions:

- Welding shall be by the butt welding arc process using at least two passes on the outside;
- Casing shall be 6 ¼ inches outside diameter and ¼ inch wall thickness;
- Casing shall be furnished in 6 metre lengths.

Screen slot size: 1mm slots are recommended. Before installation of casing and screen, the Contractor shall ensure that the hole is clear to total depth and shall flush out any backfilled material if present. The Supervisor, prior to the installation by the Contractor, shall provide the design of casing and screen string.

Externally projecting socketed push-fit and glued or threaded joints will not be acceptable. Where joints are deemed by the Supervisor to be below standard, each joint shall be further secured by means of solvent welding and three self-tapping screws installed at 1200 intervals around the casting diameter. The screws shall be of length sufficient to securely fasten the two sides of the joint together, but shall not project into the wellbore. The top of the casing string shall terminate not less than 0.2 m above original ground level.

2.11.3.4.6. Verticality test

The Contractor shall conduct a verticality test during and after drilling by approved methods to demonstrate that the departure from the verticality does not exceed 3 in 100 between ground level and the base of the borehole. If this departure is exceeded, the Contractor shall make the necessary corrections to the approval of the Engineer. If the error cannot be corrected, drilling shall cease and a new borehole shall be drilled at a position nearby as shall be indicated by the Engineer.

2.11.3.4.7. Gravel pack

The Contractor shall supply suitable gravel pack. The gravel pack shall consist of well-rounded particles of uniform grading with 90% siliceous material and conform to the 2-4 mm diameter. There shall be no clay, shales, silt, fines, excessive amounts of calcareous materials and no crushed rock. The gravel shall be washed before installation. Sufficient amount of gravel pack shall be installed to completely cover the uppermost screen and yonder by an additional 2-metre to allow for setting. A good supply of water shall be introduced with the gravel to prevent bridging. The gravel pack shall be capped with a 2-metre vertical column of clay seal to prevent any seepage that may contaminate aquifers with subsequent pollution of ground water.

The annular space above the clay seal shall be back filled with inert drill-cuttings. The quantity of the gravel pack and backfill to be installed shall be measured using a suitable volumetric method as approved by the Engineer. The Contractor shall provide the Supervisor with the bulk density of the pack material, expressed as kg per m^3.

2.11.3.4.8. Sanitary seal and backfill material

To provide an effective seal to the entry of contaminants, up to 2.0-metres depth of the borehole from the surface shall be grouted using cement slurry 1.65-2.15kg/litre. Grout is to be injected, by a method approved by the Engineer, into the annulus between the casing and the wall of the hole. In addition, any aquifer bearing saline or poor-quality water shall also be sealed.

Backfill material shall comprise fine or clayey drill cuttings and shall be installed from the top of the filter pack to 5 m below ground level (bgl) unless otherwise directed by the Supervisor. The installation method shall ensure that no bridging occurs within the annular space. The Contractor shall measure the depth to the top of the backfill and provide the means by which this level may be measured.

2.11.3.4.9. Yield estimate during drilling

A 900 V-notch flow measurement shall be used in the drain line so that continuous monitoring of air-lift yields can be obtained if the Contractor decides to use rotary drilling method. Care shall be taken to ensure that no floating debris impede the flow of water over the V-notch. The weir shall at all times be kept clear of a build-up of silt and other fines. The Contractor shall provide the calibration curve, to be verified and approved by the Engineer, for the V-notch weir. Average yields shall be read and rated at every aquifer struck and as otherwise directed by the Engineer. For percussion drilling, a bailer test of at least 30 minutes duration shall be carried out for each aquifer encountered.

2.11.3.4.10. Development and cleaning of boreholes

Each borehole shall be comprehensively developed in accordance with modern borehole construction practices. The methods that will be considered include using high-velocity water-jetting and polyphosphate clay strippers to first degrade polymer, and then remove clays, fines and other undesirable debris. This method calls for super-chlorination as a means of hastening polymer degradation by polymer oxidation.

Surging ("Rawhiding") using air, either with or without eductor pipes, is an acceptable alternative method of development. The use of eductor pipe effectively focuses the development energy to specific parts of the screen, allowing development in detail. Fines are flushed to the surface by airlift pumping. Development will be considered complete only when less than 15 ppm of suspended solids remain in the water, provided that pumping test data do not indicate further development taking place during the boreholes pumping tests.

2.11.3.4.11. Physical development

Physical development shall adopt any of the commonly used methods, including but not necessarily restricted to, the following:

- Surging with a surge block;
- High-velocity water jetting;
- Airlift rawhiding;
- Airlift rawhiding with eductor pipe;
- Polishing using a submersible pump

2.11.3.4.12. Test pumping

A test-pumping unit shall be provided for the testing of each borehole. The method for varying the discharge rate of the pump used shall depend on the type of the pump used. Test pumping shall start at least 12 hours after completion of the development and cleaning of the borehole. Sufficient time shall be allowed for the recovery of water levels between each type of test.

Discharge measurement shall be made by volumetric method or otherwise approved calibrated measuring devise. During the test pumping, the discharged water shall be handled and disposed of in an appropriate manner to a point of overland drainage sufficiently far from the well to prevent recharge. The water shall be diverted over a distance of at least 100metre from the wellhead.

During all test-pumping operations, once the flow rate has been determined and preliminary adjustments made, the measured discharge rate shall be maintained within 5% of the required rate for the duration of the test. Failure of the pump operations during the tests shall require abortion of the whole test and the test shall be repeated after recovery of the water level.

The British Standards BS 6316:1992 Code of Practice for test pumping of water wells prescribes the following elements of test pumping:

- A period of recovery after production pumping/development;
- A pre-test (Calibration, typically 2 to 3 hours);
- A period of recovery after pre-test
- A step draw-down test (typically five steps, each of 2 hours duration; total 10 hours);
- A period of recovery after step draw-down test;
- A constant discharge test (typically 48 hours); and
- A recovery test (typically 24 hours).

Test pumping shall comprise of the following activities:

Calibration test: The boreholes shall be subjected to calibration test to establish the approximate yield and draw down characteristics and to decide upon pumping rates for step draw down or constant discharge test. The total duration of calibration test shall not exceed 2 hours.

Step draw down test: This test shall comprise pumping the well at three to five separate discharge rates as shall be specified by the Engineer. Each discharge rate shall be pumped for a period of one hour. The change from one pumping rate to the next shall be effected without stopping the pump, but by means of regulating a gate valve in the discharge pipe, or by other means to be approved by the Engineer. The change from one step to the next shall take place in the shortest time possible. During each step of the test, water levels and discharge measurements shall be taken at appropriate time intervals as shall be instructed by the Engineer; while at the same time electrical conductivity (EC) readings shall be taken. After completion of the last step, the borehole shall be tested at a constant discharge for 24 hours after which a recovery test is to be undertaken. If the borehole's yield is very low (<3 m^3/h), the Engineer may waive the requirement of step draw down test.

Constant discharge test: Separate constant discharge test for maximum duration of twenty-four (24) hours of pumping and twelve (12) hours of recovery shall be implemented at the end of the last step of the step draw down test. The discharge rate at which the well is to be pumped shall be specified prior to the test. During the test, water level discharge measurements shall be taken at the same time intervals as for the step draw down test. Test pumping data from all tests conducted from the borehole shall be supplied to the Engineer. These will show dates, water levels, discharge rates, EC values, times of starting and stopping the pumping, change in discharge, weather and other conditions that could affect the test data. The total duration of the test shall not exceed 36 hours and 12 hours recovery, unless with the written instructions of the Engineer.

2.11.3.4.13. Analysis of test results

Step draw down test results shall be analysed to determine the turbulent pressure losses at the well face, and an estimate of the aquifer's transmisivity to determine a suitable pump rate for the constant discharge test. The constant discharge test shall be analysed to determine whether the aquifer is confined, unconfined or semi-confined; the aquifer's transmisivity; and where measurements from an observation well are also available, the aquifer's storage coefficient.

2.11.3.4.14. Water level observation

The Contractor shall supply appropriate electric contact level gauges for measuring water levels in the borehole to the nearest 10-millimetre at pre-determined intervals. Wellhead arrangements shall permit these gauges to be inserted and passed freely. At the same time the Contractor shall install a dipping tube, minimum 19-millimetre internal diameter (ID) lowered approximately 1-metre above the pump intake or approximately 2-metres below anticipated maximum draw down level. Other methods for measuring water levels are subject to the approval by the Engineer.

2.11.3.4.15. Electrical conductivity (EC) measurement

The Contractor shall have an operational EC meter on site to take electrical conductivity readings whenever required during drilling, development and test pumping.

2.11.3.4.16. Records

The Contractor shall keep daily activities records for each borehole. The records shall contain the following information:

Daily records: The daily records shall contain:

- Site name;
- Borehole reference number;
- Date of reporting;
- Names of drilling team staff;
- Drilling method;
- Bore diameter and depth, including diameter changes and their corresponding depths;
- Depth of the bore at the start and end of shift/working day;
- Depth and size of casing at start and end of shift/working day;
- Description of rocks drilled with depths of transitions encountered;
- Depths of water struck levels;
- Depths of main aquifer;
- Estimated yield of airlift measurement when drilling and developing with air;
- Time log (min/meter), for penetration rates for given type of bit and standby time due to breakdown;
- Depth intervals at which each formation samples are taken;
- Records of components and quantities used or added to the drilling or air;
- Water level at the start of each working day;
- EC measurements;
- Problems encountered during drilling;
- Details on installation in the borehole (if any);
- Depth and description of well plain and screen casing, and
- Details of work to be invoiced at hourly rates (e.g. test pumping)

A copy of the daily record shall be made available daily to the Engineer for signature, including any other pertinent data as may be requested by the Engineer.

Borehole completion records: The following records shall be submitted to the Supervisor within fourteen days of completion of the works at each borehole:

- Borehole number/name and schematic diagram of borehole in section;
- Pumping test times, discharge and water level data;
- Results of chemical analysis;
- Originals of signed daily reports;
- Drilling penetration log;
- Geological log, and
- WAB 28 Borehole Completion Record

2.11.3.4.17. Water sampling

Water samples for testing the chemical water quality shall be taken by the Contractor at the end of the test pumping. The Contractor shall take the samples to a qualified laboratory for bacteriological and chemical analyses.

2.11.3.4.18. Capping of the borehole

The Contractor shall seal the top of each borehole pending installation of a production pump. This seal shall comprise a round plate of mild steel, of thickness not less than 6 mm and diameter 266 mm. This shall be spot-welded to the mild steel sanitary seal casing at 300 centres, such that the plate can be removed with a hammer and cold chisel.

2.11.3.4.19. Acceptance of the proposed borehole

Each borehole shall only be accepted by the Engineer and the Proponent upon satisfactory completion of construction operations as per the technical specifications, and clearance of the site.

2.11.3.4.20. Loss of equipment down the borehole

Any equipment lost down in the proposed borehole shall be removed or the borehole will be considered a lost bore. A replacement borehole will have to be constructed and tested.

2.11.3.4.21. Lost bore/abandoned borehole

In case the Contractor is unable to finish the drilling or has to abandon a well due to the loss of tools or any other accident or contingency, the borehole will be deemed a lost bore. The Contractor shall remove any casing or drill pipe already placed in the hole where this is possible, and refill it to surface with clay or concrete.

2.11.3.4.22. Construction of wellhead

A sanitary seal shall be constructed at the wellhead of each proposed borehole. This shall comprise the following elements:

- A 2m length of 209 mm (8") Outside Diameter (OD) plain mild steel sanitary steel casing installed around the permanent casing string;
- A grout seal between the 209mm sanitary seal casing and the 152mm permanent casing string;
- A 1x1x1 m concrete block cast around the sanitary seal casing.

2.11.3.4.23. Sanitary seal casing

A 2-meter length of 209 mm (8") OD mild steel casing shall be installed around the 152 mm (6") permanent casing string in the conductor pipe hole drilled to 2 meters. This shall project not less than 0.2 m above original ground level and shall be flush with the permanent casing string.

2.11.3.4.24. Grout seal

A sanitary grout seal shall be installed between the 152 mm (6") and 209 mm (8") OD casing and grouted into place. Grout shall be of cement slurry, or cement and fine sand, and shall have a density of at least 1.75 kg/l. This shall be introduced into the annular space from the top of the inert backfill to ground level, using a method that must be approved by the Supervisor.

2.11.3.4.25. Concrete plinth

The ground surface at the wellhead shall be excavated to a depth of one meter, and be one meter square, to allow a concrete plinth to be cast. The 1 x 1 x 1 m pit shall be filled with concrete, to be finished flush with the ground surface. Concrete shall be 1:2:4, OPC: sand: half-inch ballast. This must be cast with two 0.8 m lengths of 12 mm reinforcing bar welded to the 209mm (8") OD casing 0.7 m below ground level.

2.11.3.4.26. Borehole disinfection

The Contractor(s) before demobilization from site will carry out disinfection of the boreholes. This will be done by placing a chlorine solution into the well so that a concentration of at least 50 mg/l of available chlorine exists in all parts of the borehole at static conditions. The borehole's surface above the static water level shall be completely flushed with the solution. The solution shall remain in the borehole for a minimum of 2 hours before pumping the borehole waste.

2.11.3.4.27. Anticipated Wastes

It is anticipated that the following wastes will be generated in drilling of the boreholes:

- Exhaust emission from drilling machines and contractor's vehicles;
- Waste water;
- Drilling mud and foam;
- Drilling cuttings, chips and rock debris; and
- Used oil, and oil filters.

2.11.3.4.28. Clearing the sites

On completion of the boreholes, the sites will be left clean and free from all debris, hydrocarbons and waste, and all pits filled to the approval of the Engineer. If the sites are not delivered clean the boreholes may be unacceptable.

2.11.3.4.29. Water abstraction monitoring

Borehole water meters will be installed to monitor water abstraction levels at each site.

2.11.4. Reinstatement and erosion control

Prior to the commencement of the construction program, the Contractor would develop project-specific Reinstatement Plans based on the project Reinstatement Specification. The project-initiated access roads, pipeline ROW and all other project areas would be re-instated in accordance with the Reinstatement Plans on completion of the works. The contractor would also be required to incorporate reinstatement measures in his method statements for each critical element of the construction program.

The key areas that would require reinstatement include:

- Working areas at the weir/reservoir site and treatment works site;
- The pipeline ROW;
- Construction camps and materials storage yards; and
- Waste management and disposal sites.

2.11.5. Site clean-up

Prior to demobilization of construction personnel and equipment, clean-up activities would be conducted in accordance with environmental standards and industry best practice. Clean-up activities would consist of the removal and/or disposal of temporary buildings, equipment, tools, and excess material brought onsite or generated during the construction and commissioning program.

2.11.6. Operational activities

The main activities that would be undertaken during project operations include:

- Abstraction of water from Miwongoni River;
- Treatment and transmission of water to storage tanks;
- Distribution of water to consumers; and
- Maintenance of the water supply infrastructure.

For the weir and reservoir, regular maintenance and inspections would be required to ensure it remains in a good operating condition. The following regular inspections would be carried out:

- Weekly or more frequent inspections would be carried out by the owner/operator.
- Biennial or intermediate inspections and surveillance reports carried out by a suitably qualified person
- Comprehensive surveillance reports carried out every 5 years by a suitably qualified person

2.11.7. Project decommissioning and abandonment plans

The environmental (Impact Assessment and Audit) Regulations 2003 provide for outlining of activities that shall be undertaken during the project construction, operation and **decommissioning** phases. Further, the environmental management plan shall detail project activities, impacts, mitigation measures, time schedule, costs, responsibilities and commitments proposed to minimize environmental impacts of activities, including monitoring and environmental audits during implementation and **decommissioning** phases of a project.

Decommissioning and abandonment plans for the water supply infrastructure would entail:

- Draining of the reservoir and demolition of the weir;
- Removal of all surface installations;
- Abandonment or demolition of buildings and structures at intakes, treatment works and storage tank sites;
- Disconnection of pipelines from supply of water, and abandonment in place or removal where abandonment causes a risk to the environment; and

- Re-vegetation of the sites consistent with the terrain features and other prevailing conditions.

An ESIA would be prepared prior to implementation of this plan, to assess and minimize potential environmental and social impacts arising from the decommissioning and abandonment operations. This decommissioning/abandonment ESIA would be submitted to NEMA for approval.

2.11.8. Expected inputs and outputs

Table 2-6 Inputs and outputs

Phase	Inputs	Outputs
Pre-construction (Site clearance)	Fossil fuels for running machinery/ equipment; human labor	Biomass from cleared vegetation; Exhaust emissions Dust, noise and vibrations
Construction	• Fossil fuels for running machinery/ equipment; • Water; • Raw materials such as rock, ballast, sand, cement, gravel, iron/steel bars, Steel and HDPE pipes, masonry blocks, etc	Exhaust emissions; Material spoils (wastes); dust, noise and vibrations; construction wastewater
Operation	Routine maintenance/ repairs; Various consumables Chemicals for treatment of water	Sludge from water treatment process and other ordinary wastes
Decommissioning	Fossil fuels for running machinery/ equipment	Solid waste/ rubble; Exhaust emissions; Dust, noise and vibrations

2.11.9. Project cost

A summary of the cost estimates for the proposed project is provided in the Table below.

Table 2-7 Cost estimates for the proposed water supply project

Item No.	Description	Estimated Cost (KShs)
1	Rehabilitate 5No. existing boreholes	11,000,000
2	10No. new boreholes including E&M works	110,500,000
3	Replace existing booster pumps to Mutituni	3,000,000
4	Rehabilitation of Kimutwa, Mutituni Market, Kiseveni/Kivandini, Mwanyani/Kyeni, Kenya Israel/Katelembu and Kathemboni Water supply networks	50,000,000
5	Construction of MAWASCO office Block	40,000,000
6	Weir on Miwongoni River	1,128,000,000
7	Raw water main from intake weir on Miwongoni River	11,112,500
8	New 10,000m^3/d Miwongoni treatment works (including T/W pumps, booster pump at Katelembu junction, electrical works, surge equipment, laboratory, administration office and staff houses)	342,000,000
9	Treated water rising mains to Katelembu/Iveti/Kilima tanks	295,705,680
10	Storage tanks - 6000, 4000, 3000 RC and 250m^3 (elevated)	220,500,000
11	Gravity distribution mains	103,760,814
12	Distribution network in Machakos Town	35,968,000
13	Rehabilitation of Existing Pipelines	10,871,500
14	Rehabilitation of Emali/Nguu-Masimba water supply scheme	48,507,136
15	Rehabilitation of Nzai water supply scheme	28,392,340
16	Environmental and Social Management Plan (ESMP) Budget	18,000,000
	Sub-Total	2,457,317,970
	Add 10% contingency	245,731,797
	Sub-Total	**2,703,049,767**

3. Analysis of project alternatives

3.1. Overview

Various options were analyzed for the Machakos water supply project. The options included the 'No Development' consideration, a run-of-the river system vs impoundment, different dam site locations, and dam design options.

3.2. The 'No Development' option

This alternative assumes the status quo is maintained with no development of the proposed water source and associated distribution network. This would avoid a realization of the impacts concomitant to development and operation of a dam and water supply system. However, with the projected population increase and the growing deficit in water supply, a lack of development of new water sources or expansion of the distribution network could hamper the socioeconomic development of Machakos Town and its environs. Residents could experience an increase in water-borne diseases from consumption of contaminated water, and other economic costs from lost time in search of clean water and/or treatment.

The No development option was therefore discounted on the basis that adequate supplies of clean water are a necessity for population health and socioeconomic growth.

3.3. Run-of-the-river system vs impoundment

Surface water resources in the vicinity of Machakos Town mainly consist of rivers which are seasonal. These rivers and streams do not contain enough flows to enable run-of-the-river supply to meet the high-water demand of the municipality. A hydrological study of Miwongoni river was carried out which established that a run-of-the-river abstraction based on Q_{95}, is not sufficient even for the initial (year 2020) demand of 14,164m^3/d for Machakos Town. Impoundment of the river to store flood flows would therefore be required as it was the only viable option.

3.4. Location of the of the dam

Various studies have identified potential dam sites that could be used as sources of water supply for Machakos Town. Four potential dam sites were identified as follows:

3.4.1. Miwongoni dam site

Miwongoni Dam site is near the existing Maruba Dam. The location of this dam was proposed by Machakos Integrated Dam Project (MIDP) in January 1985. Preliminary work was then carried out on the proposed dam and land set aside for its construction. Compensation for acquisition of the land at Miwongoni dam site commenced with the Commissioner of Lands gazetting an Intention to Acquire the land in 1987. However, this process was suspended by the Ministry of Water in 1992 due to lack of compensation funds. With the commissioning of the Nol-Turesh supply in the early 90's, plans for the development of Miwongoni Dam were shelved. There is renewed interest in the dam now as the amount of water available from Nol-Turesh has reduced considerably. From the time the initial plans for the dam were prepared up to the present time, settlements have come up on part of the area originally set aside for the dam.

3.4.2. Mwania dam site

This is the site of the collapsed KARI Dam on Mwania River that was washed away during the El Nino rains of 1998. The site is located just upstream of the confluence with Mitheu River, into which treated sewage from the existing ponds is discharged. The elevation at this site is about 1550m and therefore water would have to be pumped into the town.

3.4.3. Iimbani dam site

This site is located on the Iveti Hills at an elevation of about 1950m and was identified by the colonial government in the 1950's. It is expected that the quality of water from this dam would be good as the catchment is wholly located in the forest with few human settlements. Furthermore, water could be supplied to the town by gravity. However, the catchment area is very small and therefore storage resulting from

impoundment would be equally small. This dam would be suitable only for the surrounding rural areas that can be served by gravity.

3.4.4. Kiiu dam site

This dam site is located near Mithanga Primary School in Iveti Location at an elevation of about 1700m. It was identified by the Machakos Integrated Dam Project (MIDP) in the early 70's and was intended for supply to the rural areas of Machakos Municipality and the nearby towns of Kaani, Ithaini and Masii. Water may be supplied from this proposed dam by gravity to Machakos Town, although it would require considerable treatment in view of the intense agricultural activity in the catchment. The catchment area is also quite small and the required reservoir volume would be low. However, this dam could be used for water supply to the areas to east as originally intended.

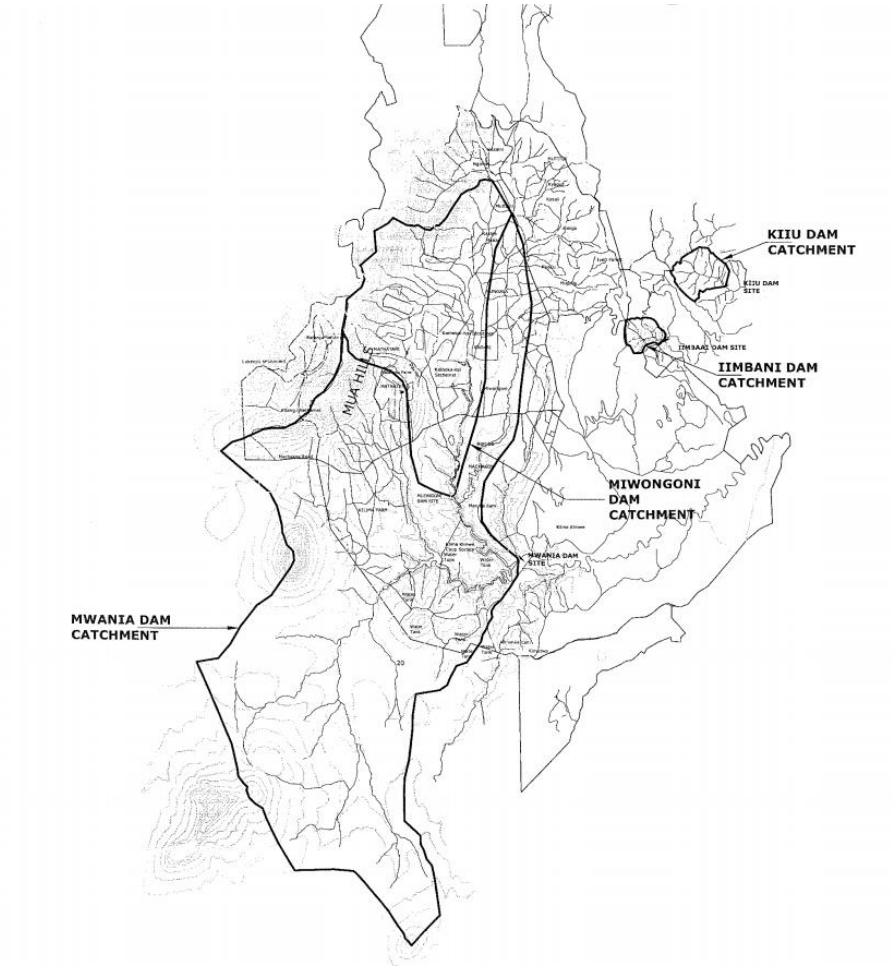


Figure 3-1 Potential dam site locations and catchment areas

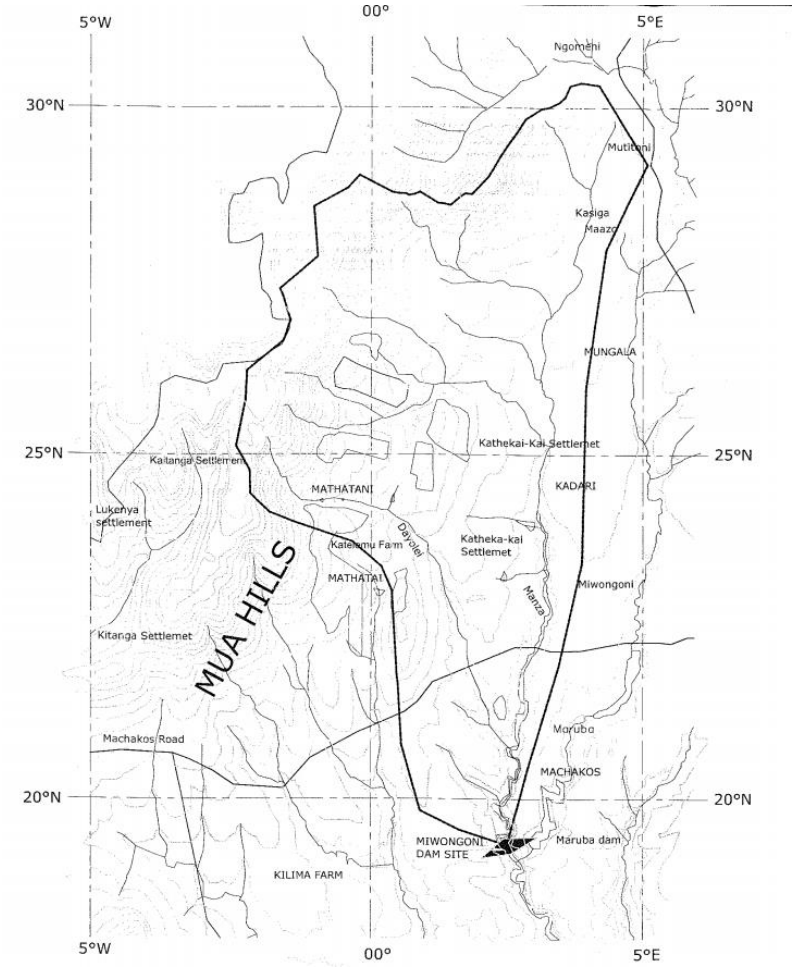


Figure 3-2 Miwongoni dam site and catchment area

The Table below summarizes the advantages and disadvantages of each of the dam sites:

Table 3-1 Advantages and disadvantages of the potential dam sites

Dam site	Advantages	Disadvantages
Miwongoni	• High yield as catchment is large (~55km^2) • High storage efficiency of 9.2 • Close to area of supply • Easy access to site • Identified in previous studies, preliminary studies carried out and land acquired	• Water has to be pumped to Machakos Town • Catchment has little vegetation, therefore heavy siltation likely • Water requires extensive treatment • Possible risk of contamination as a major road traverses the catchment
Mwania	• High yield as catchment is large (>100km^2) • Close to area of supply • High storage efficiency • Easy access to site	• Water has to be pumped to Machakos Town • Catchment has little vegetation, therefore heavy siltation likely • Water requires extensive treatment
Iimbani	• Good quality water as there is little contamination • Gravity flow to Machakos Town	• Low yield as catchment is small (~2 km^2) • Difficult access to site
Kiiu	• Gravity flow to Machakos Town	• Low yield as catchment is small (~4 km^2) • Far from Machakos Town • Difficult access to site • Water requires extensive treatment

As shown in the table above, only Miwongoni and Mwania dams have a large enough yield to meet a large part of the demand of Machakos Town in view of their large catchment. Although Mwania dam has a larger catchment than Miwongoni, it is located further from Machakos Town at a lower the elevation and therefore more pumping energy would be required. Miwongoni dam site is therefore more preferred due to its advantages over other sites.

3.5. Dam design

Two options were considered on the design of the embankment. Option I comprised of an earth-fill embankment with the following details: A height of 26m, and length of 505m; crest width of 5m and crest elevation of 1613m asl; earth fill volume of approximately 365,000m^3; upstream embankment slope 1:3; and downstream embankment slope of 1:2:5.

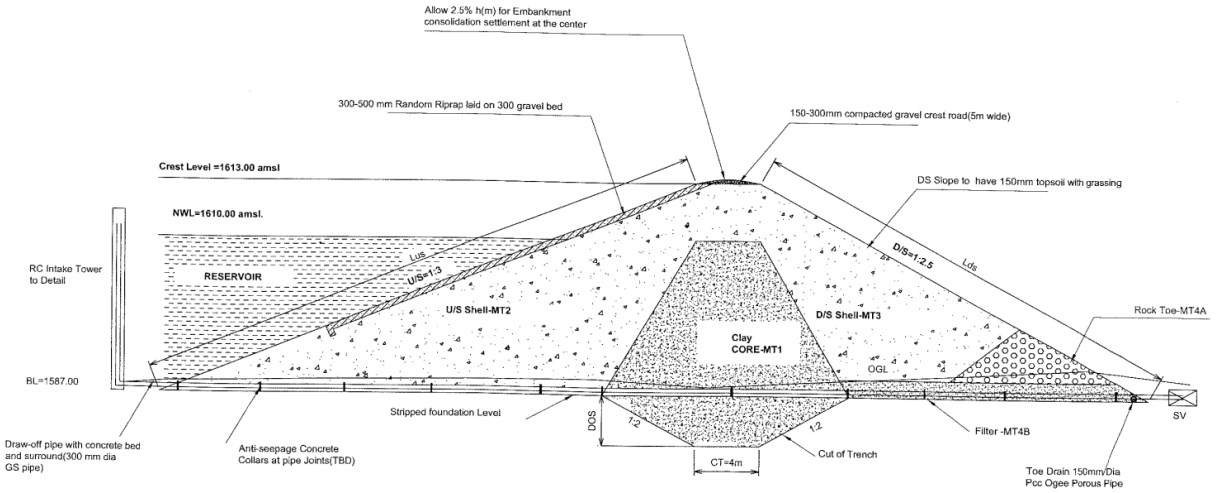


Figure 3-3 Earth-fill embankment dam design

Option 2 comprised of a concrete weir with the following details: a height of 15m and length of 340m; a crest width of 2m and crest elevation of 1587m asl.

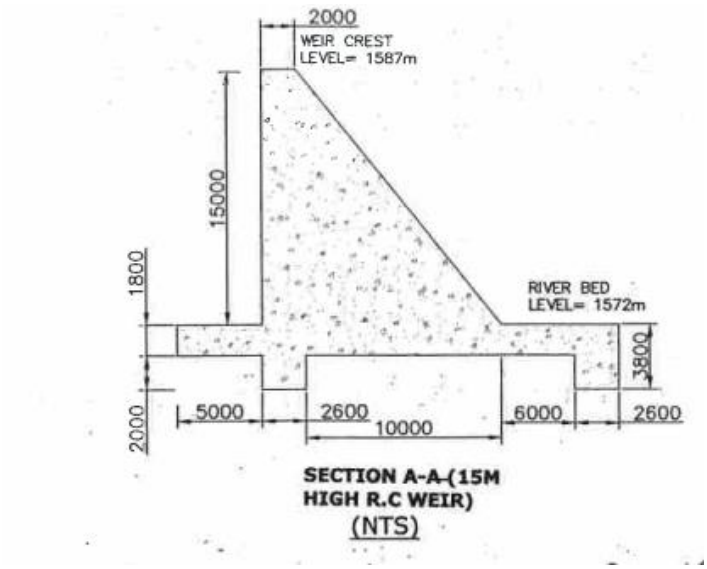


Figure 3-4 15m-high concrete weir design

The concrete weir design was adopted due to ease of construction, and the future ability to construct a higher embankment (to increase storage) with the weir forming the core of the embankment.

4. Policy, legal and regulatory framework

4.1. Introduction

This section sets out the policy, legal and regulatory framework relevant to the proposed Project. It identifies the most pertinent policies, legislation, regulations and standards governing the anticipated activities in implementation of the proposed project.

4.2. National policies

Table 4-1 Relevant National Policies

National Policy	Summary
National Policy on Water Resources Management and Development (Seasonal Paper No.1 of 1999).	The management of water resources in Kenya is guided by four specific policy objectives, namely: • Preserve, conserve, and protect available water resources and allocate it in a sustainable rational and economic way; • Supply water of good quality in sufficient quantities to meet the various water needs, including poverty alleviation, while ensuring the safe disposal of wastewater and environmental protection; • Establish an efficient and effective institutional framework to achieve a systematic development and management of the water sector; and • Develop a sound and sustainable financing system for effective water resources management, water supply and sanitation development.
The National Water Policy 2012 (Draft)	The Policy is built on the achievements of the sector reform commenced with the Water Act 2002 and based on the sector principles lined out in the National Water Policy 1999. On water resources management, the policy seeks the management of water resources along natural catchment/basin boundaries following the Integrated Water Resource Management approach. It aims to ensure a comprehensive framework for promoting optimal, sustainable, and equitable development and use of water resources for livelihoods of Kenyans through: • progressive restoration and protection of ecological systems and biodiversity in strategic water catchments; • increasing per capita water availability above the international benchmark of 1000 m^3 by 2030; • Maximizing use of trans-boundary water resources in coordination with other riparian countries; • Enhancing storm water management and rainwater harvesting; • Enhancing inter-basin water transfer in Kenya as a strategic intervention for optimized used of water resources; • Enhancing pollution control; • Improving effluent waters treatment and recycling for use; • Ensuring sustainable groundwater resources for present and future generations; and • Developing a water management system which contributes to the protection of the environment.
Kenya Vision 2030	The Vision for the water and sanitation sector is "to ensure water and improved sanitation availability and access to all by 2030". Kenya is a water-scarce country with renewable fresh water per capita at 647 m^3 against the United Nations recommended minimum of 1,000 m^3.

National Policy	Summary
	The water strategy aims to intensify Kenya's access to safe water and better sanitation using the national network of water services boards, and the private sector, where necessary. The water programmes will integrate both water and sanitation components, thereby ensuring simultaneous development of water and sanitation with the right pricing. This is expected to bring individual and social benefits that will outweigh the investment costs. In the vision, specific strategies will be introduced to raise standards of the country's overall water, resource management, storage and harvesting capability. Some of the flagship projects for water and sanitation include the rehabilitation and expansion of urban water supply and sanitation in the key satellite towns identified under the economic pillar With the expected increase in urban population and development of the 15 medium towns (towns of Narok, **Machakos**, Maralal, Wajir, Wote, Hola, Chuka, Ruiru, Athi River, Siaya, Ol Kalou, Matuu, Maua, Moi's Bridge and Limuru) and the new resort cities at the Coast, Isiolo and Lodwar, water and sanitation systems in those sites will be accorded priority
The National Environment Policy, 2013	The goal of the policy is to ensure a better quality of life for present and future generations through sustainable management and use of the environment and natural resources. The objectives of the Policy are *inter alia* to: • Provide a framework for an integrated approach to planning and sustainable management of Kenya's environment and natural resources; • Strengthen the legal and institutional framework for good governance, effective coordination and management of the environment and natural resources; and • Ensure sustainable management of the environment and natural resources, such as unique terrestrial and aquatic ecosystems, for national economic growth and improved livelihoods. Some of the guiding principles in the implementation of the policy include: • **Environmental Right**: Every person in Kenya has a right to a clean and healthy environment and a duty to safeguard and enhance the environment; • **Right to Development**: The right to development will be exercised taking into consideration sustainability, resource efficiency and economic, social and environmental needs; • **Sustainable Resource Use**: Environmental resources will be utilized in a manner that does not compromise the quality and value of the resource or decrease the carrying capacity of supporting ecosystems; and • **Public Participation**: A coordinated and participatory approach to environmental protection and management will be enhanced to ensure that the relevant government agencies, county governments, private sector, civil society and communities are involved in planning, implementation and decision making processes.
The National Environment Action Plan Framework 2009 - 2013	The NEAP framework recognizes that the high population growth rate and expansion of economic activities have caused pressure on water resources. This is expected to increase unless urgent measures are taken to boost supply and rationalise demand. Water resources are under pressure caused by soil erosion and siltation, water catchments destruction, low level compliance to water quality regulations, inefficient water use strategies, invasive alien species, uncontrolled sand harvesting and over-abstraction of water resources. The framework proposes such interventions as: • Implementation of soil and water conservation measures; Provision of incentives for conservation of water catchments • Enforcement of EMCA, 1999 and other subsidiary regulations

National Policy	Summary
	• Enforcement of the Water Act 2002 and other related legislations; • Promotion of efficient water harvesting, storage and usage; • Strengthening hydrological monitoring systems; • Promotion of integrated water resource management;
The National Land Policy (Sessional Paper No. 3 of 2009)	The overall object of the national land policy is to secure land rights and provide for sustainable growth, investment, and the reduction of poverty in line with the governments overall development objectives.
The Kenya National Biodiversity Strategy and Action Plan, 2000	The overall objective of the NBSAP is to address the national and international undertakings elaborated in Article 6 of the Convention on Biological Diversity' (CBD). It is a national framework of action for the implementation of the Convention to ensure that the present rate of biodiversity loss is reversed, and that present levels of biological resources are maintained at sustainable levels for posterity.
Economic Recovery for Wealth and Employment Creation Strategy 2006	The overall goal of the strategy is to ensure clear improvement in the social and economic wellbeing of all Kenyans; thereby giving Kenyans a better deal in their lives, and in their struggle to build a modern and prosperous nation. The key areas covered in the strategy are: • Expanding and improving infrastructure; • Reforms in trade and industry; • Reforms in forestry; • Affordable shelter and housing; • Developing arid and semi-arid lands, and • Safeguarding environment and natural resources.

4.3. National legislation

Table 4-2 Relevant Legislation/Regulation/Standard

Legislation/Regulation/ Standard	Provisions	Relevance to the Project/ License or Permit Required/ or Activity requiring regulation
The Constitution of Kenya (2010)	• Provides for protection and conservation of the environment and ensuring ecologically sustainable development and use of natural resources; • Mandates the State to: - Establish systems of environmental impact assessment, environmental audit and monitoring of the environment; - eliminate processes and activities that are likely to endanger the environment; - utilise the environment and natural resources for the benefit of the people of Kenya; and - Encourage public participation in the management, protection and conservation of the environment. • Accords every person the right to a clean and healthy environment and where this is being or is likely to be, denied, violated, infringed or threatened, the person may apply to a court for redress in addition to any other legal remedies that are available in respect to the same matter	• Consultations and agreement is required with the community, Machakos County government, WRMA and other stakeholders before developments are executed; • Miwongoni River on which impoundment and abstraction of water is proposed for expansion of water supply is a natural resource that requires sustainable utilization. • Gender equity needs to be pursued during project development and operations

Legislation/Regulation/ Standard	Provisions	Relevance to the Project/ License or Permit Required/ or Activity requiring regulation
	• Provides that every person is equal before the law and has the right to equal protection and equal benefit of the law. Further, women and men have the right to equal treatment, including the right to equal opportunities in political, economic, cultural and social spheres	
Environmental Management and Coordination Act 1999	Provides for protection and conservation of the environment, environmental impact assessment, and environmental auditing and monitoring.	An EIA of the proposed project should be carried out and an EIA License acquired before commencement of development
Environmental Management and Coordination (Amendment) Act 2015 *(legal Notice No 5 of 2015)* Legal Notice No 150 of 2016 on the EMCA	• Provides for a full ESIA study of Storage dams, barrages, piers, and Large-scale flood control schemes • Categorises Water resources and related infrastructure including storage dams and barrages and flood control schemes as high-Risk projects for which a full ESIA study shall be carried out. Categories water supply and distribution infrastructure as a Medium Risk project	• The proposed Miwongoni dam component qualifies for a full ESIA study under the Amendment Act • The dam component is considered High Risk, thus qualify for full ESIA study The improvement and network expansion component is considered Medium Risk, thus is excluded from full ESIA study
Environmental Impact Assessment Guidelines and administrative procedures, 2002	• The guidelines provide the steps in implementation of an EIA, Monitoring and Environmental Audit • Provides for screening of the proposed development activity and preparation of a Project Report • Provides for carrying out of an EIA Study where a Project will have significant environmental impacts and the Project Report does not disclose adequate mitigation measures • Provides for scoping studies and preparation of ToRs where an EIA study is to be carried out • Provides for the contents/format of an EIA Study Report	• The EMC (Amendment) Act, 2015 and Legal Notice No. 150 on the EMCA now defines projects to undergo full ESIA Study. Under the new legislation, a Scoping study and ToRs would be required before the ESIA
Environmental (Impact Assessment and Audit) Regulations, 2003	• Provides for the procedure for carrying out Environmental Impact Assessment (EIA) and Environmental Audit (EA). • Provides for the carrying out of an environmental audit study following commencement of project operations. • Provides for the contents of an EIA and an EA Report.	• The EIA to be carried out on the proposed project should be carried out in accordance to the regulations. • An initial environmental audit should also be carried out in the first year of operation of the project.
Environmental Management and Co-ordination (Water Quality) Regulations 2006	• Provides for the protection of ground and surface water resources. • Provides the water quality standards for sources of domestic water. **Parameter** / **Guide Value (Max. allowable)** pH: 6.5 – 8.5 Suspended solids: 30 (mg/l) Nitrate – NO_3: 10 (mg/l) Ammonia – NH_3: 0.5 (mg/l) Nitrite – NO_2: 3 (mg/l) Total dissolved solids: 1200 (mg/l)	• The quality of water at the potential new intake must be within the specified range to be a source of domestic water.

Legislation/Regulation/ Standard	Provisions	Relevance to the Project/ License or Permit Required/ or Activity requiring regulation

Ecoli	Nil/100ml
Fluoride	1.5 (mg/l)
Phenols	Nil (mg/l)
Arsenic	0.01 (mg/l)
Cadmium	0.01 (mg/l)
Lead	0.05 (mg/l)
Selenium	0.01 (mg/l)
Copper	0.05 (mg/l)
Zinc	1.5 (mg/l)
Alkyl benzyl sulphonates	0.5 (mg/l)
Permanganate Value (PV)	1.0 (mg/l)

- Provides that an EIA shall be carried out and license obtained to abstract water or carry out activities that may have adverse impacts on the quantity or quality of water in lakes, rivers, streams, springs and wells
- Provides the water quality standards for effluent discharged into the aquatic environment.

- Measures must be provided for protection of water resources from pollution incidences during construction.
- Impacts of impounding Miwongoni River must be determined

The discharge from the water treatment works into receiving waters must be within the specified range

Parameter	Maximum Allowable (Limits)
1,1,1-trichloroethane (mg/l)	3
1,1,2-trichloethane (mg/l)	0.06
1,1-dichloroethylene	0.2
1,2-dichloroethane	0.04
1,3-dichloropropene (mg/l)	0.02
Alkyl Mercury compounds	Nd
Ammonia, ammonium compounds, NO_3 compounds and NO_2 compounds (Sum total of ammonia-N times 4 plus nitrate-N and Nitrite-N) (mg/l)	100
Arsenic (mg/l)	0.02
Arsenic and its compounds (mg/l)	0.1
Benzene (mg/l)	0.1
Biochemical Oxygen Demand (BOD 5days at 20 ^oC) (mg/l)	30
Boron (mg/l)	1.0
Boron and its compounds – non marine (mg/l)	10
Boron and its compounds –marine (mg/l)	30
Cadmium (mg/l)	0.01
Cadmium and its compounds (mg/l)	0.1
Carbon tetrachloride	0.02
Chemical Oxygen Demand (COD (mg/l)	50
Chromium VI (mg/l)	0.05
Chloride (mg/l)	250
Chlorine free residue	0.10
Chromium total	2
cis –1,2- dichloro ethylene	0.4
Copper (mg/l)	1.0
Dichloromethane (mg/l)	0.2
Dissolved iron (mg/l)	10
Dissolved Manganese(mg/l)	10
E.coli (Counts / 100 ml)	Nil
Fluoride (mg/l)	1.5
Fluoride and its compounds (marine and non-marine) (mg/l)	8
Lead (mg/l)	0.01
Lead and its compounds (mg/l)	0.1
n-Hexane extracts (animal and vegetable fats) (mg/l)	30
n-Hexane extracts (mineral oil) (mg/l)	5
Oil and grease	Nil
Organo-Phosphorus compounds (parathion,methyl parathion,methyl demeton and Ethyl parantrophenyl phenylphosphorothroate, EPN only) (mg/l)	1.0
Polychlorinated biphenyls, PCBs (mg/l)	0.003
pH (Hydrogen ion activity----marine)	5.0-9.0
pH (Hydrogen ion activity--non marine)	6.5-8.5
Phenols (mg/l)	0.001
Selenium (mg/l)	0.01
Selenium and its compounds (mg/l)	0.1
Hexavalent Chromium VI compounds (mg/l)	0.5
Sulphide (mg/l)	0.1
Simazine (mg/l)	0.03
Total Suspended Solids, (mg/l)	30
Tetrachloroethylene (mg/l)	0.1
Thiobencarb (mg/l)	0.1
Temperature (in degrees celious) based on ambient temperature	□ 3
Thiram (mg/l)	0.06

Legislation/Regulation/ Standard	Provisions	Relevance to the Project/ License or Permit Required/ or Activity requiring regulation

Total coliforms (counts /100 ml)	30
Total Cyanogen (mg/l)	Nd
Total Nickel (mg/l)	0.3
Total Dissolved solids (mg/l)	1200
Colour in Hazen Units (H.U)	15
Detergents (mg/l)	Nil
Total mercury (mg/l)	0.005
Trichloroethylene (mg/l)	0.3
Zinc (mg/l)	0.5
Whole effluent toxicity	
Total Phosphorus (mg/l)	2 Guideline value
Total Nitrogen	2 Guideline value

Legislation/Regulation/ Standard	Provisions	Relevance to the Project/ License or Permit Required/ or Activity requiring regulation
Environmental Management and Co-ordination (Noise and Excessive Vibration Pollution) (Control) Regulations 2009	• Prohibits the generation of unreasonable, unnecessary or unusual noise which annoys, disturbs, injures or endangers the comfort, repose, health or safety of others and the environment. • Provides for the maximum noise levels permissible in various environmental set ups such as residential areas, places of worship, commercial areas and mixed residential	• Sound level limits of 55dB (day) and 35dB (night) to be observed during construction and operations. • License to emit noise/vibrations in excess of permissible levels to be acquired if necessary.
Environmental Management and Co-ordination (Waste Management) Regulations 2006	• Provides for standards for handling, transportation and disposal of various types of wastes including hazardous wastes. • Requirements to ensure waste minimization or cleaner production, waste segregation, recycling or composting. • Provides for licensing of vehicle transporting waste. • Provides for the licensing of waste disposal facilities.	• Disposal of generated waste including soil, vegetation, boulders; and • Generation of hazardous wastes such as used oil and oily parts from construction machinery.
Environmental Management and Co-ordination (Fossil Fuel Emission Control) Regulations 2006	Provides for emission standards for internal combustion engines.	• Use of diesel-powered engines in construction machinery
Environmental Management and Coordination (Controlled Substances) Regulations 2007	• Provides for measures for storage, handling packaging and disposal of products with ozone-depleting substances including air conditioning and refrigeration equipment	• Measures for management of controlled substances at facilities such as camp sites must be provided
Environmental Management and Coordination (Air Quality) Regulations, 2014	• Provides for ambient air quality tolerance limits. • Prohibits air pollution in a manner that exceed specified levels. • Provides for installation of air pollution control systems where pollutants emitted exceed specified limits.	• Exhaust emissions from construction machinery. • Site clearance and excavation of foundations. • Transportation and disposal of spoil.

Zone		Sound Level Limits dB(A) (Leq, 14h)		Noise Rating Levels (NR) (Leq, 14h)	
		Day	Night	Day	Night
A	Silent Zone	40	35	30	25
B	Places of worship	40	35	30	25
C	Residential: Indoor	45	35	35	25
	Outdoor	50	35	40	25
D	Mixed residential (with some commercial & places of entertainment)	55	35	50	25
E	Commercial	60	35	55	25

Legislation/Regulation/ Standard	Provisions	Relevance to the Project/ License or Permit Required/ or Activity requiring regulation
	• Provides for the control of fugitive emissions within property boundary. • Provides for the control of vehicular emissions. • Provides for prevention of dispersion of visible particulate matter or dust from any material being transported. • Provides for acquisition of an emission license.	
The Physical Planning Act, 1996	• Provide for controls on the use and development of land and buildings in the interest of proper and orderly development of an area. • Requires that development permission be sought through a development application.	• Development of buildings and other infrastructure on land under the jurisdiction of Machakos County Government
The Public Health Act (Cap 242)	• Provides for the prevention of the occurrence of nuisance or conditions dangerous/injurious to humans. • Provides that the relevant local authority shall take all lawful, necessary and reasonably practicable measures -: - for preventing any pollution dangerous to health of any supply of water which the public within its jurisdiction has a right to use and does use for drinking or domestic purposes (whether such supply is derived from sources within or beyond its jurisdiction); and - for purifying any such supply which has become so polluted, and to take measures (including, if necessary, proceedings at law) against any person so polluting any such supply or polluting any stream so as to be a nuisance or danger to health.	• Generation of wastes during construction of the water supply infrastructure • Handling and storage of waste at the site • Protection of the water source from pollution
Occupational Safety and Health Act (OSHA), 2007	• Provides for the safety, health and welfare of workers and all persons lawfully present at work places. • Provides for the registration of workplaces. • provides for maintenance of cleanliness of workplaces, adequate lighting and ventilation, provision of sanitary conveniences, • Outlines safety requirements in use of machinery to prevent accidents and injuries.	• Construction sites require registration as a workplace; • Safety measures are required in use of tools and machinery on site; and • Protection of the workers and general public with any form of interaction with the construction sites is necessary.
The Factories and Other Places of Work (Noise Prevention and Control) Rules, 2005	• Rules provide for the maximum noise exposure levels for workers in places of work and for the provision of protective equipment for those exposed to high noise levels. • Provide that an occupier shall also institute noise reduction measures at the source of noise in the workplace. • Provides for development of a noise prevention program where noise in a workplace exceeds the continuous equivalent of eighty five dB(A)	• Use of noisy machinery at the construction sites will require provision of PPE to workers

Legislation/Regulation/ Standard	Provisions	Relevance to the Project/ License or Permit Required/ or Activity requiring regulation
Water Act 2016	• provides that subject to the Land Act, 2012, land required for national public water works may be acquired in any manner provided by law for the acquisition of land for public purposes • Compensation on just terms shall be payable by the Government to the owner of the land on which any such works are constructed • A permit is required for the discharge of a pollutant into any water resource • Every person in Kenya has the right to clean and safe water in adequate quantities and to reasonable standards of sanitation • A person shall not, without authority conferred under this Act throw, convey, cause or permit to be thrown or conveyed, any rubbish, dirt, refuse, effluent, trade waste or other offensive matter or thing into or near to any water resource in such manner as to cause, or be likely to cause, pollution of the water resource	• Compensation will be necessary for sites acquired to construct the infrastructure; • Easement will be required where the water supply lines traverse private land • A permit will be required for impoundment and abstraction of water from Miwongoni River; • MAWASCO will require to pay for use of water from the River.
Water Resource Management Rules 2007	• Provides for application and approval by WRMA to abstract water from a river. • Provides that an application to abstract water shall be accompanied by a hydrological assessment report. • Provides for payment of Water Use charges on the basis of water abstracted • Provides that no person shall discharge or apply any poisonous, toxic, noxious or obstructing matter, radioactive waste or other pollutants or permit any person to dump or discharge such matter into any water resource unless the discharge of such poisonous, toxic, noxious or obstructing matter, radioactive waste or pollutant is treated to permissible standards as authorized by the Authority • Provides that No person shall: - Discharge effluent into a water resource without a valid discharge permit issued by the Authority. - Discharge wastewater or effluent, which does not meet the water quality requirements stipulated in the effluent discharge permit. - Generate and discharge effluent onto land or into any water resource without compliance with an approved Effluent Discharge Control Plan. • Provides for an application for water resource use with respect to an effluent discharge point • Provides for maintenance of records of all water discharged giving the date, time quality, quantity and methods of discharge	• A permit will be required for abstraction of water from the River; • Hydrological studies on Miwongoni River is necessary in application for abstraction; • MAWASCO to pay water use charges for amount of water abstracted • Waste water from the WTP to be treated to acceptable standards before discharge into the river

<table>
<tr><th>Legislation/Regulation/ Standard</th><th>Provisions</th><th>Relevance to the Project/ License or Permit Required/ or Activity requiring regulation</th></tr>
<tr><td></td><td>• Provides Guidelines for Effluent Discharge into surface water resources
<table><tr><th>Parameter</th><th>Max Allowable (Limits)</th></tr><tr><td>Arsenic as As (mg/1)</td><td>0.1</td></tr><tr><td>Biochemical Oxygen Demand (BOD 5days at 20 °C) (mg/1)</td><td>30</td></tr><tr><td>Cadmium as Cd (mg/1)</td><td>1.0</td></tr><tr><td>Chemical Oxygen Demand (COD (mg/1)</td><td>100</td></tr><tr><td>Chromium as Cr (mg/1)</td><td>Less than 0 01</td></tr><tr><td>Lead as Pb (mg/1)</td><td>Less than 0 01</td></tr><tr><td>Oil and grease</td><td>Absent</td></tr><tr><td>pH (Hydrogen ion activity)</td><td>5.0-9.0</td></tr><tr><td>Phenols total (mg/1)</td><td>0.05</td></tr><tr><td>Sulphide as S (mg/1)</td><td>2.0</td></tr><tr><td>Total Suspended Solids (mg/1)</td><td>30</td></tr><tr><td>Temperature (in degrees Celsius) based on ambient temperature</td><td>± 5</td></tr><tr><td>Cyanides as CN (mg/1)</td><td>Less than 0.2</td></tr><tr><td>Nickel as Ni (mg/1)</td><td>Less than 2.0</td></tr><tr><td>Detergents (ABS) (mg/1)</td><td>Less than 5.0</td></tr><tr><td>Mercury as Hg (mg/1)</td><td>Less than 0.01</td></tr><tr><td>Total Phosphorus as P (mg/1)</td><td></td></tr><tr><td>Total Nitrogen as N (mg/l)</td><td>10</td></tr><tr><td>Total pesticide residues</td><td>Absent</td></tr><tr><td></td><td></td></tr></table></td><td></td></tr>
<tr><td></td><td>• Provides for the classification of dams as either A - Low Risk, B – Medium Risk, or C – High Risk,
• Provides for a dam safety inspection schedule by class of dam
• Provides for compensation flow from a dam or weir located on a body of water</td><td>• The proposed Miwongoni dam has a catchment area of 55km^2 which would classify it as Class A (Low Risk).
• The maximum depth of water at NWL is <15m, which therefore classifies it as Class B – Medium Risk
• The impoundment at normal water level (NWL) is > 1,000,000m^3 which would classify as Class C (High Risk)</td></tr>
<tr><td>The National Land Commission Act 2012</td><td>• Provides for the management and administration of land in accordance with the principles of the land policy set out in Article 60 of the Constitution and the national land policy
• Gives power to the National Land Commission (NLC) to manage public land on behalf of the national and county governments, and to monitor and have oversight responsibilities over land use planning throughout the country
• Mandates the NLC to investigate and provide recommendations on historical land injustices including development-induced displacement for which no adequate compensation or other form of remedy was provided, including conversion of non-public land into public land</td><td>• The NLC has the mandate to hear any land disputes arising from implementation of the project</td></tr>
<tr><td>The Land Act 2012</td><td>• Mandates the Land Commission and other public officers to use the following guiding principles and values:
- equitable access to land; security of land rights;
- security of land rights;</td><td>• conservation and protection of ecologically sensitive areas such as the river system, riverine areas, and other significant terrestrial habitats is required in development of the project;</td></tr>
</table>

Legislation/Regulation/ Standard	Provisions	Relevance to the Project/ License or Permit Required/ or Activity requiring regulation
	- sustainable and productive management of land resources; - conservation and protection of ecologically sensitive areas • provides for the conversion of private land to public land through compulsory acquisition, transfer, surrender or reversion of leasehold interest to Government; • provides that just compensation shall be paid promptly in full to all persons whose interests in the land have been determined; and • Provides for the creation of a public rights of way (ROW) or wayleave by the National Land Commission. • Provides for the establishment of settlement programmes to provide access to land for persons displaced by development projects or other causes that may lead to movement and displacement • Provides for eviction of unlawful occupation of private, communal or public land giving at least three months' notice	• compulsory acquisition may be necessary if land owners are not willing to avail the land for development of the project; • just compensation is required for all whose land will be acquired; and • Creation of ROW will be necessary where the proposed pipelines pass through private land.
The HIV and AIDS Prevention and Control Act, 2006	• Provides for basic information and instruction on HIV and AIDS prevention and control to employees of all Government Ministries, Departments, authorities and other agencies, and employees of private and informal sectors; • Prohibits compulsory testing for HIV as a precondition to, or for the continued enjoyment of employment • Provides that a person who is and is aware of being infected with HIV shall take all reasonable measures and precautions to prevent the transmission of HIV to others	• A HIV/AIDS and STI Management Plan is required with measures to civic education of contractor's employees and the local community on HIV/AIDS
Sexual Offenses Act, 2006	• Identifies and prohibits sexual offences including rape, assault, indecent acts, defilement, harassment etc • Prohibits the deliberate transmission of HIV or any other life threatening sexually transmitted disease	• Provisions are applicable in management of construction labour force, and their interaction with the surrounding communities
The Energy Act 2006	• Provides for energy management and conservation measures by users exceeding annual consumption of 180,000kWh	• Energy conservation measures are required at energy intensive sites such as the construction/labor camp
The Energy (Energy Management) Regulations 2012	• Provides for the development of an energy management policy and maintenance of records on monthly and annual electricity, fuel and water consumption	
The Energy (Solar Water Heating) Regulations, 2012	• Provides that all premises within the jurisdiction of a local authority with hot water requirements of a capacity exceeding one hundred litres per day shall install and use solar heating systems	

Legislation/Regulation/ Standard	Provisions	Relevance to the Project/ License or Permit Required/ or Activity requiring regulation
National Gender and Equality Commission Act, 2011	• Establishes the National Gender and Equality Commission with the mandate to among others, promote gender equality and freedom from discrimination in accordance with Article 27 of the Constitution; co-ordinate and facilitate mainstreaming of issues of gender, persons with disability and other marginalized groups in national development	• The commission needs to be involved for advice, coordination or facilitation in mainstreaming of issues of gender in the project

4.4. International guidelines

4.4.1. AfDB Operational Safeguards

AfDB has adopted a series of five Operational Safeguards which set out the Bank's overarching requirements to identify, assess, and manage the potential environmental and social risks and impacts of a project, including climate change issues. The safeguards also and set out specific requirements relating to different environmental and social issues, including gender and vulnerability issues, that are triggered if the assessment process reveals that the project may present certain risks **(African Development Bank Group, 2013)**.

4.4.1.1. Operational Safeguard 1: Environmental and social assessment

The OS provides for conducting the environmental and social assessment (Strategic Environmental and Social Assessment, or Environmental and Social Impact Assessment) and for developing, as an integral part of project documentation, an appropriate plan for managing possible impacts. The OS requires:

- Screening of the project for environmental and social impacts including climate change impacts, potential adaptation and mitigation measures, and the vulnerability of populations and their livelihoods—to determine the specific type and level of environmental and social assessment;
- scoping of the project's components, including delineating the project's geographic and temporal area of influence, consideration of alternatives, and assessment of cumulative impacts, where relevant. Scoping activities also determine the range of likely potential risks and impacts and also determines whether specific requirements of the Bank's OSs apply. All relevant direct and indirect environmental and social risks and impacts, including those specifically covered the other Operational Safeguards would be addressed in an integrated manner;
- Consideration of real alternatives to the project's location and/or design to avoid adverse impacts. The mitigation hierarchy to be applied includes: if avoidance is not possible, reduce and minimize potential adverse impacts; if reduction or minimization is not sufficient, mitigate and/or restore; and as a last resort compensate for and offset;
- Assessment to comply with the relevant legislation and standards applicable in the local jurisdiction, bearing in mind the equivalence of standards with those of the Bank. Assessment to also take into consideration national or regional- level programming documents that are under implementation or in preparation;
- assessment process to support and strengthen existing country systems for environmental, climate, and social risk management, including those specifically related to OSs 2-5, such as systems and institutions covering resettlement, biodiversity protection, pollution control, and labor standards;
- The assessment to be conducted according to the principles of proportionality and adaptive management. The level of assessment and management required should be proportionate to the level of risk that the project poses as identified during categorization and scoping—and the management measures adopted should be capable of being adapted to changing circumstances during the full project cycle;
- Assessment to include the development of a comprehensive and implementable ESMP with a realistic timeframe, incorporating the necessary organizational capacity (including further training requirements) and financial resources to address and manage the environmental and social risks that may occur during the full project cycle;

- Categorization of projects following the principle of using the appropriate type and level of environmental and social assessment for the type of operation. The categories include:
  - ✓ Category 1- projects likely to induce significant and/or irreversible adverse environmental and/or social impacts, or to significantly affect environmental or social components that the Bank or the borrowing country considers sensitive
  - ✓ Category 2: Projects likely to have detrimental site-specific environmental and/or social impacts that are less adverse than those of Category 1 projects. Likely impacts are few in number, site-specific, largely reversible, and readily minimized by applying appropriate management and mitigation measures or incorporating internationally recognized design criteria and standards
  - ✓ Category 3: Projects which do not directly or indirectly affect the environment adversely and are unlikely to induce adverse social impacts. They do not require an environmental and social assessment. Beyond categorization, no action is required.
  - ✓ Category 4: Projects which involve Bank lending to financial intermediaries that on-lend or invest in subprojects that may produce adverse environmental and social impacts
- The environmental and social assessment process to systematically identify vulnerable groups on the basis of a careful screening and analysis of the social and economic context in which the project will operate. particular attention to be given to assessing the risks and potentially adverse impacts of the project on local communities, including direct and indirect impacts on their health or safety and indirect impacts on their socioeconomic conditions and livelihoods;
- Assessment to identify and qualify the tangible and intangible cultural heritage likely to be affected by the project, and appropriate measures for avoiding or mitigating these impacts;
- Free, prior and informed consultation with communities likely to be affected by environmental and social impacts, and with local stakeholders, and also for ensuring broad community support;
- maximum disclosure, enhanced access to information, and limited exceptions in the environmental and social assessment process ensuring progressive disclosure of documents at key stages during the project cycle and making documents available to the public on request;
- establishment of a credible, independent and empowered local grievance and redress mechanism to receive, facilitate and follow up on the resolution of affected people's grievances and concerns about the environmental and social performance of the project; and
- Implementation of the environmental and social mitigation measures contained in the ESMP and Resettlement Action Plan (RAP) during project implementation, and reporting to the Bank on key management or monitoring tasks set out in the ESMP and RAP

4.4.1.2. Operational Safeguard 2: Involuntary resettlement - land acquisition, population displacement and compensation

The OS relates to Bank-financed projects that cause the involuntary resettlement of people. It seeks to ensure that when people must be displaced they are treated fairly, equitably, and in a socially and culturally sensitive manner; that they receive compensation and resettlement assistance so that their standards of living, income-earning capacity, production levels and overall means of livelihood are improved; and that they share in the benefits of the project that involves their resettlement. The OS requires:

- Consideration of feasible alternative project designs, including re-siting and re-routing, to avoid or minimize physical or economic displacement, while balancing environmental, social, and financial costs and benefits;
- Open, inclusive and effective consultation with local communities entailing appropriate notice to all potentially affected persons that resettlement is being considered, advance dissemination of relevant information, and public hearings that provide affected persons and/or their legally designated representatives with opportunities to challenge the resettlement design and process;
- Consultations with the affected people about their preferences pertaining to resettlement and presentation of genuine choices among technically, economically, and socially feasible resettlement options
- The carrying out of a comprehensive socioeconomic survey in line with international standards for social and economic baseline studies as agreed to in the environmental and social assessment process, including a population census and an inventory of assets (including natural assets upon which the affected people may depend for a portion of their livelihoods;
- Conformance to any relevant host government procedures;

- Establishment of a grievance and redress mechanism to resolve, in an impartial and timely manner, any disputes arising from the resettlement process and compensation procedures;
- Preparation of a Full Resettlement Action Plan (FRAP) for (i) any project that involves 200 or more persons or (ii) any project that is likely to have adverse effects on vulnerable groups. an Abbreviated Resettlement Action Plan (ARAP) is to be prepared for any project in which the number of people to be displaced is fewer than 200 people and land acquisition and potential displacement and disruption of livelihoods are less significant;
- Consultation with those to be displaced to decide on the units that are entitled to compensation (e.g., family, household, and individual);
- That affected people are compensated for all their losses at full replacement costs before their actual move; before land and related assets are taken; and, if the project is implemented in phases, before project activities begin for each particular phase;
- That the criteria for assessing the value of land, housing and other property are standardized and transparent, and the benefits of the resettlement are clearly established;
- A detailed analysis of host communities to identify potential problems associated with receiving displaced people, and to address these problems so that adverse impacts on host communities are minimized and the host communities are able to share in the development opportunities provided through the resettlement process;
- The protection of the physical, social and economic integrity of vulnerable groups and paying particular attention to health needs, particularly for women, including access to female health care providers and to such services as reproductive health care and appropriate counselling for sexual and other abuses;
- The implementation, monitoring and evaluation of the activities set out in the Resettlement Action Plan. Monitoring activities include a review of the grievance and redress mechanism and of the physical progress and impact of the Resettlement Action Plan; and
- The carrying out of an independent ex-post evaluation to examine the effectiveness of the mitigation measures recommended and implemented and to derive lessons learned to inform similar types of projects in the future

4.4.1.3. Operational Safeguard 3: Biodiversity, renewable resources and ecosystem services

The OS provides for (i) identification and implementation of opportunities to conserve and sustainably use biodiversity and natural habitats, and (ii) observing, implementing, and responding to requirements for the conservation and sustainable management of priority ecosystem services. The OS requires:

- Identification and assessment during the environmental and social assessment, the potential opportunities for, risks to, and impacts on biological diversity and ecosystem services, including direct, indirect, cumulative and pre-mitigation impacts;
- That attention be given to the major threats to biodiversity and ecosystem services, such as pollution and contamination, land conversion, habitat fragmentation, natural habitat loss, deforestation, over-exploitation of natural areas and resources, invasive alien species, migration barriers, the capturing of wild animals, the harvesting of endemic species and indigenous ornamental flora and fauna, and wildlife poaching;
- That if projects are to be developed in natural habitats, or are to have potential adverse downstream impacts on natural habitats, they should include mitigation measures to achieve either net benefit or no net loss of biodiversity;
- That any proposed development should be consistent with the protected area/internationally recognized area's management plan or, in the absence of a management plan, with the objectives determined by the responsible natural resource, protected area, or wildlife agency;
- Taking precautions to avoid introducing any potentially invasive alien species (that is, species not currently established in the country or region of the project unless such an introduction is in accordance with any existing applicable regulatory framework or the introduction is subject to a risk assessment, which may be part of the environmental assessment, to determine the potential for invasive behavior;
- That for projects that affect water resources, altering flow regimes in ways that prevent water resources from fulfilling their functions for important upstream and downstream ecosystems and their services to local communities should be avoided;

- The assessment and management of environmental flows for the conservation and sustainable use of biodiversity and ecosystem services;
- The maintenance of flows so that they are optimally managed to allow for the multipurpose use of water, including water's ecological functions, and the integrity of river systems and wetlands;
- That the environmental and social assessment uses appropriate methodologies to address the issue of environmental flows according to best practice, including the recommendations of the World Commission on Dams;
- Environmental flow analysis and management are carried out to the extent feasible in the context of river basin planning, so that the basin's entire water balance, now and in the future, is the framework in which environmental flows are determined;
- The development and implementation of a sustainable resources procurement policy, procedures, and action plan to ensure that only resources of a legal and sustainable origin are purchased, and that the resources do not originate from legally protected areas or internationally recognized areas of high conservation value; and
- Performing an ecosystem services review to identify the risks where it is determined that the project may affect important ecosystem services

4.4.1.4. Operational Safeguard 4: Pollution prevention and control, hazardous materials and resource efficiency

The OS provides for the main pollution prevention and control requirements to achieve high quality environmental performance, and efficient and sustainable use of natural resources, over the life of a project. The OS requires:

- The application of pollution prevention and control measures consistent with national legislation and standards, applicable international conventions, and internationally recognized standards and good practice, particularly the World Bank Group Environmental Health and Safety (EHS) Guidelines;
- The inclusion of resource-efficiency and pollution prevention principles as part of the project policy, in accordance with the principles of cleaner production;
- The avoidance or, where avoidance is not possible, the control and reduction in the generation of pollutants at their source;
- The prevention of discharge of pollutants into the air, surface water and groundwater, land and soil during planned activities as well as unplanned events or emergencies that may result in local, regional, and transboundary impacts. If total prevention is not feasible, specific actions to reduce or minimize the effluents or volume of discharges should be taken;
- The avoidance or, where avoidance is not possible, control and reduction of the generation of hazardous and non-hazardous waste at source, in compliance with applicable international conventions;
- That any chemicals that are banned or subject to phase-out by international treaties, including ozone-depleting substances and persistent organic pollutants shall not be manufactured, traded, donated or used;
- A determination of whether the project poses any operational risk of accident or emergency events, and an assessment of the options for responding to such situations. If appropriate, an emergency response plan proportionate to the risk should be developed, to respond to accidents or emergency events that may pose risks to human health and the environment; and
- An evaluation and, if appropriate, implementation of financially feasible and cost-effective measures for improving efficiency in the project's consumption of resources such as energy, water, raw materials, and other resources

4.4.1.5. Operational Safeguard 5: Labour conditions, health and safety

The OS provides for the protection of the rights of workers and meeting their basic needs. The OS requires:

- The development and implementation of a human resources policy and procedures appropriate to the nature and size of the project, with the scale of the workforce in alignment with this OS and with applicable national laws;
- That employees be provided with documents that contain information on their employment terms, conditions and rights, including national employment law;

- The provision of reasonable working conditions and terms of employment that, at a minimum, comply with national law and are otherwise consistent with this OS;
- The provision of all basic services including water and sanitation and medical care where residential or temporary accommodation is provided to workers;
- That employment decisions will not be made on the basis of personal characteristics unrelated to inherent job requirements, including race, gender, nationality, religion or belief, disability, age, sexual orientation, or ethnic, social and indigenous origin;
- That special measures be taken to address harassment, intimidation, and/or exploitation, especially in relation to women. In addition, measures shall also be taken to prevent social exclusion of or employment inequalities to women and workers with family responsibilities;
- That a workforce grievance mechanism be permanently available to workers (including workers supplied by third parties) and their organizations to raise reasonable workplace concerns in a transparent manner without fear of retribution;
- That children shall not be employed in any manner that is economically exploitative, or is likely to be hazardous or to interfere with the child's education or to be harmful to the child's health or physical, mental, spiritual, moral, or social development as stipulated in national laws in compliance with the provisions of ILO Convention C138 and C182;
- That no forced labour will be employed, that is, any work or service not voluntarily performed that is exacted from an individual under threat of force or penalty;
- That workers be provided with a safe and healthy work environment, taking into account risks inherent in the particular sector and specific classes of hazards in the work areas, including physical, chemical, biological, and radiological hazards;
- The implementation of a health, safety and environmental programme that includes plans or procedures to prevent accidents, injury, and disease arising from, associated with, or occurring in the course of work; and
- Compliance with all local and national environmental, health and safety laws and regulations

4.4.2. Other international guidelines

The table below summarises the provisions of the International Finance Corporation (IFC) Performance Standards and World Banks' Operational Policies (OP). the provisions are similar and comparable to AfDB's Operational Safeguards 1 – 5.

Table 4-3 Other international guidelines

Standard/Guideline	Provision
International Finance Corporation (IFC) Performance Standard (PS) 1 on Assessment and Management of Environmental and Social Risks and Impacts	• Provides for identification and evaluation of environmental and social risks and impacts of a project; • Provides for the adoption of a mitigation hierarchy to anticipate and avoid, minimize, and, where residual impacts remain, compensate/offset for risks and impacts to workers, affected communities, and the environment. • Provides for improvement in environmental and social performance through the effective use of management systems; • Provides for mechanisms to ensure that grievances from affected communities and external communications from other stakeholders are responded to and managed appropriately; • Provides for mechanisms for adequate engagement with affected communities throughout the project cycle on issues that could potentially affect them; • Provides for measures to ensure that relevant environmental and social information is disclosed and disseminated
World Bank OP 4.01 on Environmental Assessment	• Provides for environmental assessment (EA) of projects proposed for Bank financing to help ensure that they are environmentally sound and sustainable, and thus to improve decision making

Standard/Guideline	Provision
IFC PS 2 on Labour and Working Conditions	• Provides for measures to promote the fair treatment, non-discrimination, and equal opportunity of workers; • Provides for measures to establish, maintain, and improve the worker-management relationship; • Provides for measures to promote compliance with national employment and labor laws; • Provides for measures to protect workers, including vulnerable categories of workers such as children, migrant workers, workers engaged by third parties, and workers in an organization's supply chain; • Provides for mechanisms to promote safe and healthy working conditions, and the health of workers; and • Provides for measures to avoid the use of forced labor.
IFC PS 3 on Resource efficiency and Pollution Prevention	• Provides for measures to avoid or minimize adverse impacts on human health and the environment by avoiding or minimizing pollution from project activities. • Provides for measures to promote more sustainable use of resources, including energy and water. • Provides for measures to reduce project-related GHG emissions.
IFC PS 4 on Community Health, Safety and Security	• Provides for mechanisms to anticipate and avoid adverse impacts on the health and safety of the affected community during the project life from both routine and non-routine circumstances; and • Provides for measures to ensure that the safeguarding of personnel and property is carried out in accordance with relevant human rights principles and in a manner that avoids or minimizes risks to the affected communities.
IFC PS 5 on Land Acquisition and Involuntary Resettlement & World Bank OP 4.12 on Involuntary Resettlement	• Provides for measures to ensure the avoidance, and when avoidance is not possible, minimization of displacement by exploring alternative project designs; • Provides for measures to ensures the avoidance of forced eviction; • Provides for measures to ensure the anticipation, avoidance or minimization of adverse social and economic impacts from land acquisition or restrictions on land use by (i) providing compensation for loss of assets at replacement cost and (ii) ensuring that resettlement activities are implemented with appropriate disclosure of information, consultation, and the informed participation of those affected; • Provides for measures to ensures the improvement or restoration of the livelihoods and standards of living of displaced persons; and • Provides measures to ensure the improvement of living conditions among physically displaced persons through the provision of adequate housing with security of tenure at resettlement sites.
IFC PS 6 on Biodiversity Conservation and Sustainable Management of Living Natural Resources	• Provides for measures to ensure the protection and conservation of biodiversity; • Provides for measures to ensure the maintenance of benefits from ecosystem services; and • Provides for measures to promote the sustainable management of living natural resources through the adoption of practices that integrate conservation needs and development priorities.
World Bank OP 4.04 on Natural Habitats	• Provides for the application of a precautionary approach to natural resource management to ensure opportunities for environmentally sustainable development;

Standard/Guideline	Provision
	• Provides for measures for the identification of (a) natural habitat issues and special needs for natural habitat conservation, including the degree of threat to identified natural habitats (particularly critical natural habitats), and (b) measures for protecting such areas in the context of the country's development strategy; • Provides for measures to rehabilitate degraded natural habitats; • Discourages the significant conversion or degradation of critical natural habitats; and • Provides for measures to take into account the views, roles, and rights of groups, including local nongovernmental organizations and local communities, affected by Bank-financed projects involving natural habitats, and to involve such people in planning, designing, implementing, monitoring, and evaluating such projects.
IFC PS 7 on Indigenous Peoples & World Bank OP 4.10 on Indigenous Peoples	• Provides for measures to ensure that the development process fosters full respect for the human rights, dignity, aspirations, culture, and natural resource-based livelihoods of Indigenous Peoples; • Provides for measures to ensure the anticipation and avoidance of adverse impacts of projects on communities of Indigenous Peoples, or when avoidance is not possible, to minimize and/or compensate for such impacts; • Provides for measures to promote sustainable development benefits and opportunities for Indigenous Peoples in a culturally appropriate manner; • Provides for measures to establish and maintain an ongoing relationship based on Informed Consultation and Participation (ICP) with the Indigenous Peoples affected by a project throughout the project's life-cycle; and • Provides for measures to respect and preserve the culture, knowledge, and practices of Indigenous Peoples.
IFC PS 8 on Cultural Heritage & World Bank OP 4.11 on Physical Cultural Resources	• Provides for measures to protect cultural heritage from the adverse impacts of project activities and support its preservation; • Provides for measures to promote the equitable sharing of benefits from the use of cultural heritage; and • Provide for measures to address impacts on physical cultural resources in projects proposed for Bank financing, as an integral part of the environmental assessment (EA) process.

5. Environmental and social baseline conditions

5.1. General

Machakos County is in what was formerly known as Eastern province and is comprised of 8 sub-counties/ constituencies namely; Mavoko, Matungulu, Machakos Town, Masinga, Yatta, Kangundo, Kathiani, and Mwala. The County covers an area of approximately 6,281.4 km^2 most of which is semi-arid. High and medium potential areas where rain fed agriculture is carried out consist of 1,574km^2 or 26% of the total area.

5.2. Environmental baseline conditions

5.2.1. Topography and climate

Machakos County is situated on a predominantly semi-arid, eastward-facing slope, which becomes progressively lower and drier to the east where the topography varies from gently undulating to rolling with a central flat portion on the Yatta Plateau. The semi-humid to humid area (Agro-climatic Zone I-III) of Machakos County is about 4% or 247Km^2, while the semi-humid/semi-arid to very arid (Agro-climatic Zone IV-VII) land forms about 96% or 5,962Km^2 of the County.

The area is part of Kenya's Eastern Foreland Plateau, an eroded basement complex broken by residual hill masses such as the Mua, Iveti, Kanzalu range and Donyo Sabuk hills and occasionally overlain by Tertiary volcanics. The Athi River skirts the western side of this lava flow and the drainage system from the adjacent Kanzalu range is down cutting, mainly by gully erosion. The Machakos Hills area can be described as hills dropping down to a series of plains, separated by steep slopes

The region has a gradient of decreasing altitude (from 2,100 m to 440 m), increasing temperatures, and decreasing moisture (from 1,270 to 381 mm average annual rainfall) from west to east.

Elevation controls the quantity of rainfall at the regional scale, whereas topography strongly influences rainfall distribution at the local scale. Rainfall, except in the hilly regions, is low and unreliable. The precipitation pattern is bimodal, with long rains falling between March and May and short rains from October to December. The mean monthly temperatures vary between 18°C and 25°C. The coldest month is usually July while October and March are the hottest months. The highland areas which receive higher rainfall are more suitable for rain-fed agriculture than the lowland areas, while the plains support ranching.

5.2.2. Water resources and hydrology

The Athi River and its tributaries are the major permanent water courses and drain most of the County. There are a few other permanent rivers in the North. However, majority of the water courses in the County are seasonal and their flow is very irregular in the lowlands in the dry season, forming ponds or drying up. There are sandy deposits along the beds of these dried-up rivers, which are an important source of water for the rural populations during the dry periods.

The hills in the central part of the County are a catchment area for numerous springs and streams such as Manza, Miwongoni, Maruba, Kyondu, Kethese streams that supply water to Maruba dam, the major source of water in Machakos County. In this area, the protection and development of springs is common and the shortage of water is not as acute as in the lowlands. These streams, and others such as Mitheu, Mwania, Mbanyani, and Ikondeni drain into Ikiwe River which in turn drains into Thwake River further east, and finally into Athi River. These rivers and streams form a dendritic drainage pattern in the Athi river drainage basin.

5.2.2.1. Groundwater

Groundwater around Machakos Municipality flows from the higher altitude areas in the east to the western and southern areas. The movement of groundwater is therefore controlled by the sub-surface morphology of the underlying rocks. Weathered and/or fractured zones as well as buried valleys, faulty zones and joints are the main media for groundwater movement. A water table therefore occurs between the fractured/weathered contacts of the rock formations.

Whereas the primary recharge source of the aquifer is lateral flow from the elevated catchment areas, secondary replenishment of the aquifer occurs through infiltration and percolation of precipitation through open fissures to the aquifer zones.

Much of the groundwater is found along dry river beds such as the five boreholes that are located to the northwest of Machakos Town alongside the seasonal Iyini River. Other boreholes have been sunk in various places with varying yields. Some have been found to be dry, while others (such as those in Katheka-kai) have high yields of up to 20.7m^3/h.

Shallow hand dug wells are also found to the west of Machakos Town, with water found at depths of up to 25 metres.

5.2.3. Soils and geology

Soils of Machakos, County reflect the largely metamorphic parent material and the rainfall regimes that contribute to their formation. In Machakos, the dominant soil groups are alfisols, ultisols, oxisols, and lithic soils. These soils are all generally of low fertility, and many are highly erodible. The ultisols and alfisols are also susceptible to sealing (capping), which increases runoff and makes the clay soils hard to plough by the end of the dry season. A rough estimate of the agricultural quality of the region's soils indicates that less than 20% of Machakos has well-drained, deep, friable red and brown clays of good fertility; more than 60% of the region has very erodible, relatively shallow, sticky, red, black, and brown clays of variable fertility, on steep slopes; 20% has poorly drained, shallow, Stoney soils of low fertility.

5.2.4. Biodiversity of the project area

Apart from agricultural crops that form 45.3% of the land cover in the County, the dominant natural vegetation of the County is dry bush with trees, and, in the higher areas, savanna with scattered trees. The hills were once forested, but by the beginning of the colonial period most of the "desirable" agricultural land had been cleared leaving patches and corridors of forest along ranges, rivers, ravines, and hilltops, as well as dry forest in large expanses of grazing land. Characteristic vegetation at the higher altitudes (above 1,700 m) includes remnant evergreen forest (of *Podocarpus* spp.) and bracken, mist forest, and evergreen thicket clumps in grassland. Elevations at 1,200-1,700 m are dominated by *Combretum* sp., with particular plant associations correlated with topography and moisture. The most widespread vegetation type in the County is semi-arid deciduous thicket and bushland, particularly *Acacia/Commiphora* associations in the 800-1,200 m elevation range. In the dry areas below 900 m, *Commiphora/Sanseveria* thorn bush grades into semi-desert vegetation.

The forest zone is now largely under cultivation, with shrubby secondary growth dominating non-cultivated areas. The soils characteristic of the moist *Combretum* areas are fairly productive for agriculture, but the dry *Combretum* zones have sandy soils of limited fertility. The *Acacia/Commiphora* zone includes perennial grasses valued for grazing, but even in these areas forest and shrub land are increasingly being converted to cropland.

Ecologically sensitive areas in Machakos County include, Iveti, Tulimani, Katunga Forest Reserves, Mwea and Oldonyo Sabuk National Parks, Lukenya Cooperative Ranch and Mitaboni –Katani Company Ranch.

Machakos valleys – an area of about 5000ha near Katumani has been identified as an Important Bird and Biodiversity Area based on the presence of: significant populations of globally threatened species; and significant populations of endemic species known only to be found in a limited area. This area comprises river and stream valleys in the catchment of the Ikiwe and Ngwani rivers, south of Machakos town, draining eastwards into the Athi river system. The land slopes gradually down from the Athi-Kapiti plains in the west, with an intricate system of river valleys draining between small hills. The riverbeds consist of sand and rock, with a dense band of bush and thicket (dominated by *Grewia trichocarpa* with *Teclea* and *Aspilia* species) for about 10 m on either side, grading into open *Acacia hockii* and *A. xanthophloea* woodland. The land is owned by a number of large ranches, including Potha, Kilima and Kimutwa, some of which have been divided up into small agricultural plots. The boundaries of the IBA are presently undefined, requiring further survey work; it includes sections of the Ikiwe, Kimutwa, Love, Makilu, Mwania, Potha, Syuuni, Wamua and Wamui rivers.

A 2009 IBA monitoring assessment of the area identified it as highly threatened and in very unfavourable condition as shown in the table below:

Table 5-1 IBA monitoring assessment of Machakos valleys

Most recent IBA monitoring assessment			
Year of assessment	Threat score (pressure)	Condition score (state)	Action score (response)
2009	high	very unfavourable	negligible

(Source: http://datazone.birdlife.org)

Wildlife commonly found in Machakos County include the plains game such as hartebeests, zebras, wildebeests, giraffes, elands and ostriches although these are now mostly found in commercial ranches after rapid changes in land-use systems over the years.

Within Machakos valleys, the riverine thickets and woodland shelter the globally threatened *Turdoides hindei*, which has a very restricted range in central Kenya. This is one of the few sites where it is known to occur in natural habitat, although at relatively low densities. The babblers are commonest in the higher parts of the IBA, and are likely to occur in river valleys immediately to the south as well. The rest of the avifauna is characteristic of semi-arid areas in Kenya, with 18 species from the Somali–Masai biome (BirdLife International, 2018). The Table below lists the other birds' species found in the IBA:

Table 5-2 Birds' species of Machakos valleys

Species	Common name	IUCN Red List Category
Argya rubiginosa	Rufous Chatterer	LC
Bradornis microrhynchus	African Grey Flycatcher	LC
Calamonastes simplex	Grey Wren-warbler	LC
Caprimulgus fraenatus	Sombre Nightjar	LC
Criniferoides leucogaster	White-bellied Go-away-bird	LC
Drepanorhynchus reichenowi	Golden-winged Sunbird	LC
Granatina ianthinogaster	Purple Grenadier	LC
Melierax poliopterus	Eastern Chanting-goshawk	LC
Ploceus baglafecht	Baglafecht Weaver	LC
Ploceus spekei	Speke's Weaver	LC
Pternistis leucoscepus	Yellow-necked Francolin	LC
Rhinopomastus minor	Abyssinian Scimitarbill	LC
Tockus deckeni	Von der Decken's Hornbill	LC
Trachyphonus erythrocephalus	Red-and-yellow Barbet	LC
Turdoides hindei	Hinde's Babbler	VU
Turdoides hypoleuca	Northern Pied Babbler	LC
Turdus tephronotus	Bare-eyed Thrush	LC
Vidua fischeri	Straw-tailed Whydah	LC

(Source: https://www.ibat-alliance.org)

5.3. Socioeconomic baseline conditions

5.3.1. Present populations

Machakos County has a population of 1,098,584 and a population density of 177 persons per km^2. The average household size in the County is eight persons. Urban population accounts for 52% of the total population of the County. Kangundo, Kathiani and Central Divisions have the highest population densities at 539, 486 and 307 people per Km^2 respectively due to their higher economic potential in comparison to other divisions. These divisions have fertile soils and receive moderate rainfall that enables growing of cash and

food crops. Athi River Division has the lowest density of 51 people per km^2. Over 50% of this population is, however, concentrated around Athi River town where most industries are found.

Machakos Central Ward, where the project area is located had a population of 30,205 comprised of 14,772 males and 15,433 females.

5.3.1.1. Population pyramid

Machakos County is at the beginning of a transition from a child rich population structure where those aged between 0 - 14 years at 39%, are at the onset of a decline while those aged between 15-34 years old who constitute 34% of the total population are beginning to increase. This is also evidenced by the fact that the percentage household size of 0-3 members is 42.3% and 4-6 household size members is 42.6%

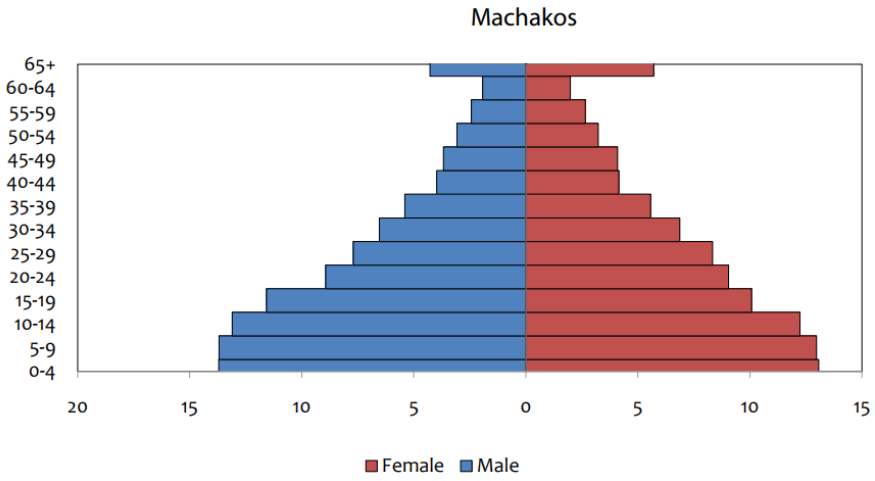


Figure 5-1 Machakos population pyramid

In the project area, the percentage of those aged 0-14yrs is 31.5%, while those aged between 15-34 yrs 40.6%. The percentage household size of 0-3 members is 54.1%, 4-6 members is 36.2%, while 7+ members is 9.7%.

5.3.2. Livelihoods and poverty levels

Following the Kenya Integrated Household Budget Survey(KIHBS) 2005/06, the poverty rate in Machakos County was recorded as 59.6%, and the County contributed about 4.4% to the national poverty. The 2009 Kenya Population and Housing Census however recorded a poverty incidence of 42.6%, with over 462,000 people living below the poverty line. The County's contribution to national poverty was 2.7% 70% of the population derives its income from Agriculture, 10% from rural self-employment, 11% from wage employment while 2% are unemployed.

Adult literacy levels in Machakos County, i.e. the population aged 15 years and above who can both read and write a simple statement in at least one language ranges between 80-90% (KIHBS, 2005/06). More males than females are literate in the County.

5.3.3. Employment

The 2009 population and housing census covered the labour status and compared employment by education levels of the population in Machakos County.

Table 5-3 Overall employment by education levels in Machakos county

Education Level	Work for pay	Family Business	Family Agricultural Holding	Intern/ Volunteer	Retired/ Homemaker	Fulltime Student	Incapacitated	No work	Number of Individuals
Total	29.1	11.3	22.9	1.0	14.5	13.8	0.7	6.8	603,316
None	22.9	10.1	28.5	2.7	23.2	1.6	4.6	6.4	25,604
Primary	26.7	10.7	26.6	0.8	16.7	11.1	0.6	6.8	318,701
Secondary+	32.7	12.0	17.8	1.1	10.9	18.2	0.3	7.0	259,011

In the County, 23% of the residents with no formal education, 27% of those with a primary level of education and 33% of those with secondary level of education or above work for pay.

The figure below shows employment levels in the project area (Machakos Central Ward), while the Tables show employment by education levels for male and female headed households.

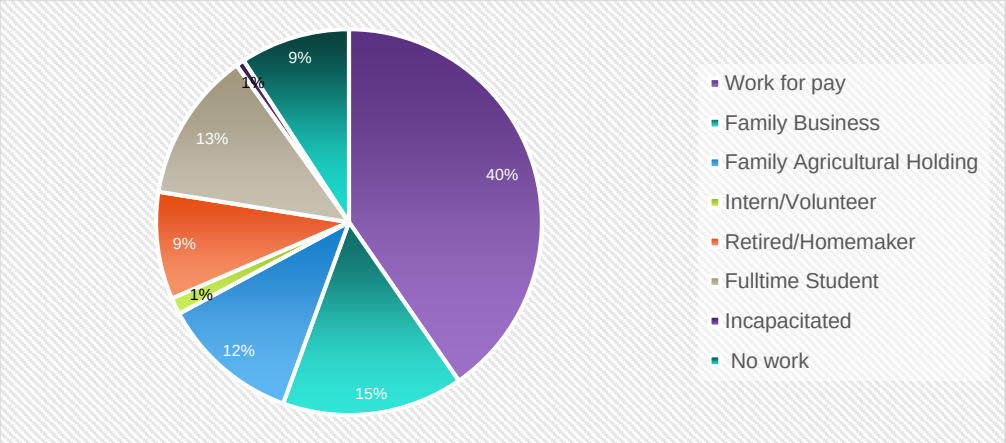


Figure 5-2 Employment levels in the project area

Table 5-4 Employment by education levels in the project area

Education Level	Work for pay	Family Business	Family Agricultural Holding	Intern / Volunteer	Retired / Homemaker	Full-time Student	Incapacitated	No work	Number of Individuals
Total	40.4	15.2	11.6	1.4	9	12.6	0.7	9.2	19,564
None	30.3	19.5	15.3	3	12.2	2.8	5.1	11.8	568
Primary	36.1	15.3	15.6	1	11.9	8.3	0.8	11	7,777
Secondary+	43.9	14.9	8.7	1.5	6.7	16.1	0.4	7.7	11,219

Table 5-5 Employment and education levels in male headed households in the project area

Education level	Work for pay	Family Business	Family Agricultural Holding	Intern / Volunteer	Retired / Homemaker	Full-time Student	Incapacitated	No work	Number of Individuals
Total	41.9	15.5	11.9	1.3	8.7	11.5	0.5	8.7	13,890
None	35	19.2	14.3	2.9	9.9	2.9	5.5	10.2	343
Primary	37.7	15.2	15.8	1	11.6	7.6	0.6	10.4	5,527
Secondary+	45.1	15.6	9.1	1.4	6.7	14.5	0.3	7.4	8,020

Table 5-6 Employment and education levels in female headed households in the project area

Education Level	Work for pay	Family Business	Family Agricultural Holding	Intern / Volunteer	Retired / Homemaker	Fulltime Student	Incapacitated	No work	Number of Individuals
Total	36.7	14.4	11	1.6	9.6	15.5	1	10.4	5674
None	23.1	20	16.9	3.1	15.6	2.7	4.4	14.2	225
Primary	32	15.5	15	1	12.8	10	1.1	12.6	2250
Secondary+	40.9	13.2	7.8	1.9	6.9	20.2	0.6	8.5	3199

5.3.4. Infrastructure

Paved roads in Machakos County comprise of 6.9% of total roads in the county while good and fair roads make up 26.9% of total roads. 17% of the households in the County have access to electricity while 58.1% have access to clean water.

5.3.4.1. Sources of water

In Machakos County, 37% of residents use improved sources of water, with the rest relying on unimproved sources. Improved sources of water comprise protected spring, protected well, borehole, piped into dwelling, piped and rain water collection while unimproved sources include pond, dam, lake, stream/river, unprotected spring, unprotected well, jabia, water vendor and others. Use of improved sources is mostly common in male headed households at 39% as compared with female headed households at 33%.

In the project area (Machakos Central Ward) 39% use improved sources, while 61% use unimproved sources of water. The Table below indicates the various sources of water for the project area residents:

Table 5-7 Unimproved sources of water for project area residents

Pond	Dam	Lake	Stream/River	Unprotected Spring	Unprotected Well	Jabia	Water vendor	Other	Unimproved Sources
0.2	0.2	0	7.5	17.1	10.5	0.2	25.4	0	61

Table 5-8 Improved sources of water for project area residents

Protected Spring	Protected Well	Borehole	Piped into Dwelling	Piped	Rain Water Collection	Improved Sources
1.2	10.4	6.5	10.5	10.2	0.2	39

There is little variance in the sources of water between male and female headed households in the project area as shown in the figure below:

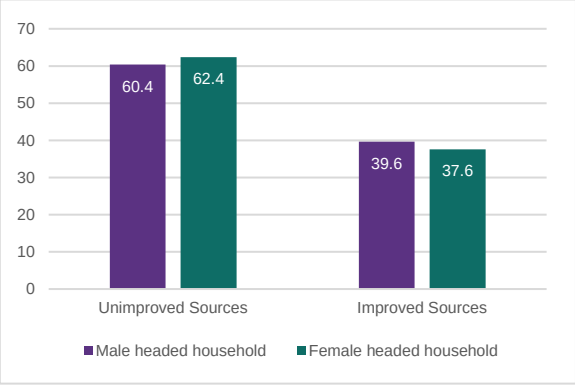


Figure 5-3 Sources of water for male and female headed households in the project area

5.3.4.2. Sanitation

A total of 61% of residents in Machakos County use improved sanitation, while 39% use unimproved sanitation. Improved sanitation includes use of main sewer, septic tank, cess pool, VIP latrine and pit latrine for human waste disposal. Unimproved sanitation includes use of uncovered pit latrines, bucket, bush or other means for human waste disposal. Use of improved sanitation is slightly higher in male headed households at 62% compared with female headed households at 52%.

In the project area, 74% of the residents use improved means of sanitation while 26% use unimproved means of sanitation as shown in the Table below:

Table 5-9 Waste disposal methods for Machakos County and project area residents

County / Ward	Main Sewer	Septic Tank	Cess Pool	VIP Latrine	Pit Latrine	Improved Sanitation	Pit Latrine Uncovered	Bucket	Bush	Other	Unimproved Sanitation
Machakos County	3.3	2.72	0.37	7.51	47.13	61.03	36.18	0.1	2.5	0.19	38.97
Machakos Central	21.79	10.82	0.56	10.17	30.41	73.75	25.49	0.54	0.16	0.06	26.25

There is however no significant difference in waste disposal methods between male and female headed households in the project area as shown in the figure below:

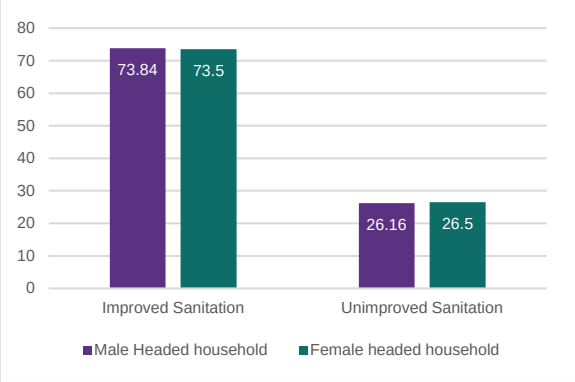


Figure 5-4 Waste disposal methods for male and female headed households in the project area

5.3.5. Housing

Residential dwellings in Machakos County are either of permanent and semi-permanent construction; 59.2% are brick/block walled, 23.9% stone walled, and 12.3% mud/wood walled. Others include 1.5% which are wood walled, and 2.7% with corrugated walls respectively.

5.3.6. Socio-economic activities

Most of the population (about 76.4%) in Machakos practices subsistence agriculture with maize and drought-resistant crops such as sorghum, millet, cassava, pigeon peas and sweet potatoes being grown due to the area's semi-arid state. Most of what is produced is majorly used as own food in the household and the few that remains is sold to supplement the income and food intake. The county also plays host to the open-air market concept with major market days where farm produce is traded. Fruits, vegetables and other food stuffs like maize and beans are sold in these markets. (Anglican Development Services-Eastern, 2017)

Biophysical agricultural potential in Machakos County is a function of soil characteristics and moisture availability, both of which are largely controlled by elevation and topography. Approximately 76% Machakos falls into agro-ecological zones 4 (semi-humid to semi-arid) and 5, with fully 58% falling in zone 5 (suitable for livestock, sorghum, and millet).

Landholdings range from 0 to 1000's of hectares (ha), with most households in agro-ecological zone 4 owning 2-10 ha and in zone 5 owning 2-15 ha. As land is subdivided and allocated or sold to the rising generation, however, farm sizes of 0.5-1 ha have become commonplace in zone 4. Among all holdings in Machakos County, 30% are less than 0.9 ha in size. Increasing numbers of people in zone 4 have been rendered landless, or forced to migrate to urban areas (mostly men), to plantations (mostly women), or to zone 5 frontier areas. As migrants from zone 4 and resident young people subdivide the available land in zone 5, the landholding size there is also shrinking rapidly.

Most households (about 54.7%) keep both cattle and goats, with an average of two cattle and eight goats or sheep. The most common food crops are maize, beans, cowpeas, pigeon peas, pumpkins, sweet potatoes, green gram, and bananas.

The County also hosts a number of industries, especially in Athi River division. The major industrial land users include steel and glass manufacturers, flower farms, meat processing and cement industries.

Tourist attractions in the county include the national parks like Donyo Sabuk and private ranches which hold expansive land coverage in sections of the county.

5.3.7. Public health

The general shortage of water and the consumption of water from unsafe sources during the dry season and periods of drought have serious consequences for human health. The incidence of water borne diseases is very high, making up an estimated 50-70 per cent of all diseases in the County. In particular, Schistosomiasis is endemic in the area and its incidence is related to the number of sites used to collect water and to the distance to the water point most frequently used.

In the year 2001, Machakos had over 110 health facilities spread across the County. The doctor/population ratio was about 1:62,325 showing over-utilization of doctors. However, access to health facilities has been improving with time. Many health facilities have been constructed under the Economic Stimulus Programme (ESP) and Constituency/Sub County Development Fund (CDF). The doctor to patient ratio is now 1:60,000. (County Government of Machakos, 2015) The most prevalent diseases are Malaria and skin diseases while the childhood diseases include anaemia, marasmus, eye infection, pneumonia, malaria, Kwashiorkor etc. HIV/AIDs is also a major health problem in the County with the prevalence averaging 4.5%.

5.3.8. Environmental issues

The unavailability of water has had a significant influence on the patterns of human settlement in the County. The population tends to concentrate in the highlands, where water sources and fertile land is more abundant. However, the increasing pressure on these areas resulting in land fragmentation into uneconomic holdings and destruction of forests has environmental consequences, mostly the high susceptibility of cropland to erosion. Other factors contributing to soil erosion in the County include; the tendency of the soils to "cap"; and the fact that 70 per cent of the most erosive rainstorms occur in the first month of the rainy season, before crops can establish an effective cover. Cattle, goats, and sheep also have pronounced effects on the soils that have a propensity to form a pavement-like surface when denuded by overgrazing and physically compacted by trampling. The resulting land degradation, in turn, reduces future crop and livestock production.

In the lowlands, the concentration of people and livestock around waters sources has also contributed to soil erosion, as the land on these areas soon becomes overgrazed.

Machakos is marginal for agriculture and possesses some of the most severe soil erosion problems in Kenya (Moore, 1979). Soil conservation was first introduced by the colonial government in the 1940s, but there was strong resistance to soil conservation since the techniques used were based on enforced communal work. The change in attitude was brought about by campaigns and support from the National Water and Soil Conservation Project (Machakos District) in the 1970s (Critchley, 1991).

Soil erosion is a cause and consequence of flash floods during the wet season in the County. These floods increase the water shortage, since many structures for water collection and storage are destroyed. The shortage of water also constrains agricultural production and economic growth in Machakos County. Periods of drought often mean crop failure, loss of livestock and food insecurity. However, it is found that these effects are greatly reduced in the areas where water harvesting structures have been efficiently developed.

The population of the County has developed some methods of halting the mutually reinforcing links between water availability and soil erosion. Two thirds of the fields are terraces on hillsides, which helps to reduce soil erosion. Many farms also have retention ditches to seep water to cultivated areas and cut-off drains to collect and discharge water without erosion to the fields.

The ecologically significant Machakos Valleys is mainly ranchland, but (as in other marginal land in Kenya) agriculture is increasing, with attendant destruction of habitat. Of particular concern is the subdivision of large ranches into small parcels of land that are then cleared of all natural vegetation. The riverine woodland and thickets, which provide suitable habitat for *Turdoides hindei*, are particularly vulnerable. Because of the babblers' low densities, which imply large home ranges (mean territory length estimated as 1.25 km of watercourse), even moderate habitat loss might lead to serious population declines. A 2000 survey found signs of recent bush clearing and tree felling along all the watercourses surveyed. Subsistence hunting is also likely to be a threat to the babblers in this area (BirdLife International, 2018).

5.3.9. Current development plans

As part of vision 2030, the government has proposed development of Konza ICT technopolis in Machakos County. The city to be developed over a 20year period on 5000 acres of land is located about 47 Km form Athi River town. The proposed city will be a centre of ICT development, business process outsourcing, tourism and advanced education.

In line with the proposed city development and the wider strategies of Vision 2030, there are also plans by the Kenya National Highways Authority, to dual a section of the Nairobi - Mombasa highway. This is an international trunk road which passes through the County between Athi River and Malili towns.

These proposed developments are large scale and will likely have greater implications on energy requirements, associated cumulative environmental impacts and economic development in Machakos County.

6. Stakeholder engagement

6.1. Introduction

The need for public involvement in project development is enshrined in the Constitution of Kenya, 2010. This requirement is also provided for in the EMCA, 1999, the Environmental (Impact and Audit) Regulations, 2003, and is one of the guiding principles of the National Environment Policy, 2013.

Public participation ensures that communities and stakeholders are part and parcel of the proposed development(s). It presupposes that the public has access to timely and accurate information on the environment and the proposed development(s), and therefore assures that the developments are sustainable and resources are also used sustainably. It has also been demonstrated successfully that projects that go through this process acquire a high level of acceptance and accrue benefits to a wider section of society.

Public consultation also forms a useful component for gathering, understanding and establishing likely impacts of projects, determining community and individual preferences and selecting alternatives.

6.2. Benefits of public consultation

6.2.1. Benefits to the developer

- The developer is likely to benefit from local knowledge;
- Costs may be saved as key issues are identified by the public and studies are focused on key issues as opposed to a broad range of issues;
- Measures to reduce adverse impacts and enhance benefits will be identified with stakeholders;
- Relations with the communities in the vicinity of the development are likely to be improved;
- Delays in decision making may be reduced because of good participation early in the process;
- The public are unlikely to raise objections to the project; and
- The developer's image and reputation is likely to be enhanced.

6.2.2. Benefits to the public

- Capacity is built through people playing an active role during the process. The skills learnt can be used in other community projects;
- Public rights are exercised and protected in participating; and
- Inputs are likely to influence the form and nature of the development and is likely to lead to better development that takes society's needs into account.

6.2.3. Benefits to decision makers

- Public participation is likely to improve decisions since there is access to a broader range of perspectives and opinion on the proposed rehabilitation/augmentation;
- The development is likely to be more sustainable as it takes people's needs and views into account; and
- The legitimacy of project commencement and implementation is likely to be improved.

6.3. Public consultations in the project area

The Public consultation process involved visiting the project area and its environs. Project stakeholders were identified and consulted with the aim of informing them about the proposed project, collect their views on anticipated positive and/or negative impacts, get recommendations on how the adverse impacts can be mitigated or avoided, and gather local knowledge that would be useful to the proposed project.

6.3.1. Objectives

The main objectives of the public consultation process were as follows:

- To inform stakeholders about the proposed project;

- To share with stakeholders, the impacts (positive and/or negative) that they should expect from the proposed project during construction and operation; and
- To collect stakeholders' views, comments, concerns and local knowledge regarding the proposed project.

6.3.2. Engagement methodology

To complete the public consultation exercise, a systematic approach was implemented that consisted of a reconnaissance visit to the project area, review of relevant documentation, conducting interviews, administration of questionnaires to the project stakeholders and holding stakeholders' meetings. The Public consultation exercise commenced in April 2017 with the reconnaissance visit, and culminated with community meetings held on 31st May and 7th December 2017.

6.3.2.1. Reconnaissance visit

Project site visits were carried out in April 2017 to familiarise with the project area and scope. During these visits, would-be project stakeholders covering government institutions, individual households and the neighbouring communities were identified.

6.3.2.2. Literature review

A review of relevant information including the project's Feasibility Study Report and County Data Sheets for Machakos was done to provide a background on the project and area, and a basis for collection of additional information to fill identified gaps.

6.3.2.3. Stakeholders identification and analysis

The following were identified as project stakeholders:

6.3.2.3.1. Community

- Residents of Uyini and Manza Villages– this community neighbours the proposed Miwongoni dam and the water treatment plant, and also reside along the proposed pipeline route from the treatment works to Katelembu;
- Residents of Katelembu and Kilima - the communities that will host the Katelembu and Kilima tanks which will store clean water prior to distribution to various consumers;

6.3.2.3.2. Machakos County Government

Table 6-1 Identified stakeholders in Machakos County Government

Position	Institution
The Governor	Machakos County
County Minister of Environment, Water and Natural Resources	Ministry of Water, Environment, & Natural Resources
County Director of Environment	NEMA, Machakos County
Deputy County Commissioner	Machakos Sub county
County Lands Officer	Machakos County
County Social Affairs Officer	Machakos County
Chief	Katheka-kai Location

6.3.2.3.3. Water sector stakeholders in the project area

Table 6-2 Water sector stakeholders

Position	Institution
Regional Manager	Athi Catchment Area - (WRMA)
Water Resource Users Association	WRUA-Project Area
Machakos Water and Sewerage Company	Machakos County

In this study, the 'importance' of a stakeholder is defined by whether the stakeholder is directly or indirectly affected by project activities. For instance, stakeholders expected to be directly affected by activities accruing from the proposed water supply project are viewed as more 'important' as they are likely to experience first-hand, the associated impacts. The stakeholders are as analysed below:

Table 6-3 Stakeholders analysis

	Details					Impact Level	
	Community	Government	Business	Other		Directly Affected	Indirectly Affected
Residents of Manza village in Katheka-kai location					• Community living in the project area: some neighbouring the proposed Miwongoni dam and treatment works sites and others neighbouring transmission lines. • Some of the land owners will be affected by the land acquisition process for Miwongoni dam and Treatment Works sites.		
Residents of Katelembu and Kilima Residents of Machakos town and environs					• Areas where new water storage tanks will be located. Communities unlikely to be significantly affected. The parcel of land at Kilima will however need to be acquired though undeveloped. • These are the major beneficiaries of this project as the water supply system is being developed for their use.		
Machakos County Government					• The County Government of Machakos hosts several technical stakeholders whose inputs were sought on project components to be located in Machakos County.		
WRMA – Athi Catchment Area					• Government authority in charge of water resources management, and a key stakeholder as the manager of the river proposed for impoundment and abstraction		
WRUA – Miwongoni River					• Association that works with WRMA in its effort to manage and protect water resources in the project area		
Machakos Water and Sanitation Company (MAWASCO)					• Stakeholder currently in charge of water supply and sanitation in Machakos Town.		

6.3.2.4. Stakeholders' consultation

Stakeholders were consulted through the following methods:

6.3.2.4.1. Key informant interviews

This method was used to collect needed information, ideas, and insights from a select group of individuals knowledgeable in the project, the project area and community issues. The Table below provides a summary of outcomes of the interviews.

Table 6-4 Summary of key informant interviews

Stakeholder's Name	Organization	Position	Benefits	Concerns	Recommendations/Other Remarks
Preferred anonymity	Water Resources Management Authority (WRMA)	Deputy Technical Coordination Manager	• The project will provide job opportunities to youth during construction. • Employment opportunities will keep youth off activities like sand harvesting which degrade water resources. • The project will help Machakos solve its current water challenge.	• Dumping of soil near water resources during construction may occur.	• Do not dump soil along water resources/riparian areas during construction. • Proponent to comply to all permits required for water abstraction.
Winfred Mbai Isaac Musya	Machakos Water and Sewerage Company	Managing Director	• The project will create job opportunities. • It will improve hygiene in Machakos.	• The project is likely to interrupt water services during construction.	• The proposed project is long overdue because the existing system has passed its ultimate design period and cannot adequately cater for the current population's water demand.
Engineer Stephen Ndwiki	County Government of Machakos	CEC – Water	• The project will create employment opportunities.	• Air pollution during construction.	• Speedy implementation of the project to ensure minimal interference with normal land use.
Lillian Kitavi	Mavoko Sub County	Sub County Administrator	-	-	• The Mavoko Sub county leadership is in support and willing to support the Machakos Water and Sewerage Project.
Eng. Alphaxard Kitheko	AWSB	Project Engineer			• The Water Project will involve: ✓ Construction of a 15m high R.C Dam on Miwongoni River, capacity 1.6M3; ✓ Construction of a new Miwongoni treatment works of capacity 20,000m3/d about 300m to the Southwest of the existing Maruba Treatment; ✓ Rehabilitation of existing treatment works at Maruba; ✓ Construction of a clear water pumping main and rehabilitation of existing rising main and transmission mains;

					✓ Construction of 36km new water distribution lines and 4No. RC storage tanks of different capacities and Elevated steel tank; ✓ Strengthening and rehabilitation of existing water distribution infrastructure within Machakos town and its environs and; ✓ Drilling and equipping of 5No. boreholes. • The project will commence when there is land and allowing 3 months tendering procedure as per the set requirements.
Chief Pius Ngomoli Peter Ngovu Mutua	Muvuti Location Mikuyu Sublocation	Senior Chief Assistant Chief	• Project will assist the community as currently water supply is a challenge. • It will create job opportunities during construction.	• It is likely to lead to displacement of people because of land requirements.	• Reported that they are ready and willing to support all involved to ensure smooth implementation of the project.

6.3.2.4.2. Questionnaires administration

This method was applied in collecting data on the respondents' perception of the proposed project, including the positive and/or negative impacts they expect from the proposed project and any recommendations for enhancement of to the project. A total of 55 questionnaires were administered to respondents in Katheka-kai location, and these are attached in **Appendix C**.

6.3.2.4.3. Community meetings

Two community consultation meetings were held on 31st May 2017 and 7th December 2017 in Uyini and Manza villages, Mikuyu sub-location near the proposed dam and treatment works site. The meetings aimed at the following:

- Informing participants about the proposed project;
- Educating participants about the potential project impacts – both positive and negative and;
- Giving participants a forum where they can provide their comments, concerns and/or recommendations after understanding the proposed project.

Minutes of this meeting are attached in **Appendix C.**

Figure 6-1 Community meeting held in Uyini village

Figure 6-2 Community meeting held in Manza village

6.3.3. Consultation findings

6.3.3.1. Perceived benefits to the community

Respondents contacted explained that they expect the local community to benefit from the proposed project in the following ways:

- The project would create employment opportunities during construction and create business opportunities for local suppliers of construction materials;
- Employment opportunities to young people will lead to reduction in environment-degrading activities such as sand harvesting and impoundment of sewage for irrigation – activities which have negative impacts to water resources and human health;
- The project will increase clean water supply to the community to augment the existing supply and enhance reliability;
- Access to clean water will improve the quality of life and reduce waterborne diseases
- The project will enhance irrigation activities making food production less dependent on rainwater;
- The project will help MAWASCO and the government in its mandate to provide communities with adequate and good quality water.
- The project will generate water use fees which will be used for managing the water resources in that catchment.

6.3.3.2. Community concerns on the project

Respondents were concerned about the issues outlined below, and gave some proposals on their resolution:

- There were concerns about resettlement which were unresolved during construction of Maruba dam. These concerns needed to be addressed first before construction of another dam;
- Miwongoni dam would result in displacement of people and the community was not sure whether they would be adequately compensated;
- Land acquisition for the project might result in conflicts with the community if not properly handled;
- The project will increase water supply yet Machakos does not sufficient capacity to handle the resultant waste water
- Waste water generated from the proposed project (treatment works) during operation could end up in the area's water resources and cause water pollution;
- Dumping of soil along water courses may occur during construction causing siltation of Miwongoni and Manza rivers;
- During operation, over abstraction may occur leading to decreasing flows downstream which might result to conflicts.
- Interruption of water services during construction may be experienced by existing consumers with water supply connections.
- Local air pollution from dust may occur due to construction activities at the work sites;
- There may be little or no flow of water downstream of Miwongoni River after construction of the weir as the river is seasonal
- Construction activities might result in destruction of crops near construction sites;

6.3.3.3. Recommendations by the community on the project

To resolve the above-listed concerns, the community had further recommendations including:

- The project proponent should properly engage land owners and offer compensation as will be agreed;
- There should be a component of waste water treatment plant to handle the resultant waste water;

- To prevent water pollution by the proposed Miwongoni treatment plant, the proponent should develop a wastewater treatment facility to handle the resultant waste water;
- Siltation of rivers should be prevented by ensuring that no dumping of soil takes place along riparian reserves or near water courses;
- To avoid over-abstraction of the river, compliance to permit conditions should be observed;
- To mitigate the impact of water supply interruptions, mobile water supply services should be provided for the duration of service interruption;
- To minimize air pollution by construction activities, the proponent/contractor should protect the existing tree cover;
- To ensure that water continues to flow downstream after construction of the weir the proponent should manage his abstraction levels so as not to interfere with the flows downstream;
- Ensure speedy implementation of the project to ensure minimum interference with the normal land use;
- Educate the local community about the proposed project and its benefits;
- Ensure high integrity levels during implementation of the project in order to deliver value to the community;
- Consider constructing an access road from Katelembu to the intake site as this would benefit the local community as well;
- Work closely with the local community in delivering the project;
- Ensure the water treatment works site is fenced to avoid accidents especially involving children; and
- Ensure water supplied will be affordable so that it can benefit the intended persons.

The table below presents a summary of the issues (concerns, views and proposals) from the community, and the responses given by the project team at the meeting:

Table 6-5 Summary of issues from community consultations

Issue	Response
There were concerns about resettlement which were unresolved during construction of Maruba dam. These concerns needed to be addressed first before construction of another dam.	The Machakos water supply project is an independent project from Maruba dam therefore its resettlement issues will be handled separately.
Miwongoni dam will result in displacement of people and the community is not sure whether they would be adequately compensated. Land acquisition for the project might result in conflicts with the community if not properly handled.	The project affected persons and the local community will be properly engaged and compensation offered as will be agreed.
The project will increase water supply yet Machakos does not have sufficient capacity to handle the resultant waste water.	The Machakos project also includes a sewerage component which will take care of the resultant waste water.
There's fear that water charges will be too expensive and unaffordable to the local community.	All relevant water players in Machakos County will work together with MAWASCO and the community to ensure water supplied will be affordable so that it can benefit the intended persons.
Fear of over-abstraction from Miwongoni River and interference with the flows downstream.	The Proponent to ensure he complies to the conditions they receive from WRMA in the project's abstraction permit.
Local air pollution from dust may occur due to construction activities at the work sites.	Any dusty areas will be regularly sprinkled with water to manage the dust.
Fear of siltation of rivers by the project's construction works.	The Proponent will ensure that no dumping of soil takes place along riparian reserves or near water courses.

Work closely with the local community in delivering the project.	Public participation and stakeholder engagement will be observed throughout the project's life to ensure sustainability.
Risk of accidents at the treatment works.	The water treatment works site will be fenced and manned to avoid accidents especially involving children.
Interruption of water services during construction may be experienced by existing consumers with water supply connections.	Where this is the case, customers will be alerted in advance so that they are able to plan.
Construction activities might result in destruction of crops near construction sites.	The Proponent will indicate to land owners the amount of working space they might require, and advise them to salvage any crops likely to be affected, or pay for any damages.

6.3.4. Conclusion

The consultations exercise established that, in principle, the project was welcome. Expectations of the affected community were that the project would create employment opportunities, increase clean water supply to their area, and improve the quality of life of the community. Their concerns were on whether there would be adequate compensation for displacement especially by Miwongoni dam, environmental pollution during construction and operation especially at the treatment works site, and over abstraction of Miwongoni river. Mitigation measures for concerns raised by the community, and other environmental and social impacts have been proposed in this ESIA.

7. Prediction and evaluation of impacts

7.1. Introduction

This Chapter sets out the methodology used to assess impact significance. In this Report, an impact is defined as "*Any change to the environment, whether adverse or beneficial, wholly or partially resulting from a project developer's activities or products, and which can interact with the environment*".

An impact is defined where an interaction occurs between a project activity and an environmental receptor. The ESIA process ranks impacts according to their significance determined by considering project activity **event magnitude** and **receptor sensitivity**.

Determination of event magnitude will entail the identification and quantification (as far as practical) of the sources of potential environmental and socio-economic effects from routine and non-routine project activities. Determining receptor sensitivity requires an understanding of the biophysical and human environment.

The approach to evaluating the significance of potential environmental and socio-economic impacts is outlined below.

7.2. Environmental impacts

7.2.1. Method for determining Event Magnitude

Event magnitude is determined based on the following parameters, which are equally weighted and are each assigned a rating of 1, 2, or 3

7.2.1.1. Extent/Scale

Events range from those where the effect extends across an area:

1 – Near to the source (in the range of tens to hundreds of metres);

2 – At intermediate distance from the source (in the range of hundreds to thousands of metres); and

3 – At far distance from the source (in the range thousands of metres and above).

7.2.1.2. Frequency

Events range from those occurring:

1 – Once or twice; to

2 - Repeatedly but intermittently; to

3 – Frequently and persistently.

7.2.1.3. Duration

Events range from those where effects occur over:

1 – Instantaneous/short term (i.e. hours to days); to

2 - Medium term (between a week and 3 months); to

3 - Long term (more than 3 months to permanent).

7.2.1.4. Intensity

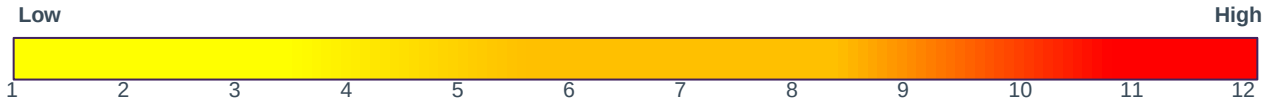
Concentration of an emission or discharge with respect to standards of acceptability that include applicable legislation and international guidance, its toxicity or potential for bioaccumulation, and its likely persistence in the environment. And degree/permanence of disturbance or physical impact (e.g. disturbance to species, loss of habitat or damage to cultural heritage). Ranges from:

1 - A low intensity event; to

2 - A moderate intensity event; to

3 - A high intensity event

Overall, event magnitude is scored from low (1) to high (12) by adding the individual parameter scores:



Resulting individual ratings are summed to give the overall event magnitude ranking. The Table below presents the score ranges for magnitude rankings of Low, Medium and High.

Table 7-1 Event magnitude rankings

Event Magnitude	Score (Summed Parameter Rankings)
Low	1 - 4
Medium	5 - 8
High	9 - 12

7.2.2. Method for determining Receptor Sensitivity

Receptor sensitivity considers the type of receptor (namely, biological/ecological, human and physical receptor/feature); and is determined based on the following parameters, which are equally weighted and are each assigned a rating of 1, 2, or 3:

7.2.2.1. Biological/Ecological Receptors

Presence ranges from:

3 – Internationally threatened species/protected area within the area impacted by the project activities during period of high sensitivity (e.g. during breeding, spawning or nesting) and during routine or reliably predictable peak presence; to

2 - Internationally threatened species/protected area within the area impacted by the project activities outside of period of high sensitivity or during routine or reliably predictable peak presence.

Internationally near threatened species within the area impacted by the project activities during period of high sensitivity (e.g. during breeding, spawning or nesting) and/or during routine or reliably predictable peak presence.

Nationally protected species and/or species which are of importance to the local and regional ecosystem within the area impacted by the project activities.

1 - Presence of species which is none of the above.

Resilience (to the identified stressor) ranges from:

3 - Species and/or population which has little or no capacity to absorb or adapt to change (i.e. little or no capacity to move away from or adapt to the project impact), leading to potential for substantial change of character and/or loss of ecological functionality.

2 - Species and/or population which has moderate capacity to absorb or adapt to change (i.e. has capacity to move away from or adapt to the project impact), leading to potential temporary but sustainable effect which does not substantially alter character or result in significant loss of ecological functionality.

1 - Species and/or population has high capacity to absorb or adapt to change (i.e. has capacity to move away from or adapt to the project impact), and is potentially unaffected or marginally affected.

7.2.2.2. Human Receptors

Presence ranges from:

3 - People being permanently present (e.g. residential property) in the geographical area of anticipated impact; to

2 - People being present some of the time (e.g. commercial property); to

1 - People being uncommon in the geographical area of anticipated impact.

Resilience (to the identified stressor) ranges from:

3 - Most vulnerable groups (i.e. ambient conditions such as air quality are at or above adopted standards); to

2 - People being vulnerable to change or disturbance (i.e. ambient conditions such as air quality are below adopted standards); to

1 - People being least vulnerable to change or disturbance (i.e. ambient conditions such as air quality are well below applicable legislation and international guidance)

7.2.2.3. Physical Receptors/Features:

Presence (to the identified stressor) ranges from:

3 - Presence of feature which has, in reverse order, national or international value (e.g. state protected monument); to

2 – Feature with local or regional value and is sensitive to disturbance; to

1 - Feature which is none of the above.

Resilience (to the identified stressor) ranges from:

3 – Highly vulnerable (i.e. potential for substantial damage or loss of physical integrity);

2 – Undergoes moderate but sustainable change which stabilises under constant presence of impact source, with physical integrity maintained; and

1 – Feature/receptor is unaffected or marginally affected (i.e. resilient to change);

Overall, receptor sensitivity is then scored on a scale from low (1) to high (6) by adding the individual parameter scores:

The Table below presents the score ranges for sensitivity rankings of Low, Medium and High

Table 7-2 Receptor sensitivity ranking

Receptor Sensitivity	Score (Summed Parameter Rankings)
Low	1 - 2
Medium	3 - 4
High	5 - 6

7.3. Socio-economic impacts

The socio-economic impact assessment uses a semi-qualitative assessment approach to describe and evaluate potential impacts based on the event magnitude and receptor sensitivity rankings set out in the tables above. Indirect socio-economic impacts (i.e. induced effects) will also be assessed using a similar approach.

Table 7-3 Event magnitude rankings

Magnitude	Criteria
Low	Changes in social, economic or cultural dynamics with slight and temporary effect on any given sector performance and/ or population wellbeing. These impacts are unlikely to result in concerns being raised by governmental bodies or stakeholders. Events may include: • Minor disruption to livelihoods or living conditions resulting in a localized, reversible and temporary nuisance; • Temporary disruption to businesses that does not result in a loss of revenue or any reputational damage; • No change in the health status of local communities; and • Temporary disruption to public infrastructure (such as a road closure) that results in minor inconveniences to affected communities.
Medium	Changes in social, economic or cultural dynamics with moderate and noticeable adverse effect on any given sector performance and/or population wellbeing. Such impact may result in concerns being raised by governmental bodies or stakeholders. Events may include: • Negative change in livelihood status, household assets/income or living conditions; • Temporary disruption to businesses resulting in a small drop in business revenue; • Increased risk to public health that can be controlled using detailed mitigation measures; and • Disruption to public infrastructure (such as a road closure, or failure of a sewer) that results in an inconvenience to other users.
High	Changes in social, economic or cultural dynamics with major adverse effect on any given sector performance and/or population wellbeing. Such impacts may result in immediate intervention by governmental bodies and stakeholders. Events may include: • Negative change in livelihood status, household income/assets or living conditions affecting a high proportion of people resulting in economic loss and protests against the project; • Reputational damage and/or drop in business revenue that threatens the future viability of the economic activity; • Increased risk to public health leading to a fatality or injury to a member of a community; and • Damage to public infrastructure (such as a sewer, regional water pipeline, etc.) leading to environmental or socio-economic impacts to other users.

Table 7-4 Receptor sensitivity ranking

Sensitivity	Criteria
Low	Receptor sensitivity is considered low when there is a moderate to high capacity and means to adapt to a given change and maintain / improve quality of life. Receptors of low sensitivity may include:

	• Individuals who are able to quickly adapt to temporary disruption in their living conditions, livelihood status or a change in the status of public infrastructure (such as a road closure); and • Businesses with a robust economic model that are able to adapt easily to any restrictions placed upon their activities, or who are able to gain economically from such changes.
Medium	Receptor sensitivity is considered medium when there is limited capacity and means to adapt to a given change and maintain / improve quality of life. Receptors of medium sensitivity may include: • Individuals who rely heavily on their livelihood to maintain their socio-economic status and have a limited ability to adapt to change; and • Businesses that have a limited ability to adapt to change and are sensitive to any reduction in economic revenue or reputation.
High	Receptor sensitivity is considered high in the case of vulnerable receptors, who have little capacity and means to adapt to a given change and maintain / improve quality of life (e.g. homeless people, Internally Displaced Persons community in temporary accommodation, people with low access to recourse (e.g. no land titles), people with no or low representation (e.g. migrants, seasonal herders with no permanent assets in the area). Receptors of high sensitivity may include: • Individuals with a marginal livelihood, low socio-economic income or poor quality living conditions; • Individuals who are vulnerable due to their age, disability or other reason and who may require special assistance during engagement activities; and • Businesses with a marginal economic existence which are not able to easily adapt to change.

7.4. Environmental and socioeconomic impact significance

For both environmental and socioeconomic impacts, **impact significance**, as a function of **event magnitude** and **receptor sensitivity**, is ranked as **Negligible**, **Minor**, **Moderate** or **Major** as presented in the table below.

Table 7-5 Impact significance

		Receptor Sensitivity		
		Low	**Medium**	**High**
Event Magnitude	**Low**	Negligible	Minor	Moderate
	Medium	Minor	Moderate	Major
	High	Moderate	Major	Major

Any impact classified as **Major** is considered significant and, where the impact is negative, requires additional mitigation. Impacts of **Negligible**, **Minor** or **Moderate** significance are considered as being mitigated as far as practicable and necessary, and therefore, do not require further mitigation.

8. Environmental impacts & mitigation measures

8.1. Introduction

This Chapter discusses the environmental aspects and potential environmental impacts that could arise from the construction, operation, decommissioning and abandonment of the proposed water supply project. It also discusses the proposed environmental mitigation measures that will be applied to reduce or remove the potential impacts.

8.1.1. Identification of environmental aspects

The environmental aspects of the water supply interventions have been identified for all activities associated with construction and operation of all components of the water project (weir, reservoir, treatment works, pipelines, and storage facilities). The activities have been discussed in Section 2.10 of this Report.

To identify project aspects, all proposed activities, have been considered in terms of their direct or indirect potential to:

- Breach relevant policy, legal and administrative provisions including national legislation, standards and guidelines;
- Interact with the existing natural environment including its physical and biological elements; and
- Interact with the existing socio-economic environment.

Activities assessed during site preparation, construction, reinstatement, operation and decommissioning include:

- Planned routine activities;
- Planned but non-routine activities; and
- Unplanned or accidental events.

8.2. Impacts on local air quality

8.2.1. Construction phase impacts

Construction activities are likely to generate air pollutants which will have potential to adversely affect the local air quality, and thereby affect human and vegetation health. The activities include:

Dust Generation: construction activities such as site clearance and grading, excavations/earthworks, stockpiling of materials and spoils, and vehicular movements in the project area will generate dust and affect the local air quality. Once airborne, dust will generally travel downwind before resettling. The distance travelled depends primarily on wind speed and particle size. For example, smaller particles and strong winds result in greater dilution effects but mean that the dust is deposited over a larger area.

The potential impacts are nuisance and adverse health effects on workers and people in the surrounding area, coverage of crops (possibly leading to reduced yields) and deposition on natural vegetation.

The long-term impact of nuisance dust will decline as disturbed areas of land re-vegetate. Due to the temporary nature of construction, dust emissions are not anticipated to have a long-term impact on local air quality.

Exhaust Emissions: Construction vehicles and machinery are also likely to emit oxides of carbon, nitrogen, and sulphur, further compromising the local air quality.

Burning of waste: Disposal of waste (vegetation and other combustible materials) by burning will also cause local air pollution in the emission of gases and particulate matter. There is the additional risk of spread of fire to unintended areas with potential to cause damage/destruction of property and vegetation.

Due to the nature of the construction process, emissions will not be constant and will fluctuate according to the operating periods for each item of plant and the combination of machinery being used at any one time. The emissions are likely to be of low to medium significance due to the localized nature. The location of emission sources will also change as the construction spread progresses especially along the pipeline routes. Potential receptors, such as residents in local villages and flora and fauna will not, therefore, be continually exposed to construction emissions for extended periods. Other mitigating aspects include a high diffusion potential from favorable meteorological conditions that enhance dispersion.

Pollution from exhaust emissions is also dependent on the maintenance conditions of the engines.

Impact significance

Table 8-1 Nuisance and health effects on humans

Extent/Scale	Frequency	Duration	Intensity	Score	Event Magnitude
1	2	2	1	6	Medium
Human Receptors		Receptor Sensitivity	Receptor Sensitivity Ranking		Impact Significance
Presence	Resilience				
2	2	4	Medium		**Moderate**

Table 8-2 Adverse impacts on natural vegetation

Extent/Scale	Frequency	Duration	Intensity	Score	Event Magnitude
1	2	2	1	6	Medium
Biological Receptors		Receptor Sensitivity	Receptor Sensitivity Ranking		Impact Significance
Presence	Resilience				
1	3	4	Medium		**Moderate**

8.2.1.1. Air quality management

In order to control point source and fugitive emissions that may occur during construction of project components, the following measures should be implemented:

- Maintenance of equipment and machinery to manufacturers' specifications by regular servicing to maintain efficiency in combustion and reduce carbon emissions;

- Use environmentally friendly fuels such as low sulphur diesel;
- Minimize idling of machinery;
- Ensure no burning of waste on sites/non-designated areas;
- Sprinkling of all active construction areas as and when necessary. This may however depend on the availability of water;
- Control of construction vehicle speeds by imposition of speed limits especially along dusty roads;
- Rehabilitation of disturbed areas once completed;
- Use of tarpaulins to cover trucks carting away spoil using public roads. Additionally, the trucks should maintain at least two feet of freeboard;
- Proper planning in transportation of spoil to ensure that the number of trips done or the number of vehicles used is as minimum as possible; and
- Provision of appropriate Personnel Protective Equipment such as dust masks to site workers;

8.2.2. Operation phase impacts

Project operations are unlikely to have any significant impact on the local air quality. The likely source of impact is vehicle movements along unsurfaced roads to the reservoir site and treatment works. The number of vehicles and the use of vehicles on un-surfaced roads, and hence disturbance to the ground surface during operation, will be very low (**negligible**). Dust mitigation measures, including appropriate driving speeds and the use of designated accesses will, however, still be implemented.

8.3. Visual and landscape impacts

8.3.1. Construction phase impacts

The aspects of the project that will impact on the landscape and visual integrity of the area are the clearance of natural and planted vegetation for permanent components such as the reservoir, treatment works, storage tanks and access roads, and the temporary use of land for construction (the pipeline ROW, construction camps and materials storage yards).

During construction, the visual integrity of the landscape will be reduced since the pipeline ROW and the temporary facilities will be visible from the time of vegetation or topsoil removal until reinstatement is complete and vegetation has re-established fully. On the other hand, the reservoir and treatment works sites are located on a river valley and there are few vantage points along public roads that would offer views to these sites during construction activities. It is expected that the arable land will recover soon after reinstatement. However, natural and semi-natural habitats with slow growing plants may take longer to recover.

In all areas of construction activities, items such as large machinery/equipment, earthworks, pipe sections and other vehicles will be visible throughout construction. This is a temporary impact, the duration of which will be minimized by the prompt removal of vehicles, plant and materials on completion of the works.

Impact significance

Table 8-3 Visual disturbance effects on humans

Extent/Scale	Frequency	Duration	Intensity	Score	Event Magnitude
1	2	2	1	6	Medium
Human Receptors		Receptor Sensitivity	Receptor Sensitivity Ranking		Impact Significance
Presence	Resilience				
2	1	3	Medium		Moderate

Table 8-4 Adverse impacts on natural vegetation

Extent/Scale	Frequency	Duration	Intensity	Score	Event Magnitude
1	2	2	1	6	Medium
Biological Receptors		Receptor Sensitivity	Receptor Sensitivity Ranking		Impact Significance
Presence	Resilience				
1	2	3	Medium		Moderate

8.3.1.1. Visual and landscape impact management

All disturbed areas should be reinstated in accordance with the project's reinstatement specification. The Contractor should prepare a Reinstatement Plan for the project based on the specifications. The main objective of reinstatement of the sites should be to return the visual integrity of the landscape as closely as possible to its previous condition.

Wherever possible, the removal of existing mature trees which form important visual focal points should be avoided. Provided that the integrity of the pipeline is not jeopardized, any removed trees should be replaced during the reinstatement phase using indigenous species, preferably of local provenance. It will be necessary to protect newly planted trees from browsing animals.

8.3.2. Operation phase impacts

Once the temporary working areas have been reinstated, the majority of the landscape will return to its former condition. The buried pipeline will have **negligible** visual impacts during its operational life. The only persistent visual impacts will take the form of pipeline markers required to identify the route.

The reservoir, treatment works and storage tanks are permanent and visible features of the project. However, with the exception of the reservoir, the other facilities will either be entirely out of sight for public (the treatment works will be at the bottom of the river valley with limited viewpoints) or in the view of the immediate neighboring residents. Apart from the Kilima tank which will be located on a greenfield site, other storage tanks are existing (Iveti tanks), or will be developed on a brownfield site (Katelembu tank). The additional

visual impact from a new tank is expected to be **negligible**. Planting and maintenance of vegetation around these facilities will further enhance the visual integrity of these sites.

8.4. Impacts on the water environment

Although Miwongoni River is seasonal, its flow during the wet season will be captured in the reservoir and released at a controlled rate as compensation flow. The project will therefore create a new lake environment and have a long-term impact on the downstream river. During filling of the new reservoir, a greater proportion of the existing flow will be intercepted with consequent short-term impacts downstream.

The presence of a large body of water in the new reservoir is likely to also impact on groundwater conditions in the surrounding area.

During construction and long-term operation, there may be increased risks associated with pollution of water affecting the reservoir itself and the river, and effects on surroundings water sources including groundwater.

8.4.1. Construction phase impacts

8.4.1.1. Water pollution risks during construction

8.4.1.1.1. Spillage of contaminants

Various risks to water quality could arise from sources of pollution during construction including spillage of fuels, lubricants and other toxic materials at the construction site, discharge of silt laden run off from sites, and the inadequate treatment and disposal of waste and wastewater from worker facilities.

Materials such as oil, diesel fuel, concrete additives, and solvents are likely to be stored and used on construction sites and lay down areas and in construction vehicles and equipment. Storage and handling of these materials could lead to spills on site, along roads and in surrounding areas.

Contaminated run-off from spill sites could adversely affect soils and vegetation and if it reaches the river, would have an adverse impact on water quality. The extent of impact would depend on the size, frequency and timing of spills in relation to flow conditions in the receiving waters and the nature of the materials involved including their toxicity and likelihood for bio-magnification or bio-accumulation.

Impact significance

Table 8-5 Contamination of water resources by spillages

Extent/Scale	Frequency	Duration	Intensity	Score	Event Magnitude
2	1	1	1	5	Medium
Physical Receptors		**Receptor Sensitivity**	**Receptor Sensitivity Ranking**		**Impact Significance**
Presence	**Resilience**				
2	2	4	Medium		**Moderate**

The risk of water pollution for these sources can be reduced by adopting protective measures to prevent spills and putting in place suitable spill response plans to be implemented in the event of accidents occurring. Suitable measures to collect, treat and dispose of chemical wastes will also be required. With good construction site practices, the risk of water pollution from spills and waste could be downgraded to **minor**.

8.4.1.1.2. Erosion and sedimentation

Soil disturbance is likely to occur at a number of locations, including around the reservoir site, the coffer dam and diversion channel, quarries/borrow pits, workers' camp(s), treatment works site, along the pipeline route and tank sites. Significant disturbance will arise from excavation of soil and rock to create the bed of the reservoir, and foundations for establishment of treatment works along the river valley. Access roads to these sites will also be created to enable construction vehicle movement. Loosening of soils and compaction in other areas by construction traffic has potential to cause soil erosion and pollution of the river with silt. The increased sediment load is likely to affect water quality with consequent effects on river habitats and species.

Cleaning and hydro-testing of the water supply pipelines will also be carried out prior to pipeline commissioning, and this may require significant volumes of water depending on the length of pipe being tested at a time. The principal hazard introduced by hydro-testing is in the event of a failure of the line under test, resulting in the unplanned discharge of water. This could result in local erosion, particularly in poorly consolidated soils and pollution of water resources with silt.

The significance of the impact of soil erosion on water resources during construction is considered to be **Major**.

Impact significance

Table 8-6 Siltation of Miwongoni River by construction activities

Extent/Scale	Frequency	Duration	Intensity	Score	Event Magnitude
3	2	2	3	10	High
Physical Receptors		Receptor Sensitivity	Receptor Sensitivity Ranking		Impact Significance
Presence	Resilience				
2	2	4	Medium		Major

The risks of soil erosion and degradation can also be significantly reduced by adoption of good construction site management practices, such as establishment of vegetative buffer zones, slope stabilization, protection of soil storage areas, controlled site drainage and use of sediment traps. With suitable mitigation, the impact of sediments on water quality is likely to be **minor**.

8.4.1.1.3. Direct discharge of waste into the river

Inappropriate disposal of waste and wastewater from construction camp(s) would also have negative effects on water quality. The extent of impact will depend on the location of discharge points and the dilution potential of receiving waters.

Impact significance

Table 8-7 Contamination of water resources by direct discharges

Extent/Scale	Frequency	Duration	Intensity	Score	Event Magnitude
2	2	1	2	7	Medium
Physical Receptors		Receptor Sensitivity	Receptor Sensitivity Ranking		Impact Significance
Presence	Resilience				
2	2	4	Medium		Moderate

Impacts in nearby water bodies, could include reduction in dissolved oxygen levels, nutrient loading causing increased algal growth, and the spread of pathogenic disease vectors. Uncontrolled discharge of waste would have a **moderate** adverse effect on water quality but this would be mitigated by adequate provision for on-site waste and wastewater management during construction, reducing the magnitude of these impacts to **minor**.

8.4.1.2. Effects on water demand during construction

Significant quantities of water are likely to be needed during the construction process. It is likely that some of the water required will be drawn directly from the river or diversion channel. The water will be required in mortar and concrete works, for drinking and cleaning purposes. Due to seasonality of the river, the volumes of water abstracted may have a significant impact on the overall river flow, especially during the driest periods of the year. It is opined that standard good construction site management practices would mitigate this effect, and therefore the significance of the effect is viewed as **Moderate**.

Impact significance

Table 8-8 Increased water demand

Extent/Scale	Frequency	Duration	Intensity	Score	Event Magnitude
1	2	2	1	6	Medium
Physical Receptors		Receptor Sensitivity	Receptor Sensitivity Ranking		Impact Significance
Presence	Resilience				
2	2	4	medium		Moderate

8.4.2. Operation phase impacts

8.4.2.1. Erosion and sedimentation

Over the lifespan of the reservoir, sediment accumulation will occur leading to the gradual loss of reservoir storage capacity. Estimating from the rates given in Government of Kenya's Small Dams and Pans Design Manual (1992), the sedimentation yield could be of the order 500 – 1,000m³/Km²/year. If the rate of erosion in the catchment area is not effectively managed, the reservoir would be silted up to 60% of its gross storage capacity in about 50-years (Siltation = 2Mm³). Apart from reducing the lifespan of the reservoir, the release of sediment-free water from the impoundment can have significant impacts on downstream river morphology.

Additional sediment could enter the reservoir as a result of land-use practices/patterns upstream of the impoundment or increased erosion around the shore. These could occur if, for example, agricultural activity intensifies or changes in soil conservation practices occur leading to land degradation.

Impact significance

Table 8-9 Siltation of the reservoir by upstream land use practices

Extent/Scale	Frequency	Duration	Intensity	Score	Event Magnitude
3	3	3	2	11	High
Physical Receptors		Receptor Sensitivity	Receptor Sensitivity Ranking		Impact Significance
Presence	Resilience				
2	2	4	Medium		Major

A raised water table around the edge of the reservoir could also destabilize soils increasing the likelihood of slippage and sedimentation in the reservoir. It would be possible to mitigate the risk of increased sediment loads from these sources through management of upstream lands and the area around the reservoir.

8.4.2.2. Impacts on the river flow regime

Filling and long-term operation of the reservoir, including abstraction of a maximum of 10,000m³/d of water (which is the design capacity of Miwongoni Treatment Works), will have a significant effect on downstream flows in Miwongoni River. River flow regimes (i.e. the seasonal and inter-annual variation in flow and flow volumes) control many physical aspects of river form and processes, including water levels, sediment transport and nutrient exchange. Changes in flow regime can therefore have significant impacts on riverine habitats and water users.

The reservoir operation would even out the flow rate of Miwongoni River throughout the year, reducing the flood peaks and increasing the low flows. In other words, in a 'normal' year the river would be noticeably higher during the low flow season, and lower during the high flow season. This is likely to have consequences for water users downstream, including aquatic and riverine habitats and existing water users.

These impacts could be mitigated in part by introduction of a compensation flow regime to achieve a flow pattern closer to the seasonal variation in natural flow conditions.

Table 8-10 Potential over-abstraction and change in river flow regime

Extent/Scale	Frequency	Duration	Intensity	Score	Event Magnitude
2	3	3	2	10	High
Physical Receptors		Receptor Sensitivity	Receptor Sensitivity Ranking		Impact Significance
Presence	Resilience				
2	3	5	High		Major

8.4.2.2.1. Short term impacts during inundation

The reservoir is likely to have a greater effect on downstream conditions during the period of inundation than during long term operation, as a greater proportion of the river flow will be intercepted. Without compensation flows during this period, there could be severe impacts on ecosystems and livelihoods in the river downstream of the impoundment, especially for the 600m downstream up to the confluence with Manza river.

The reservoir filling period is expected to be the rainy season beginning March to May. The reservoir may also benefit from the short rains later in the year. During this period, the bottom outlet of the weir would release an

amount of water into the river downstream as compensation flow which is likely to be lower than the recorded average monthly flow of the river. This implies that during the reservoir filling up period, flows in the river would be considerably lower than the average up to the time when the water begins to flow through the spillway. This impact would be mainly felt for a length of 600m downstream until the confluence with Manza river.

Impact significance

Table 8-11 Changes in the flow regime of Miwongoni River

Extent/Scale	Frequency	Duration	Intensity	Score	Event Magnitude
2	2	3	1	8	Medium
Physical Receptors		Receptor Sensitivity	Receptor Sensitivity Ranking		Impact Significance
Presence	Resilience				
2	2	4	Medium		**Moderate**

8.4.2.2.2. Long-term impacts on downstream river morphology

Reducing seasonal variation in flows down the river and removing the majority of sediment flux by trapping in the reservoir, is likely to have a significant effect on downstream morphology. Patterns of erosion, transport and deposition along the river downstream would gradually shift until a new status quo is established over time. This process is most likely already underway with the existence of Maruba dam on Manza river less than 500m east of the proposed weir. The confluence of Miwongoni and Manza rivers is approximately 600m downstream of the proposed weir.

Sediment deprivation downstream of the Maruba and Miwongoni reservoirs could (and probably has) cause erosion or down-cutting in some areas as the river channel re-establishes a natural sediment budget causing permanent changes in substrate condition and channel morphology. The river downstream of the impoundment could be deepened or widened in some areas, and effects could extend for several kilometers downstream.

8.4.2.3. Impacts on reservoir water quality

Once filling of the reservoir commences, any vegetation remaining in the area would decompose causing short term adverse impacts on water quality. There is also likely to be algal and weed growth in the period immediately following inundation.

Turbulence in the river increases gas exchange between the river and atmosphere, - a process that would no longer occur in the more static reservoir. Increased temperatures in the reservoir would also decrease the capacity of the water to maintain oxygen in solution compared to the river.

Combined, the above factors would contribute to reduced dissolved oxygen levels in the water impairing reservoir water quality in the short term and leading to long term dissolved oxygen levels lower than those in the existing river over the long term.

Organic decomposition under anaerobic conditions at the bottom of the reservoir may also lead to anoxic conditions and the production of hydrogen sulphide, production of noxious odours and harm to aquatic organisms in the reservoir and downstream.

The extent of these impacts would be determined by the detailed characteristics of the reservoir, including its circulatory patterns, temperature profile, and water chemistry. It is however viewed that organic decomposition is unlikely to have a major influence on the water quality conditions in the reservoir over the long term. The significance of this impact would therefore be judged as **Moderate**.

Impact significance

Table 8-12 Deterioration of the reservoir water quality

Extent/Scale	Frequency	Duration	Intensity	Score	Event Magnitude
1	3	3	1	8	Medium
Physical Receptors		Receptor Sensitivity	Receptor Sensitivity Ranking		Impact Significance
Presence	Resilience				
2	1	3	Medium		**Moderate**

In the longer term, water quality conditions in the reservoir would be influenced by the accumulation of nutrients, particularly nitrogen and phosphorus, contained in the influent waters. This would imply that catchment management in the future will have a significant influence. If intensive agricultural development continues in areas neighboring the reservoir, these could provide the reservoir with an increased nutrient supply of phosphorus and nitrogen causing eutrophication. Presently, the entire Miwongoni river valley is under cultivation only leaving a narrow strip of riverine vegetation along the banks of the river.

In the absence of careful catchment management, there is therefore considered to be a **moderate** risk of adverse levels of eutrophication in the reservoir.

Impact significance

Table 8-13 Eutrophication of the reservoir from upstream agricultural activities

Extent/Scale	Frequency	Duration	Intensity	Score	Event Magnitude
1	3	3	1	8	Medium
Physical Receptors		Receptor Sensitivity	Receptor Sensitivity Ranking		Impact Significance
Presence	Resilience				
2	1	3	Medium		**Moderate**

8.4.2.4. Effects of the reservoir on groundwater

Construction of the reservoir is likely to cause raising of the water table in the area surrounding the inundation zone, with an impact on local groundwater resources and their use.

Further changes to the downstream river flow regime may also influence water table conditions adjacent to the river channel. The reduction in variability in flow patterns downstream of the two reservoirs (an increase in low flows and a decrease in flood flows) is likely to give rise to similar change in the water table immediately adjacent to the river channel.

Because of these changes, land surrounding the reservoir and the river could experience either beneficial improvements or adverse effects on land quality, use and ecology, as some of the effects could include waterlogging of soils from rising water tables.

Impact significance

Table 8-14 Changes in the water table in the area surrounding the reservoir

Extent/Scale	Frequency	Duration	Intensity	Score	Event Magnitude
1	2	3	1	7	Medium
Physical Receptors		Receptor Sensitivity	Receptor Sensitivity Ranking		Impact Significance
Presence	Resilience				
2	2	4	Medium		**Moderate**

8.4.2.5. Long term risks to water quality

Operation of the project will require a low level of ongoing use of vehicles, fuels and chemicals at project facilities. The water treatment process at the Miwongoni Treatment Works will however generate wastes such as sludge and backwash wastewater which if not handled appropriately, have potential to cause pollution of water resources. Proper management of generated waste is discussed in Section 8.8 of this Report.

Table 8-15 Potential pollution of the river from sludge and backwash wastewater

Extent/Scale	Frequency	Duration	Intensity	Score	Event Magnitude
2	2	3	1	8	Medium
Physical Receptors		Receptor Sensitivity	Receptor Sensitivity Ranking		Impact Significance
Presence	Resilience				
2	2	4	medium		**Moderate**

With effective operational controls including spill response arrangements, the risk of pollution of the river is low and the impact will be **negligible**.

8.4.3. Water resources management

This section summarizes the mitigation measures proposed for the adverse impacts identified above:

8.4.3.1. Construction management

- Develop and implement a site construction waste and wastewater management plan to minimize environmental damage from construction activities. This should include the delivery of regularly updated training to construction workers in the safe and proper storage, handling, use, clean- up, and disposal of oils, fuels and other chemicals and the putting in place of a comprehensive spill response plan including equipment and training;
- Provide appropriate sanitary facilities at construction camp and sites, worker compounds and other construction facilities;
- Install secondary containment measures in areas where fuels, oils, lubricants etc. are stored and loaded or unloaded, including filling points;
- Implement soil erosion control measures;
- Install and regularly empty sediment traps in surface drains around construction areas;
- Limit sand excavation from the riverbed to the dry season when flows are low to limit the amount of sediment transported downstream;
- Maintain as much riverine vegetation at the weir site and in the reservoir area as possible until inundation begins, and maintain vegetative buffer zones alongside river and drainage channels during construction;
- Minimize soil disturbance and excavation during wet season;
- The appropriate consents should be obtained for any abstractions from, and discharges to watercourses during the construction period;
- Care should be taken in the discharge of hydro-test water to avoid erosion and deposition of sediments into watercourses

8.4.3.2. Reservoir inundation

- Consider selected clearance of vegetation prior to inundation including commercial salvage of trees;
- Design and implement agreed seasonal compensation flow regime during inundation;

8.4.3.3. Reservoir operation

- Design and implement agreed seasonal compensation flow regime during operation;
- Manage operations to avoid rapid fluctuations in downstream flow;
- Undertake regular (preferably continuous) flow monitoring downstream;
- Undertake regular water quality monitoring in reservoir, to include dissolved oxygen, nutrients (N & P), pesticides and nuisance plants;

8.4.3.4. Abstraction management

- Seek an abstraction license from WRMA and adhere to the conditions of the license;
- Cooperate with WRMA in implementing the catchment abstraction management strategy to allow for adjustments/variation in licensing conditions which may be necessary following resource assessments. From time to time, WRMA may reassess how much water may be abstracted and when. The Authority through its monitoring network continually assesses the current and past water and ecological situation, gathering information on rainfall, river level and flows, groundwater levels and ecology. The information obtained may underpin licensing conditions, and thus the need for all abstractors to cooperate; and
- Recycling of filter backwash water which is a significant amount (expected to be about 5% of the volumes abstracted).

8.4.3.4.1. Reservoir silting management measures

- Establish stock proof wire or live perimeter fencing around the dam and reservoir impoundment areas;
- Provide controlled access to water draw-off points;
- Provide convenient livestock or animal troughs downstream of the dam supplied by a gravity pipeline from the reservoir;
- Establish a tree nursery nearby to be used for afforestation of the catchment area as a sustainable long-term measure by community or local administration;
- Provide an appropriate scour pipe or siphon with effective inlet, outlet and outfall /flushing systems;

- Construction of silt check dams, traps and vegetation (capable of thriving in waterlogged conditions) at and upstream of the tail of the reservoir, along and across the valley;
- Planting and maintaining suitable grass cover on the embankment to reduce rainfall erosive effects on embankment slopes; and
- Provide and maintain riprap stone pitching down the upstream slope to prevent water wave erosion.

8.5. Impact on soil resources

Project construction will require earthworks involving site clearance, grading, topsoil removal, excavation for foundations and the reservoir bed, and trenching for the pipelines. New accesses will also be created, graded and surfaced with suitable material. There will be significant cutting and grading with the carting away of soil at these locations. The establishment of permanent facilities such as the reservoir, treatment works and access roads will result in the permanent loss of soil from these sites. Along the pipeline, excavated soil from trenching will be stockpiled and re-used in backfilling and reinstatement after laying of pipes.

Compaction of soils during construction may occur where the bearing strength is exceeded by the weight of construction vehicles. This is most likely to occur along the pipeline ROW and unsurfaced access roads, which will be subject to repeated vehicle movements. Soil compaction alters drainage characteristics and decreases the ability of vegetation to re-establish. Topsoil stripping at the various construction sites also breaks up the soil structure, and this may lead to an increase in erosion (from the topsoil and subsoil piles).

Hazardous materials spillage at construction sites and camp(s) is likely to cause soil contamination and/or eventual surface/groundwater contamination. The hazardous materials include oils, fuel, grease, paints, solvents, curing compounds, adhesives, acids, soil stabilizers and binders etc. These materials require careful handling and storage to prevent spillage. Vehicle, plant and machinery maintenance on site can also lead to soil pollution in the event of spillage of hydrocarbons (such as oil and fuel).

Impacts of soil erosion and contamination on the water environment have also been discussed in Section 8.4.

Impact Significance

Table 8-16 Soil loss resulting from erosion and carting to spoil

Extent/Scale	Frequency	Duration	Intensity	Score	Event Magnitude
1	2	2	2	7	Medium
Physical Receptors		Receptor Sensitivity	Receptor Sensitivity Ranking		Impact Significance
Presence	Resilience				
2	3	5	High		Major

Table 8-17 Soil contamination from pollution incidences

Extent/Scale	Frequency	Duration	Intensity	Score	Event Magnitude
1	2	2	2	7	Medium
Physical Receptors		Receptor Sensitivity	Receptor Sensitivity Ranking		Impact Significance
Presence	Resilience				
2	3	5	High		Major

8.5.1. Soil resources management

To avoid compaction impacts outside construction sites, deviation from established access roads and paths should be restricted. During reinstatement of the pipeline ROW, the trench back-fill material should be compacted to a similar value to the original surrounding soils to avoid subsidence as a result of rain water channelling.

Adequate reinstatement following construction will help the subsequent re-establishment of vegetation and thereby reduce the risk of soil erosion. A project specific Reinstatement Plan should be prepared and should include mitigation for impacts to soils based on the following:

- Recreation of a stable landform that mirrors the pre-disturbed condition (e.g. contours, shape, level of compaction) as this will minimize the risk of preferential erosion and therefore facilitate natural revegetation;
- Ensuring protection of topsoil through separation from subsoil and storage in a manner that, as far as possible, retains the soil structure and seed bank and minimizes the risk of topsoil loss. Backfilling should start with subsoil, followed by topsoil; and
- Development of a bio-restoration methodology that enables the re-establishment of the pre-construction vegetation cover particularly the variety and distribution pattern of plant species, and establishment of sufficient vegetation cover to minimize erosion at disturbed sites.

Effort should be made to ensure that for both temporary and permanent reinstatement, disturbed sites exhibit no more than a moderate level of erosion potential. The reinstatement works should be undertaken in a manner that achieves the following minimum standards:

- Very low risk of the depth of cover above water supply pipelines being reduced;
- Very low risk of off-site pollution and sedimentation;
- Low risk of damage to bio-restoration by washing-out of seeds and plants

To facilitate natural revegetation of the pipeline ROW and other disturbed areas, the separately stockpiled topsoil and vegetation debris should be spread over the surface of the ROW following completion of grading. Once the topsoil has been replaced, it should be stone picked to remove large stones, which are not in keeping with the surrounding soil texture. It should then be tined and cultivated as necessary to ensure effective re-vegetation.

To minimize any potential impact following hydrostatic testing of the pipeline, the release of hydrotest water should be undertaken in a controlled manner in order to avoid soil erosion or scour.

To prevent soil contamination and possible surface/ground water contamination, spillage prevention and control measures should be instituted where hazardous materials are stored in pallets and where possible under cover in secondary containment. Ample supplies of clean-up materials should be kept and be readily accessible.

The Contractor should review spill response requirements at all applicable work sites and train workers on spill prevention and clean-up. Clean-up requirements should include the following:

- Immediately clean up leaks and spills;
- Use absorbent materials for large spills;
- Avoid hosing down or burying dry material spills; and
- Properly dispose of materials used to clean up hazardous materials.

Vehicle and equipment maintenance activities should be done as much as possible away from construction sites while a designated area away from drainage courses should be identified to carry out necessary repair or maintenance activities. Drip pans and absorbent materials should be availed at these designated areas to manage spillages;

8.5.2. Operation phase impacts

Once the project is in operation, impacts on soil resources are likely to be from compaction by maintenance vehicle movements along unpaved access roads and tracks, and from erosion following unplanned events such as pipe failure. In summary, impact significance on soils during operations is assessed as **Minor.**

8.6. Impacts on ecology and biodiversity

Construction of the intake works (weir and associated structures), and the creation of the reservoir, will cause both loss and alteration of habitats, with resulting impacts on ecology and biodiversity. This section reviews these impacts, and identifies possible mitigation measures.

8.6.1. Construction phase impacts

The impacts discussed below include those anticipated during construction of the various water supply components, and inundation of the reservoir upon completion of construction.

8.6.1.1. Sedimentation and impacts on aquatic habitats

There may be short term effects downstream during construction from mobilization of sediments around construction sites caused by soil disturbance and erosion and scour of the riverbed at the outlet of the diversion channel. This could increase sediment loads downstream of construction, particularly during the wet season leading to increased turbidity and sedimentation downstream.

Increased sedimentation downstream during construction could affect aquatic habitats by covering coarse substrate providing spawning habitat for fish, filling shallow-water refuges for small fish, and smothering aquatic vegetation. This could lead to a decline in the overall productivity of the aquatic ecosystem. Increased turbidity can also damage fish gills and accumulate in gill chambers, leading to fish mortality or morbidity. The significance of the effect is viewed as **moderate** but can be considerably mitigated by erosion control measures.

Impact Significance

Table 8-18 Destruction of aquatic habitats and organisms by sediments

Extent/Scale	Frequency	Duration	Intensity	Score	Event Magnitude
2	2	2	2	8	Medium

Biological Receptors		Receptor Sensitivity	Receptor Sensitivity Ranking	Impact Significance
Presence	Resilience			
2	2	4	medium	**Moderate**

8.6.1.2. Effects on wildlife

Construction of the weir and inundation may result in the short-term disturbance of terrestrial wildlife in the vicinity of construction sites, temporary access roads and worker camps.

Inundation of the reservoir may result in drowning of any terrestrial fauna unable to escape from flooded riverine habitats. However, the reservoir is expected to fill within three months (between March and May) a period which should avoid large scale direct loss, as most animals (mostly reptiles and other small mammals) would be able to move to higher ground as the water level rises. Mortality due to drowning is likely to affect ground- dwelling and feeding mammals, such tortoise and other small animals with limited mobility. Considering that the inundated area will not exceed a width of 500m and length of I.2 km, and much of the river valley has been modified by cultivation, the number of individuals affected is not expected to be high. The overall impact of inundation on species is therefore considered to be of **minor** significance.

Establishment of construction camp and lay-down areas along the river valley has potential to displace animals from the associated vegetative cover within the site and from the immediate surrounding area. This effect is expected to be of **minor** short-term significance.

Construction activities will generate noise from people, vehicles, and equipment affecting fauna sensitive to disturbance such as reptiles and other small mammals. In addition, without adequate management of on-site construction activities, there is a risk of accidental wildlife injury and mortality due to interaction with construction machinery, traffic and workers. The effects will be **minor** and localized and some of the temporarily displaced fauna are likely to return to the area when construction is complete.

Dust from construction activities could also affect natural vegetation and crops in the area around construction operations. The affected area is likely to be relatively small (up to a few hundred metres from dust generating activities) and with good construction site management the impact is expected to be of **minor** significance.

8.6.1.3. Loss of existing vegetation

A large area of land (at least 3.84×10^5 m^2) will be occupied by the reservoir, resulting in the direct loss of terrestrial habitats, and associated disruption in the ecological integrity of surrounding areas. Direct loss will occur from the following activities:

- Inundation by the reservoir;
- Construction of other project facilities;
- Creation of site access road(s);
- Establishment of the temporary construction worker camp and lay-down areas; and
- Creation of the temporary diversion channel.

The Miwongoni river valley proposed as the reservoir site has similar characteristics as Machakos valleys – an Important Bird and Biodiversity Area about 4kms south of the proposed reservoir site. Development of the reservoir will reduce the availability of terrestrial habitat along the river valley, and associated birds' species. However, the presence of a permanent body of water and more regular flow regime would also increase the value of terrestrial habitat near the shore, thereby partially offsetting the adverse impact of habitat loss. The significance of this effect is therefore viewed to be **minor**.

8.6.1.4. Changes in biological communities within the reservoir

Filling of the reservoir will create approximately 3.84×10^5 m^2 of new lacustrine habitat, replacing approximately 1.2km of riverine habitat along the Miwongoni River. During this period, the biological communities in the reservoir will begin to acquire lacustrine characteristics, and a change in aquatic biota. Species that prefer shallow habitat are likely to colonize the periphery of the reservoir, and others that require moving water will disappear or persist as relict populations in the headwaters of the reservoir. By the end of impoundment, a more characteristically lacustrine aquatic biological community will become established, and will remain for the operational life of the project.

When construction is completed and the reservoir begins to fill, the natural sediment transport mechanism currently operating on the river will be interrupted and the reservoir will capture nearly 100% of sediment, from upstream. In addition, the existing source of sediment for deposition zones downstream will be interrupted. Sediment retention and subsequent deposition within the reservoir will cause most of the coarse substrate, rocky outcrops and other elements of the riverbed to progressively disappear under layers of silt transported from upstream. This is likely to alter the fish and macroinvertebrate composition with a reduction in riverine species and an increase in benthic species. Construction of the weir and reservoir will therefore permanently alter the fundamental hydrology and aquatic ecology of the impounded reach, and the significance of this impact is assessed as **moderate**.

The most significant habitat change will be the creation of a new shallow water littoral zone around the reservoir. This littoral habitat along the reservoir shoreline will increase habitat availability for aquatic and semi-aquatic vegetation. However, although there will be an alteration in aquatic habitat downstream, the basic riverine nature of the downstream reach will persist. The significance of the change in habitat conditions from riverine to lacustrine on aquatic species and wildlife will be **moderate**.

Impact Significance

Table 8-19 Changes in biological communities within the reservoir

Extent/Scale	Frequency	Duration	Intensity	Score	Event Magnitude
1	3	3	1	8	Medium

Biological Receptors		Receptor Sensitivity	Receptor Sensitivity Ranking	Impact Significance
Presence	Resilience			
2	2	4	medium	**Moderate**

8.6.2. Operation phase impacts

8.6.2.1. Impacts downstream

During the operational phase of the project, there will be a reduction in the variability of flows downstream and a reduction in sediment loading. Sediment deprivation downstream of the reservoir could cause erosion or down-cutting in some areas as the river channel establishes a new sediment budget causing the river

downstream of the reservoir to deepen or widen in some areas. New biological communities are likely to establish themselves over several years after start of operation, with long term changes in substrate condition and channel morphology and these will differ from those present in pre-project conditions.

8.6.2.2. Effects of changes in the water table

The creation of the reservoir will raise the water table in the area surrounding it, and in the area immediately adjacent to the river channel downstream. The impacts of this on vegetation could be an increase in soil moisture throughout the year which would benefit vegetation, particularly during the dry season, resulting in denser and possibly more diverse vegetation communities, than currently exist around the reservoir margin and along the riverbank for a short distance downstream.

The ultimate plant species composition would also depend on species-specific ability to tolerate anoxic conditions. The higher water table could saturate the root zones of plants growing in the most affected areas, depleting the oxygen available for aerobic respiration and causing plants to switch to anaerobic (oxygen-free) metabolism. This could cause mortality in plants that are intolerant to root water-logging. The overall impact of the raised water table is however likely to be of **minor** significance.

8.6.2.3. Effects on migratory fish

Interruption of the flow regime of the river is likely to have a negative impact on fish species migrating through the downstream sections of the river. Migratory fish use a variety of environmental cues to trigger seasonal migrations, including flow volume and velocity. Perturbation of the seasonal flow regime will interfere with use of flow and volume cues as migratory triggers, and disturb synergies between these and other environmental cues.

Flow perturbations are likely to have localized effects on the migratory fish community downstream of the reservoir, but may not cause loss of any species from the system if the species occur elsewhere in the watershed. Therefore, the significance of this impact is likely to be **minor**.

8.6.3. Mitigation measures for impacts on ecology and biodiversity

This section identifies possible mitigation measures that could be developed to address the impacts on ecology and biodiversity that have been identified in the preceding sections.

8.6.3.1. Detailed design

- Locate all associated structures and temporary and permanent construction-related sites (e.g. the construction camp and borrow pits) as far as possible within the zone of inundation or on disturbed habitat locations to minimize overall habitat loss;
- Minimize the width of construction right of way for construction of new pipelines, and the width of access road(s)
- Ensure that environmental flow requirements are met, and a minimum flow is maintained at all times;

8.6.3.2. Catchment Management Plan

Develop and implement a Catchment Management Plan including:

- Controls over land use in areas surrounding and upstream of the reservoir;
- Long-term wildlife and vegetation monitoring to document changes in flora and fauna in the reservoir and surrounding lands and address any problems that may occur;
- Rehabilitation/restoration of the surrounding degraded areas to the reservoir site by planting and tending of indigenous trees.

8.6.3.3. Construction mitigation

- Minimize riverbed and shoreline disturbance (e.g. restricting access of construction activities and workers to susceptible areas that could contribute to sediment loading);
- Implement education programmes for construction workers on, inter alia: respect for wildlife and vegetation, avoidance of fires and accidental damage, and generally minimizing the footprint of the construction camp and work areas;
- Prohibit development of unnecessary spur roads off main access roads, to limit land degradation and habitat disturbance;

- Develop "good construction environmental management" protocols to reduce effects on vegetation and wildlife, covering site working practices, noise management, avoidance of spills, maintenance of pollution control measures such as oil separators, and dust management plan, and a reinstatement/restoration plan;
- Replant or take measure to encourage recolonization by native vegetation in disturbed or denuded areas immediately following construction.

8.6.3.4. Inundation mitigation

- Provide for rescue of rare or distressed animals;
- Selectively harvest tall trees within the inundation area prior to impoundment to force tree-dwelling wildlife to migrate from the area prior to flooding;
- Begin reservoir inundation after the dry season once hibernating animals have emerged;
- Reduce the biomass that will be flooded by selective vegetation clearing;
- Implement 'nuisance' plant monitoring programme for the reservoir.

8.7. Impacts on energy resources

8.7.1. Construction phase impacts

Fossil fuels (mainly diesel) will be used in the running of engines at the construction sites. Fossil energy is non-renewable and its excessive use may lead to depletion of the resource. However, at the local scale, these impacts are of little significance and are best analyzed/quantified at a national/global scale.

Impact Significance

Table 8-20 Depletion of fossil fuel resources

Extent/Scale	Frequency	Duration	Intensity	Score	Event Magnitude
1	1	1	1	4	Low

Physical Receptors		Receptor Sensitivity	Receptor Sensitivity Ranking	Impact Significance
Presence	Resilience			
1	2	3	medium	**Minor**

8.7.1.1. Energy resource management

Despite the low impact on energy resources, it is prudent to institute measures to conserve fossil fuel since these also impact on local air and noise pollution levels. Proposed measures include:

- Minimize idling of machinery;
- Avoid overloading of trucks and machinery; and
- Regularly service vehicles, plant and machinery.

8.7.2. Operation phase impacts

The proposed treatment works will be connected to grid energy supply to meet the energy requirements of backwash pumps and lighting within the treatment works and the staff housing. Electricity will also be required to run the pumps supplying the storage tanks at Katelembu, Kilima and Iveti. Although there will be an increase in energy demand necessitating installation of a pole-mounted transformer at the treatment works site, the demand is not expected to be significant. The significance of this impact is assessed as **Minor**.

8.7.2.1. Energy management

To ensure efficient energy consumption at the treatment works, energy saving technologies (mainly applied in the choice of electrical appliances) and management strategies should be applied. Staff at the treatment works and staff housing should be encouraged to adopt energy conservation measures such as the use of energy efficient appliances, and switching off lights when not in use.

Energy use should be monitored during the project lifetime. Energy consumption meters should be installed with the involvement of the power distribution company, Kenya Power. Alternative sources of energy such as solar lighting should also be sought and exploited.

8.8. Impacts of generated waste

8.8.1. Construction phase impacts

Construction activities will generate inert, non-hazardous and hazardous wastes over the construction period. Wastes likely to be generated during construction include spoils (from excavations), vegetation (felled trees, shrubs, stumps and their root systems) packaging materials used for packing cement, plastics, reject materials including damaged bricks/blocks, and leftovers/excesses, wastewater (concrete washout and hydrotest water) etc.

Existing asbestos cement (AC) pipes will also be decommissioned and replaced with uPVC pipes. Due to the hazardous nature of the waste generated, elaborate procedures need to be instituted for the excavation, transportation and disposal of these pipes.

Construction camp(s) will need to dispose of ordinary waste (from kitchens, offices and other areas) sanitary waste (sewerage and wash water), and maintenance wastes (from maintenance of plant and machinery at the camps).

An informal solid waste dumping site exists downstream of Manza River approximately 2.5km from the proposed dam and treatment works sites. The dumping site has not been approved by the County Government or NEMA and should therefore not be used for disposal of construction wastes from the project. The area is also not served by a sewerage collection and disposal system and appropriate onsite sewerage disposal means would therefore be required.

Improper waste management at construction sites and camps will interfere with the aesthetic status of the surrounding while creating health and safety hazards. Improper disposal of the wastes off-site could also cause nuisance, health and safety hazards, and create breeding grounds for vermin.

Impact Significance

Table 8-21 Environmental pollution and creation of health and safety hazards from poor management of wastes during construction

Extent/Scale	Frequency	Duration	Intensity	Score	Event Magnitude
2	2	2	2	8	Medium

Human Receptors		Receptor Sensitivity	Receptor Sensitivity Ranking	Impact Significance
Presence	Resilience			
3	2	5	High	Major

8.8.1.1. Construction phase waste management

The following measures are proposed to manage wastes generated at the sites:

- Land-fill spoils as much as possible within the sites or identified fill areas;
- Felled trees, shrubs and stumps can be isolated for collection by locals as firewood;
- Organic wastes can be composted on site;
- Provide pit latrines at the camp(s) and construction sites for use by workers. The pit latrines should be backfilled upon project completion;
- Vehicle maintenance should as much as possible be done off-site (at the construction camp's garage/workshop or commercial garage) and wastes (used oil, oily rugs, cans and used parts) disposed in a designated area. Where maintenance must be carried out on site, wastes generated should be carried away from site for disposal in designated area(s). Disposal in this case should be by burying in a deep pit;
- The Contractor should ensure that construction materials left over at the end of construction are used elsewhere rather than their disposal; and
- The Contractor should put in place measures to ensure that construction material requirements are carefully budgeted and to ensure that the amount of construction materials left on site after construction is kept minimal. Additional measures for minimization of solid waste during construction of the proposed Project could include the use of durable, long-lasting materials that will not need to be replaced often, thereby reducing the amount of construction waste generated over the project lifetime.

8.8.1.1.1. Concrete waste management

- The Contractor should avoid mixing of excess concrete if possible, and should discard excess concrete in a designated area away from water courses;
- Washing of concrete coated vehicles or equipment should be done off-site or in a designated wash area a minimum of 50 feet away from drainage channels. The runoff from the on-site concrete wash area should be contained in a temporary pit where the concrete can set; and
- The temporary pit should be lined with plastic or clay to prevent seepage of the wash water into the ground. The wash water should be allowed to evaporate or collected along with all concrete debris in a concrete washout system bin.

8.8.1.1.2. Hydrotest water disposal

To the extent possible, hydrotest water should be discharged into the next section of the pipeline to be tested. If necessary, additional water can be added to make-up any losses or differences in lengths of test section. If less is required, the surplus water should be discharged in a manner that prevents erosion e.g. by discharge on vegetated ground.

8.8.1.1.3. Excavation and disposal of AC pipes

When removing asbestos cement pipes, it is important to handle the pipes in a manner that will minimize the risk of making it friable or releasing asbestos dust into the environment. A safe work method statement (SWMS) should be prepared and used by the Contractor. The general procedure below - adopted from Massachusetts Department of Environmental Protection (2015), should be followed.

Removal should start by exposing the asbestos cement pipe with minimal disturbance. Excavate no closer than 6 inches of the pipe. Carefully uncover the remainder of the soil surrounding the pipe by hand or with a shovel. An assessment should then be made to determine if the pipe is damaged, cracked or broken.

Not Damaged Asbestos Cement Pipe (intact and not deteriorated):

- ✓ Place 6 mil (0.006 inch) thick polyethylene ("poly") sheeting under the asbestos cement pipe to prevent soil contamination;
- ✓ Adequately wet the asbestos cement pipe with amended water using surfactant or liquid soap before and during removal to avoid creating airborne dust;
- ✓ Separate the asbestos cement pipe at the nearest coupling (bell or compression fitting)
- ✓ Slide the pipe apart at the joints (no saw cutting) or use other methods that do not cause the pipe to break, become friable or otherwise create the potential to release asbestos fibres;
- ✓ Wrap the wet asbestos cement pipe in two layers of 6 mil polyethylene sheeting, seal with duct tape and label in accordance with all applicable regulatory requirements. This can be done in the trench or adjacent to the trench;
- ✓ If the trench is filled with water, the placement of polyethylene sheeting is not required;

Damaged Asbestos Cement Pipe (deteriorated or not intact) or when cutting or mechanical breakage (e.g., with saws, snap or blade cutting, and/or tapping) is necessary:

- ✓ Place 6 mil (0.006 inch) thick polyethylene ("poly") sheeting under the asbestos cement pipe to prevent soil contamination.
- ✓ Adequately wet asbestos cement pipe with amended water where cutting or breaking will occur;
- ✓ Saw cutting of asbestos cement pipe shall only be conducted with a wet cutting equipment, unless it is conducted within a small enclosure that isolates the area in which the saw cutting is being conducted to prevent the release of asbestos fibres to ambient air;
- ✓ Wrap wet asbestos cement pipe in two layers of 6 mil polyethylene sheeting, seal with duct tape and label. This can be done either in the trench or adjacent to the trench;
- ✓ Manage wrapped asbestos cement pipe, polyethylene sheeting and any other material contaminated with visible asbestos debris as asbestos-containing waste materials (ACWM).

The ACWM must then be transported and disposed in accordance with the 'National Guidelines on Safe Management and Disposal of Asbestos' (NEMA, 2013) at an appropriate and licensed facility.

8.8.2. Operation phase impacts

The water treatment process will generate waste from coagulation/flocculation, sedimentation and filtration processes. The wastes are expected to emanate from sedimentation basins and filter backwashes and will contain solids derived from suspended and dissolved solids in the raw water, the addition of chemicals, and chemical reactions. The sludge generated, if not properly disposed, has potential to contaminate the underlying soil, surface and ground water resources.

Sludge production is entirely dependent on the raw water quality, the method of treatment, and efficiencies of the treatment process, and therefore varies in characteristics and quantities from time to time. The categories of waste expected from the WTP include:

Coagulant sludge: The sludge will be generated from use of aluminum sulfate (alum) as a coagulant to remove turbidity. Alum coagulation sludge will contain aluminum hydroxide, clay and sand, colloidal matter, microorganisms including algae and planktons, and other organic and inorganic matter present in the raw water.

Filter backwash wastewater: The wastewater will be produced during the filter washing operation. The filters will be washed daily and this will generate a large volume of wash water (about 5% of the water filtered) with low solids content. The composition of backwash wastewater will be similar to that of coagulant sludge, but with much finer particles. The wastewater will contain hydroxides of aluminum and iron, fine clay particles, added chemicals and reaction products which did not settle in the sedimentation tank, and a small portion of filter media.

Staff houses at the WTP will also generate domestic waste and sewerage which will require proper disposal to prevent environmental pollution.

Impact Significance

Table 8-22 Environmental pollution and creation of health and safety hazards from poor management of wastes during operations

Extent/Scale	Frequency	Duration	Intensity	Score	Event Magnitude
1	3	3	1	8	Medium

Physical Receptors		Receptor Sensitivity	Receptor Sensitivity Ranking	Impact Significance
Presence	Resilience			
2	2	4	Medium	**Moderate**

8.8.2.1. Management of generated wastes

8.8.2.1.1. Management of sludge

Management of sludge could include minimizing sludge production, sludge treatment, land application, or disposal into existing sewer systems.

Sludge generation can be minimized by the removal of water to reduce the sludge volume, reduction of the solids content present in the sludge, or a combination of both. Sludge production could also be minimized through a reduction of chemical dosage (alum), direct filtration of the water, recycling of filter wash water, substitution of coagulant, or chemical recovery.

Sludge treatment could be achieved through:

- ***Co-treatment*** – the treatment of alum sludge with the sludge from a wastewater treatment plant. Alum sludge can be discharged into the existing Machakos town wastewater treatment plant where it can be thickened and mixed with the wastewater sludge, followed by dewatering at a proper pH. The alum sludge can serve as a useful wastewater sludge conditioner, rather than a nuisance.

- ***Pre-Treatment*** – This includes flow equalization, solids separation, and solids concentration or sludge thickening. One of these methods or a combination of the three can be used in pre-treatment.

- ***Dewatering of sludge:*** Sludge can be dewatered through non-mechanical methods such as lagooning, drying on sand beds, or chemical conditioning

Ultimate disposal of the WTP sludges could involve incineration, disposal into the existing sewer system for Machakos town, compositing, spreading on land as soil conditioner or fertilizer, or landfilling.

8.8.2.1.2. Management of backwash water

The backwash wastewater from filter washing operations will be recycled into the system. Recycling of this wastewater has the advantage that less raw water from the river/dam is required (than when the waste water is discharged into the river), and that the water has less solid content thus lighter requirements in treatment.

8.8.2.1.3. Management of domestic waste and sewerage

Domestic waste generated at the treatment works staff housing should be segregated to enable composting of organic waste, recycling of paper and plastics and incineration of the incinerable waste. Efforts should also be made to minimize waste generation.

Sewerage generated should be disposed in a septic tank with a soak pit. The septic tank should be properly maintained to forestall any malfunction.

8.9. Impacts on ambient noise levels and/or vibration

8.9.1. Construction phase impacts

The construction works, carting away of spoil and the use of machinery/equipment will contribute to elevated levels of noise and vibrations within the construction sites and the immediate surroundings. Background noise in the area is generally low and is mainly from the occasional vehicular traffic along existing access roads.

Elevated noise and vibrations levels during construction of the treatment works and pipeline may be of some nuisance to the neighbouring public to the construction sites. The increase in traffic movements on minor roads may cause a noticeable increase in daytime noise levels through the settled areas. This effect will be localized and temporary, and will, for the most part, be restricted to the construction phase of the project. In addition, due to the nature of the construction process, noise levels will fluctuate in line with operating periods for each item of plant and with the combination of machinery being used at any one time. Noise levels will also vary depending on time, and distance as the construction spread progresses especially along the pipeline route. Local residents will not, therefore, be continually exposed to elevated noise levels for extended periods.

Impact Significance

Table 8-23 Vibrations and noise nuisance

Extent/Scale	Frequency	Duration	Intensity	Score	Event Magnitude
1	2	2	1	6	Medium
Human Receptors		Receptor Sensitivity	Receptor Sensitivity Ranking		Impact Significance
Presence	Resilience				
3	1	4	Medium		**Moderate**

8.9.1.1. Noise management

The significance of noise impacts depends on whether the construction activities will increase noise levels above the existing ambient levels by introducing new sources of noise. Noise impacts would be considered significant if the activities would result in the following:

- Exposure of persons to, or generation of, noise levels in excess of standards established in the applicable standards for noise;
- Exposure of persons to, or generation of, excessive ground-borne vibration or ground-borne noise levels;
- A substantial permanent increase in ambient noise levels (more than 3dBA) in the project vicinity above levels existing before the project; and
- A substantial temporary or periodic increase in ambient noise levels in the project vicinity above levels existing before the project.

The following noise-suppression techniques should be employed to minimize the impact of temporary construction noise at the project sites.

- Portable hoods should be installed to shield compressors and other small stationary equipment where necessary;
- Pumps, generators and other mobile equipment should be sited as far as practicable from housing and other noise sensitive locations;
- The contractor should endeavour to use equipment installed with noise abatement devices as much as practicable;
- Idling time on trucks and other noisy equipment should be limited to a minimum. Drivers should be encouraged to turn off vehicle engines when not in use, avoid unnecessary hooting or revving of engines; and
- Personal protective equipment such as ear muffs should be provided to workers at the sites as necessary.

8.9.2. Operation phase impacts

Noise and vibrations are not expected to increase considerably during operation phase of the water supply project. The likely source of noise is the installed pumps at the WTP. These pumps will generate some noise in normal filter backwash operations and in uplift of water to storage tanks at Katelembu, Kilima and Iveti. Due to the location of the WTP on the river valley, the noise will not be significant and is unlikely to be audible well

beyond the WTP boundary. The significance of this impact during operations is assessed as **Minor**. Regular servicing of the pumps and some acoustic shielding within the pump room can generally reduce noise to tolerable levels.

8.10. Geology and geo-hazards

8.10.1. Construction phase impacts

Impacts to geology will be limited as no blasting is expected to be necessary in the project. Localised landslides and debris flows can be triggered by human activity, including ground disturbance during construction of the treatment works, weir, raw and treated water transmission lines in Manza area where the topography is hilly.

Impact Significance

Table 8-24 Landslides and debris flow

Extent/Scale	Frequency	Duration	Intensity	Score	Event Magnitude
1	1	1	1	4	Low

Physical Receptors		Receptor Sensitivity	Receptor Sensitivity Ranking	Impact Significance
Presence	Resilience			
1	2	3	Medium	**Minor**

8.10.1.1. Management of geo-hazards

Every effort should be made to stabilize cut-slopes and other loose ground following excavations to minimize the potential for landslides and debris flow.

8.10.2. Operation phase impacts

Dam safety and potential impacts are discussed in section 9.6 of this Report. In the event of pipeline failure and significant or extended leakage of water, the potential for landslide exists albeit at a minor and localized scale especially near the weir and treatment works where the topography is hilly. This impact can be mitigated by the prompt repairs of the pipeline and regular maintenance.

8.11. Impacts on occupational health and safety

8.11.1. Construction phase impacts

The construction works inevitably expose workers to health and safety risks. Some of the likely hazards include accidents on site (involving workers and machinery, or the public and construction works such as trenches) or along accesses to the sites (involving construction vehicles and the public), or exposure to dust leading to pneumatic illnesses.

Part of the construction works will entail excavation and removal of existing Asbestos Cement (AC) pipes and replacement with uPVC pipes. Disturbance of asbestos cement pipes through cutting, drilling, and other activities may result in elevated levels of airborne asbestos fibres which can pose serious health problems such as such as asbestosis, lung cancer and mesothelioma to those exposed upon inhalation. Workers thus need to be protected from airborne asbestos fibres.

The lack of provision of potable water for sanitation during construction can also lead to health hazards affecting construction workers at the compounds.

Impact Significance

Table 8-25 Exposure of workers to health and safety hazards

Extent/Scale	Frequency	Duration	Intensity	Score	Event Magnitude
1	3	2	2	8	Medium

Human Receptors		Receptor Sensitivity	Receptor Sensitivity Ranking	Impact Significance
Presence	Resilience			
3	2	5	High	Major

8.11.1.1. Occupational health and safety management

To reduce accidents and hazards involving/ posed to workers, the contractor(s) should develop and implement Site Health and Safety rules and regulations. Other health and safety measures can include:

- Provision of all workers on site with the necessary Personal Protective Equipment, and ensuring a safe and healthy environment for the construction workers;
- A risk assessment and establishment of procedures/Safe Work Method Statements (SWMS) prior to handling removal of AC pipes should be carried out in line with the national guidelines on safe management and disposal of asbestos. Proper tools and equipment including respirators, protective clothing and cleaning materials for decontamination of the workers, tools and equipment need to be provided when handling the AC pipes;
- Workers accidents during construction can be mitigated by enforcing adherence to safety procedures and preparing contingency plans for accident response. In addition, safety education and training should be emphasized;
- The Contractor should have qualified first aid personnel among the workers and maintain fully stocked first aid kits at the sites;
- The Contractor should ensure that workers have access to sanitary facilities at the sites and provide potable water.

8.11.2. Operation phase impacts

Once the project is operational, health and safety impacts will mainly be limited to activities at the reservoir site and within the WTP. At the reservoir site, there is the risk of staff falling and drowning, while installed facilities such as sedimentation and filtration tanks, electrical equipment and the use of chemicals such as alum and chlorine at the WTP poses health and safety hazards.

Impact Significance

Table 8-26 Exposure of Staff to health and safety hazards during operations

Extent/Scale	Frequency	Duration	Intensity	Score	Event Magnitude
1	3	3	1	8	Medium

Human Receptors		Receptor Sensitivity	Receptor Sensitivity Ranking	Impact Significance
Presence	Resilience			
3	1	4	Medium	**Moderate**

These health and safety hazards can be mitigated though formulation and implementation of a health and safety policy and operation procedures that address the health and safety aspects of activities at reservoir and the WTP. Safety measures such as protection guard rails should be installed and maintained at all locations where there is a fall and drowning hazard.

8.12. Impacts on other natural resources

8.12.1. Construction phase impacts

Construction materials that will be used include masonry stones/bricks, aggregate, sand, cement, iron bars, steel pipes etc. These materials will be obtained from quarries, hardware shops and sand harvesters who extract such materials from natural resource banks such as river banks and land. Unsustainable extraction of these resources can cause serious environmental degradation in the source areas.

Impact Significance

Table 8-27 Environmental degradation at materials sites

Extent/Scale	Frequency	Duration	Intensity	Score	Event Magnitude
3	1	3	1	8	Medium

Physical Receptors		Receptor Sensitivity	Receptor Sensitivity Ranking	Impact Significance
Presence	Resilience			
2	2	4	Medium	**Moderate**

8.12.1.1. Raw materials management

The Contractor should source construction materials such as sand, aggregate and masonry stones from approved quarries and mining sites which have undergone satisfactory environmental impact assessment and are licensed according to the regulations. Since the approved quarries/mining sites are expected to apply acceptable environmental performance standards, the negative impacts of their activities at the extraction sites are considerably well mitigated.

The Contractor should implement stringent inventory management mechanisms and only order for materials after a accurate estimation of actual construction requirements.

Where possible, building elements should be manufactured off-site and delivered to site, to maximize benefits of off-site manufacture including minimizing waste, maximizing recycling (because manufacture is in one location), high quality elements, better occupational health and safety management, less noise and dust.

8.12.1.2. Material delivery, storage, and use

The Contractor should provide appropriate training of workers on proper material delivery and storage practices and procedures. He should designate on-site materials delivery and storage areas and these should be located near construction entrances and away from watercourses. Earth berms or other containment measures should surround storage areas.

The Contractor should maintain accurate and up to date records of materials delivered and stored on site. He should at all instances endeavour to minimize site inventory.

Materials safety data sheets (MSDS) should be maintained for all chemicals and other hazardous substances in use at the site. Hazardous chemicals should be well labelled and stored in their original containers. The Contractor should however minimize the handling of hazardous materials on site. Workers with emergency spill clean-up training should be present during unloading of dangerous materials or liquid chemicals.

Materials should be stored under cover during the rainy season, while chemicals, drum and bagged materials should be stored on pallets and where possible, under cover in secondary containment.

Stockpiles should be located a minimum of 50 feet away from concentrated runoff. If necessary, physical diversions should be provided to protect the stockpiles from concentrated runoff. These measures will reduce the potential of storm water pollution originating from stockpiles of construction materials.

Any significant residual materials remaining on the ground after the completion of construction works should be removed and properly disposed. If the residual materials contaminate the soil, then the contaminated soil should also be removed and properly disposed.

8.13. Cumulative impacts

Cumulative impacts can occur either when different impacts from one development interact to exacerbate effects on sensitive receptors, or when the magnitude of an impact of a development is augmented or exacerbated by impacts from other existing or future neighbouring developments, thus creating a more significant impact, on a receptor.

This assessment considers the cumulative effects that are likely to result from the proposed water supply project and the existing or future schemes, and the effects of increased water supplies to the population in the target areas.

The proposed Miwongoni dam and treatment works will be adjacent to the existing Maruba dam and treatment works and within hundreds of meters from each other. Although abstraction is from different tributaries (Maruba system from Manza river and Miwongoni system from Miwongoni river), the two rivers converge less than a kilometre downstream of the works. The two rivers are a significant contributor to the Ikiwe river system which in turn contribute to the Thwake and eventually the Athi river systems. Thwake multi-purpose dam is in advanced stages of design and construction is expected to commence in 2018. The most significant concern is potential over-abstraction of the rivers. Unsustainable abstraction from these rivers will change their natural flow regimes and reduce the resilience of the rivers' ecology to withstand natural low flows, which are increasingly likely under various climate change scenarios.

Figure 8-1 Location of the proposed Miwongoni dam and treatment works vs Maruba dam and treatment works

Changes and reductions of river flow can have the following effects:

- Reduced flow can exaggerate the impacts of barriers such as weirs, which can interfere with fish movements;

- Changes to flow dynamics can increase sedimentation rates, affecting species sensitive to sediment loadings, such as fish, and affecting spawning success;
- Reduced flows can lead to loss of habitats and changes to erosion and deposition patterns which in turn may lead to loss of in-channel geo-morphological diversity and flushing of sediment;
- Channel narrowing can occur when flows are reduced;
- It can allow invasive plant species to colonize exposed river sediments, such as gravel bars and temporary islands; and
- Where there are increased concentrations of nutrients together with low flows, algal blooms may occur.

An increase in water supply to the population around Machakos will result in increased generation of wastewater - both sewerage and wash water. Generally, a sewage factor of between 0.8 and 0.85 is adopted internationally when calculating the volume of effluent generated from land uses such as residential, commercial, educational and industrial uses. This means that 80 to 85% of the water abstracted will be discharged as waste by users with the potential to compound the sewerage disposal problems in Machakos. However, feasibility studies have also been carried out for the rehabilitation and expansion of Machakos sewerage system. The project is expected to be implemented concurrently with the water supply project and will entail construction of new sewer lines and waste water treatment plants.

The concurrent implementation of the water supply and sewerage projects may also generate cumulative impacts on the aspects aforementioned, especially around areas where both sewer lines and water supply pipelines will be laid. These include an exacerbation of the traffic nuisance, air pollution and noise levels from construction activities. On the other hand, concurrent implementation of the two projects can allow the laying of sewer lines and water lines in a common trench (with the water line above the sewer line) especially in Katelembu area and Township. This would result in a positive impact to the community as disruptions and construction work would only occur once for both projects.

8.13.1. Mitigation of cumulative impacts

To manage unsustainable abstraction of water from rivers in the Athi catchment, WRMA should continually assess abstraction licenses against the level of impact they are causing, or could cause. Following this, changes may have to be made to ensure that abstraction licensing continues to balance the needs of a changing environment with the need for water for the general public.

Changes that can be made include decommissioning some water intakes along rivers and refurbishing those that remain. This could help to balance environmental benefits and public water supply by increasing the flow of water without reducing the supply to target areas. The restoration of a more natural flow to the rivers will also ensure that there is enough water for juvenile fish and will help to protect fish movements along river systems.

To mitigate cumulative impacts from construction activities of different projects within the same locality, the following measures should be considered:

- Communication between water supply and sewerage contractors to determine how the projects will impact each other; and
- Synchronising of construction phasing (of the water supply and sewerage scheme) such that one project either bypasses an area until the other project is complete, or the two are implemented concurrently to minimise duration of disturbance;

8.14. Climate impacts

8.14.1. Impact of greenhouse gas emissions

Studies have suggested that the emission of greenhouse gases (GHG) from reservoirs due to rotting vegetation and carbon inflows from the catchment may be a significant source of global GHG emissions. Greenhouse gases (carbon dioxide and methane) are released into the atmosphere from reservoirs that flood forests and other biomass, either slowly (as flooded organic matter decomposes) or rapidly (if the forest is cut and burned before reservoir filling). Reservoir releases of carbon dioxide and methane are thought to contribute an estimated seven percent of the global warming impact of all human activities.

The magnitude of the predicted climate change impact of the dam depends on the amount of biomass that is inundated by the reservoir, the total surface area of the reservoir, and the flux rate. Provided that vegetation is at least partially cleared prior to inundation, greenhouse gas emissions would be relatively low, given that the surface area of the reservoir is not large in comparison to other man-made reservoirs in Africa. The significance of this impact is considered minor.

A measure that can be applied to reduce greenhouse gas emissions is the selected clearance of vegetation prior to inundation.

8.14.2. Evaporation from the reservoir

A feedback mechanism exists between the presence of a dam and rainfall in an area. The large open surface of the reservoir facilitates water loss by evaporation, which releases moisture into the air and increases the overall head and precipitation balance (International Rivers, 2018). As such, much more water is lost in the same period of time from the reservoir than was originally lost from the river that flowed in its place

Even though the water loss mainly depends on the climate of the area, it can also depend on the size, shape and depth of the reservoir, with reservoirs having smaller surfaces or larger depths losing less water. This added evaporation can affect the microclimate of the area as it changes the humidity and temperature and other aspects of the climate system around the reservoir. Under the right circumstances, all of these play an important role in changing the rainfall pattern in areas surrounding the reservoir. The climatic changes may also influence the biological communities and terrestrial ecosystem characteristics of the reservoir's surroundings.

8.14.3. Climate vulnerability

8.14.3.1. Overview

Droughts and floods are amongst the most significant natural hazards that might impact negatively on water supply infrastructure such as run-of the river systems and storage dams. Whereas their design has traditionally been based on historic records, climate change is altering hydrological cycles such that historic data may no longer be a reliable predictor of future hydrological pattern. The infrastructure designed for the climate of its time would therefore be ill-prepared for rapid shifts in river flows and precipitation. For example, if a dam was designed on a 30 years period that had marked higher rainfall levels than today, as a result of recurring droughts, the dam may operate at a different point from the potential of its capacity.

Kenya's geographic location makes the country inherently prone to cyclical droughts and floods, more so the arid and semi-arid areas such as the east and northeastern parts of the Country, which experience uncertainty of rainfall patterns and high evapotranspiration rates.

Periodic droughts occur in Kenya relatively frequently. Moderate drought events have been recorded on average every 3-4 years and major droughts affect the country every 10 on average. Prolonged droughts have become more common since 2000, increasing the amount of arid and semi-arid land area to 80% of the total surface area

The major climate processes at play include the El Niño Southern Oscillation (ENSO), La Niña, and Inter-Tropical Convergence Zone (ITCZ). The ENSO brings more rainfall than average, particularly during the short rainfall season in October-December, while the La Niña brings a drier than average season. The ITCZ changes position over the course of the year, migrating northwards in March – May and southwards in October-December. This phenomenon causes the 'long' and 'short' rains.

8.14.3.2. Climate projections for Kenya

Climate projections indicate increases in annual rainfall in Kenya, although some uncertainty exists due to the strong influence of the ENSO, particularly in the future inter-annual variability. The increases are expected to be largest in October, November and December (-3 to +49mm per month), and in March, April and May (The World Bank Group, 2018). The proportion of annual rainfall that occurs in heavy events is also expected to increase (GoK, 2016).

Temperature is expected to increase by 1.0 to 2.8°C by 2060. Since 1960, Kenya's mean annual temperature has increased by 1.0°C, at an average rate of 0.21°C per decade. The rate of increase has been most rapid in March-May (0.29°C per decade) and slowest in June-September (0.19°C per decade).

Extreme 'hot' days and 'hot' nights are expected to increase by 17-45% and 32-75% respectively. The increase in number of hot days per year is most pronounced between March-May and the increase in number of hot nights per year is most pronounced between September-November. The rate of cold days decrease is most rapid in September- November and the rate of cold nights decrease is most rapid in December-February.

In summary, droughts are considered likely to occur with similar frequency to the present but with increased severity. This is linked to increases in temperature affecting evaporation rates rather than reduced precipitation. Rainfall events in the short and long rainy seasons are also considered likely to become more extreme

8.14.3.3. Climate change impact on the Machakos water supply project

The projected future increased severity of drought and rainfall intensity in the catchment of Miwongoni river may potentially alter streamflow patterns affecting the operations and downstream hydrologic impacts of Miwongoni dam.

A higher rainfall intensity in the dam's catchment may result in flooding events that exceed the design limits of the dam, such that it is incapable of storing the added water in the wet season to supplement lower flows in dry months. On the other hand, increased severity of drought characterized by a sequential decline in rainfall, surface runoff, soil moisture, groundwater interaction would ultimately lead to a decline in discharge of Miwongoni River.

These changes in hydrograph and precipitation patterns in the catchment will affect the design capacity and operating characteristics of Miwongoni dam compared to its planned conditions, and affect the dam's ability to secure a reliable source of water for a wide variety of human and environmental needs in the river valley.

8.15. Decommissioning phase Impacts

The decommissioning process is part of a facility or other infrastructure disposition. Disposition starts when the development's mission ends and may include dismantlement and release for reuse, or demolition and environmental restoration. During the decommissioning phase, all buildings, utility systems, infrastructure systems and related facilities are dismantled and/or demolished safely and efficiently using appropriate procedures and work controls.

Decommissioning in the case of the proposed project refers to abandonment and/or demolition of all structures including removal of the weir and draining of the reservoir, excavation/abandonment of the water supply pipes, disposal of wastes, and environmental restoration.

8.15.1. Dam decommissioning

Dam decommissioning may be necessitated when it is silted up, when it decimates fisheries, or becomes increasingly unsafe, at which point it may be a candidate for removal. Globally, safety concerns have been the most common reason for dam removals. Dam failures can cause extreme erosion, excessive sediment deposition and destruction of aquatic habitat accompanied by the loss of the fisheries (International Rivers, 2018). These impacts can also be caused by inappropriate decommissioning of the dam.

There are several types and degrees of dam decommissioning including:

Full decommissioning/removal: This method involves removing the dam structure, and potentially the spillway, with the aim of restoring the site to conditions that existed before the dam's construction. The removal of the dam re-establishes fully the free-flowing conditions in a river because all physical obstacles will be abolished. There will be no structure remaining and the river's continuity restored. The dam removal allows for the regular occurrence of floods and low water flows. In addition to major excavation works and a range of structural and additional features, this method would require a comprehensive sediment management strategy, as well as a site revegetation and reinstatement plan (State Government of Victoria, 2016).

Partial decommissioning/partial removal: This method involves lowering the height of the dam, or the height of the spillway, to reduce storage capacity. A combination of lowering both the dam and the spillway may also be suitable. This would require excavation works with the desirable final height of the dam being influenced by factors such as future water demand, ecological considerations (eg for the conservation of an existing wetland or the creating of a lake/wetland; to retain storage capacity in an effort to manage flooding; or the need to hold back sediments trapped behind the dam), community values and dam safety improvements. A range of structural changes and additional features would also be required

Changes/modifications to dam operations: In cases in which full or partial dam removal is not considered a viable option, there are opportunities to change dam operation and to implement new water use planning without significantly limiting or abolishing the social and economic benefits of the dam. The modifications can include:

- *Establishing continuity*: By means of fish passages, the opportunity is created for fish species to pass the dam downstream and upstream to reach former spawning locations. This can positively impact migrating fish populations.
- *Modification of water release*: This action aims to create more natural flow and sediment regimes. The increase of the bottom/instream flow during critical times can be an option if there is the demand for more flow water for the ecology, flora and fauna of the river downstream.
- *Aeration and temperature modification*: This action can improve downstream water quality
- *Alteration of function*: This method involves retaining the dam but the function of the dam will be changed. For example, a dam built for water supply may be altered so that its principal use is for community recreation. This method is likely to involve a number of structural changes, including safety improvements and additional features.

There are several ways by which dams can be removed. The chosen method will depend on factors such as the size and type of the dam, the amount of sediment behind the dam, the aquatic environment below the dam, and the timeframe of dam removal.

The methods include:

Notch and release approach: The notch and release approach is commonly used because of its ecological benefits. It is a slow method in which the reservoir is drained through notches cut into the dam. New notches are cut in so the water drains out of the reservoir at a consistent flow. The sediment trapped behind the dam flows downstream in a fixed rate that allows the ecosystem to adjust to the changes. This method can take months or longer, but has proven success with restoring fish species to rivers.

Rapid release approach: The rapid release approach is both the quickest and least expensive way to remove a dam, but has significant drawbacks. In this approach, a large tunnel is dug through the base of the dam and then connected to the reservoir. The entire body of water will drain through this tunnel in a matter of minutes or hours and the massive release of water and sediment can cause severe flooding and erosion along the river downstream for miles. This can devastate the riparian ecosystem along the river as well as dangerously scour bridge pilings, buried pipes, levees, and other infrastructure.

Dig and dewater approach: The dig and dewater approach is typically the most expensive dam removal method, but is necessary in some cases. It entails emptying the entire reservoir, allowing the sediment to dry, and then transporting it to a safe location for disposal. It is costly and slow, but if the reservoir is located very near hydroelectric generating facilities that would be greatly impacted by released sediments, it may be necessary. Another situation is if the sediments behind the dam contain toxins. Hauling them away and disposing of them safely is important for the ecological health of the river.

Retained sediment approach: The retained sediment approach is the final commonly used approach and involves leaving the sediment behind where it is. To do this, the river must be rerouted around the dam site which can prove expensive and challenging. This may be carried out in places where the dig and dewater approach makes sense, but are too remote to be cost-effective.

8.15.2. Impacts of decommissioning activities

Demolition and removal of structures poses potential hazards, and also generates wastes which ought to be dealt with appropriately. Decommissioning impacts are closely related to the reason for the decommissioning and include but are not limited to:

- Decommissioning activities result in a creation of employment opportunities for workers involved in demolition and restoration activities;
- Decommissioning, and especially demolition activities, involve use of light and heavy machinery or tools that generate noise and vibrations;
- Demolition activities generate rubble that requires proper disposal and can create health and safety hazards if inadequately managed;
- Demolition activities create occupational and public health and safety hazards with the likely occurrence of accidents involving workers/general public and machinery or rubble;
- Demolition activities generate dust which if improperly managed can create health risks to workers and the general public, and cause stunted vegetation growth; and
- Dam removal can cause extreme erosion, excessive sediment deposition and destruction of aquatic habitat accompanied by the loss of the fisheries

8.15.3. Mitigation of decommissioning impacts

The project proponent in conjunction with a Health, Safety, and Environment expert should develop environmental, health, and safety procedures for decommissioning, in keeping with the formulated Decommissioning Environmental Management Plan (DEMP) as discussed in Section 2.11.7 of this Report. These procedures should, among other issues, address the following:

- A Health and safety plan;
- The extent of decommissioning;
- Pollution prevention plans including air, water, and soil pollution prevention plans;
- Waste management plans;
- Dam decommissioning plan; and
- Restoration plans.

The following steps should be used as a guidance in Miwongoni dam decommissioning:

Figure 8-2 Steps in dam decommissioning

Future outcomes of the process would be either: Retain the dam and maintain its original function; **or** retain the dam and alter its function; **or** partially remove the dam; **or** fully remove the dam.

At the end of decommissioning works, the project proponent should obtain certificates of completion from all the necessary authorities including NEMA.

9. Socioeconomic impacts & mitigation measures

This Chapter identifies the potential socio-economic impacts of the proposed water supply project and mitigation measures for the adverse impacts identified. The impacts have been identified and assessed based on professional judgment, previous project experience and discussions with various stakeholders in the project area.

9.1. Increased access to clean water

Water resources in Machakos County are under pressure from agricultural chemicals and urban and industrial wastes, as well as from use for hydroelectric power (County Government of Machakos, 2015). The County has two permanent rivers namely Athi and Tana. There are also several dams and springs that serve as water sources. Underground water sources (mainly boreholes and wells) also supplement the available surface water sources.

However, access to clean and safe water is still a major challenge for most households in the County. For Machakos Town and the neighboring areas, the existing municipal water supply is inadequate to meet the water demand of the populace. Many people thus rely on private wells, boreholes and direct drawing of water from rivers/streams to bridge this deficit, with the added health concerns due to waterborne diseases. For some of the people, a lot of time and effort is also spent in search for the water. The average distance to the nearest water source in the County is 5 km, and fetching of water is mainly done by women who end up spending much of their time on this activity.

The proposed project will increase clean water supplies to the area with the likelihood of an increase in water supply connections for households. Due to the provision of the much-needed constant and reliable drinking water, the Project will improve the quality of life of many people especially those who are the primary targeted population to receive the supply of water.

Impact significance

Table 9-1 Increased access to clean water

Magnitude	Receptor Sensitivity	Impact Significance
High	Medium	Major

9.2. Increased employment and business opportunities

Several new direct employment opportunities will be created during the construction period. The detailed labor requirements for the project will not be known until the appointment of the construction contractor. It is however expected that construction activities will require engineers, project managers/foremen, workers, and specific equipment operators, among others.

The project will provide direct business opportunities for companies and individuals supplying goods and services such as construction materials, consumables, cleaning services etc. There will also be indirect employment opportunities on the supply side as the suppliers increase their resource capacity to meet project demands. With the creation of employment and business opportunities, taxes will be remitted to the exchequer from the purchase of materials and other consumables, and payment for services offered by various parties in the construction process.

The in-migration of workers into the surrounding area has potential to provide a stimulus to the local economy since they will provide a larger market for local traders and farmers to whom to sell their goods. Others may also find opportunities to supply materials to the project. This impact is judged to be **moderate**, and positive if it is managed and monitored, and it will last for the duration of the construction phase of the project. It will continue until the construction-related opportunities cease.

Once the reservoir is created, its ecology will change from riverine to lacustrine, resulting in a change in the species, and also (as a result of the increased nutrient levels) increased abundance. This will create an opportunity for fisheries development which if exploited, can result in benefits to the community from increased fishery productivity and fishing incomes. This impact would be permanent and its significance is viewed to be **moderate**.

Impact significance

Table 9-2 Increased employment and business opportunities

Magnitude	Receptor Sensitivity	Impact Significance
Medium	Medium	**Moderate**

Generally, unemployment rates in the project area are high – estimated at 52% for Machakos County, and the project will have short-term impacts on the workers (including their families) employed during construction. There may arise complaints and dissatisfaction among the communities affected by the projects if recruitment of workers is perceived to be biased and without local representation.

To mitigate the local representation concerns, the Contractor should establish local employment targets to maximize local employment. Unemployed and able workers among the affected communities in each locality should be given first priority in recruitment of casual laborers. The Contractor should have a credible procedure to identify and verify the areas in which the potential workers live, as well as information on experience and skills. It may be necessary to enlist the help of the local administration (chiefs, assistant chiefs and headmen) in vetting the workers.

9.3. Loss of land and livelihoods

9.3.1. Permanent land take

Development of a reservoir on Miwongoni River will involve the permanent occupation of some $3.84x10^5$ m^2 or 95 acres of riparian and farmland and an additional 30 acres by the buffer zone. The reservoir will extend about 1,200m from the weir backwards along Miwongoni River, resulting in the loss of the corresponding length of riverbank from inundation. The buffer zone has been set as 30m from the reservoir's normal water level (NWL). In addition to the main reservoir area, the project will involve permanent land take for:

- Access road(s);
- Water treatment plant;
- transmission pipelines; and
- Water storage tanks

9.3.2. Temporary land take

During construction, land will be occupied temporarily for worker camps, contractor lay-down areas, cofferdam and the river diversion channel. The sites for most these will be determined by the contractor and are not known at this stage.

Additional land may be occupied by informal migration of people into the area stimulated by the construction activities. The extent and duration of impact will be determined by policies implemented to manage these population movements.

9.3.3. Impacts of land take

Inundation by the reservoir of a large area is expected to be the most significant aspect that will cause the permanent loss of farmlands and riparian vegetation cover, and the physical and/or economic displacement of about 30 households thus affecting their livelihoods. The treatment works will require about 3 acres of land, and although the site is on government land, it is seasonally cultivated by the surrounding communities. Pipelines are largely expected to be laid on road reserves but wayleaves will require to be secured across private farmlands especially for the raw and treated water mains to and from the treatment works. Small parcels of land will also be required for storage tank sites (particularly for Kilima and Katelembu storage tanks).

Impact significance

Table 9-3 Loss of land and livelihoods for affected people

Magnitude	Receptor Sensitivity	Impact Significance
Medium	High	Major

The impact of land take on people and livelihoods is expected to be **major** since the affected communities are primarily agricultural, and the inundated farmlands are the more productive areas in the region due to availability of water from the river for irrigated agriculture. The displacement has potential to destroy the existing mode of production, cause environmental problems and impoverishment of the affected people.

Due to the extent of cultivation of the river valley, a narrow strip of riparian vegetation has been left, and the loss of this vegetation will not be significant.

9.3.4. Mitigation of land take impacts

To mitigate the impacts of land take, there should be prompt and adequate compensation for persons who lose their land and property. Preference should, as much as possible, be given to alternative land compensation as opposed to monetary compensation.

It has been argued that exclusive cash compensation is least useful to resettlers in the long run since, in many instances, displaced families provided only cash compensation tended to suffer a significant reduction in income and their productive resource base compared to pre-project conditions. Therefore, for land-based

resettlement, a 'land-for-land' approach may be more beneficial since land is the key to reestablishment and contributes to cultural security. There has been criticism however that this approach denies the settlers the right to choose for themselves and that cash compensation could provide opportunities for opening family businesses.

One important mechanism for implementing the land-for-land strategy is to identify several possible relocation sites to provide alternative choice to the displacees. The productive potential, quality of soil, availability of irrigation water, and locational advantages of the new relocation sites should be ideally better or at least equivalent to the lost site in order to make it attractive to the settlers. Furthermore, in selecting relocation sites, attention should be paid to the possibility of off-farm income (e.g., fishing, seasonal wage labor, businesses) to supplement family income.

During public consultations for the project, some of the likely displacees by Miwongoni dam proposed relocation to a neighboring parcel of land owned by the county government, in addition to other compensation measures.

9.3.4.1. Land acquisition and compensation

As part of the social impact assessment, a team comprised of a Sociologist, a Registered Valuer, and a Local Administrator informed the affected people about the nature of the projects, the need for land acquisition, and their rights and obligations with respect to the acquisition process. An estimate of the number of households to be affected, including the value of affected assets was made to establish an estimate of the compensation payable to affected land owners and users. At this conceptual design stage, a Resettlement Policy Framework has been prepared to ensure that physical and economic displacement impacts of the project are adequately addressed. A Resettlement Action Plan will then be prepared once the project enters detailed design stage.

The following measures should be taken to mitigate land take impacts:

- Determine the market value of the land being acquired in calculating compensation. In addition, cash compensation should be supplemented by providing "replacement assets" (e.g., house, land, shop) in order for the displacees to be resettled
- Compensation money must be made available before the actual move so that displaced households can use the money to overcome or minimize the hurdles of dislocation.

The table below summaries the potential impacts and mitigation/management measures proposed for land acquisition and livelihoods impacts.

Table 9-4 Summary of potential impacts and mitigation measures for land acquisition and livelihood impacts

Issue/impact	Mitigation/management measures
Construction phase	
Permanent expropriation of land and related income	Cash compensation based on market value of land or provide with option of replacement land within the village if available and of equivalent size and quality.
Interruption of land use along the pipeline ROW by the construction process for the duration of the construction period	▪ Cash compensation should be provided for lost agricultural productivity during the construction period. ▪ Reinstatement of land to a least the condition it was in prior to construction.
Loss/damage to crops, trees fences along the pipeline construction corridor	▪ Compensation for property damage and loss of amenities within the designated construction corridor; and ▪ Adequate notice to be given to farmers before commencement of construction so that the farmers do not unnecessarily lose crops.
Potential damage to property outside the pipeline ROW and approved construction areas	▪ Construction activities to be carried out in predetermined working areas. Any damage by

through activities such as: clearing land beyond the project working areas for which compensation has been paid; vehicles or people straying outside working areas and causing damage to land and crops; adverse effects of dust on crops	construction works outside the boundaries to be appropriately compensated by the contractor; ▪ Requirement to keep within the working area to be enforced and emphasized to the workers during induction and toolbox talks; and ▪ Working areas to be determined prior to construction and demarcated as necessary using fencing, marker posts or signs.
Operation phase	
Following completion of construction, there will be restrictions on land use especially along the pipeline ROW precluding building or the planting of trees	Compensation for restrictions to land use be provided to land owners as set out in the Resettlement Action Plan (RAP).

9.4. Reduced availability of water downstream of the reservoir

Miwongoni River is seasonal and flow either ceases completely, or reduces to a trickle during the dry season. Those farming along the river valley abstract what is left in the river for crop irrigation.

Water use for the construction of the weir and associated infrastructure could exacerbate the water shortage during the dry season for those farming downstream. The significance of this impact is likely to be **moderate**, but temporary.

In addition, during the filling of the reservoir, there will be a reduction in the water level of the river downstream, and the contractor may (though illegally) even divert all the available water into the reservoir, halting river flows downstream completely. This could have a severe impact in the livelihoods of communities living on the river banks downstream. The impact would be temporary while the reservoir is being filled but this could have a severely adverse effect on villagers who might not be able to withstand drastically reduced flows for more than a few days. The significance of this impacts for communities living downstream would however be **moderate** considering that the confluence with Maanza River is less than a kilometer downstream, and thus, most of the communities would be assured of some river flow albeit reduced.

9.5. Impacts on cultural heritage and archaeology

9.5.1. Construction phase impacts

Aspects of the project which could impact on archaeological resources and cultural property include the removal of topsoil and subsoil during earthworks for the weir, reservoir, treatment works, trenching and opening up of new accesses. Construction activities may damage/destroy any existing archaeological monument(s) or cultural property whether marked/recorded or new discoveries.

There are no known archaeological/cultural assets existing in the immediate project area. However, a culturally significant site is reported to exist along the banks of Mitheu River approximately 2km to the east of the proposed reservoir site and treatment works. The stand of mature *Acacia* trees is said to be an Ukambani traditional shrine commonly known as *Ithemboni*. Project activities are not expected to interfere with the cultural site.

Although no known assets exist in the immediate project area, there is the possibility of encountering marked or unmarked graves within the farmlands affected by project components. Although the overall risk is assessed as **Minor**, an unmarked grave is at a higher risk of damage during earthworks.

9.5.2. Operation phase impacts

Once the project is operational, there will be no further impact on archaeology or cultural heritage of the project area.

9.5.3. Management of impacts on archaeology and cultural heritage

If areas of archaeological and/or cultural significance are revealed at any of the project sites, an appropriate response should be decided upon in consultation with the land owner and/or National Museums of Kenya.

For any encounters along the pipeline routes, considerations should be made to alter the alignment of the pipeline to avoid damage to the feature. Where the pipeline cannot be sensibly moved, significant sites may need to be excavated and recorded prior to construction activities continuing in the area.

Where graves are identified, consultations with the land owners should be carried out to relocate the graves to suitable locations.

9.6. Impacts on community health, safety and security

Poor construction management practices by the Contractor have potential to cause direct adverse effects on safety, human health and wellbeing of the surrounding community. Such include inadequate management of local air quality, wastes generated, traffic and other safety hazards posed by construction sites or construction activities.

Any incident that harms a person has potential to diminish the quality of life for that person, negatively impacting them or their household livelihood, and potentially creating tension between the local community and project teams.

Indirect impacts on the community can be the introduction of new communicable diseases such as HIV/AIDS due to in-migration, poverty and prostitution. The extent of disease transmission between the communities and in-migrants would depend on the level of interaction between the two, the workforce size and health status of the workforce and casual migrants, and their susceptibility to disease infection. In addition, the living conditions, access to healthcare and workforce management would determine the significance of disease transmissions.

Existence of a dam also introduces additional risks to the community from potential dam failure or flooding, and drowning of both humans and animals.

9.6.1. Temporary health and safety impacts during construction

During construction, works such as excavation, movement of materials and spoils, and the general increase in vehicular traffic is likely to increase dust and noise pollution in the project area. Consequently, it is likely that respiratory infections, eye infections (e.g. trachoma), hearing impairment, malaria, work-related accidents, and traffic accidents could increase in incidence.

9.6.1.1. Increased respiratory health incidence and eye infections

Dust emissions can irritate the eyes causing trachoma and respiratory problems. Although these problems are reversible, the long-term exposure to dust will have a serious impact on the health status of those close to construction areas. In addition, it is expected that the project transportation activities will increase the level of dust created in the local environment. Dust emissions from passing traffic will irritate the eyes and lead to an exacerbation of respiratory illnesses for those near key transport routes. Without mitigation, the significance of the impact is likely to be **moderate**.

The impacts are likely to be most severe on the construction workforce. However, it is expected that the work force would be adequately protected with PPE, and therefore the significance can be downgraded to **minor**.

9.6.1.2. Increased hearing impairment

In addition to the large volume of dust produced, noise levels are likely to significantly increase, especially from construction vehicles and machinery. Although intermittent, the noise levels during the peak construction period may cause hearing impairment, sleep disturbance, behavioral change or anxiety. The significance of the impacts would be **moderate** but could be downgraded to **minor** if these will only affect construction workers.

9.6.1.3. Increased incidence of accidents

The likelihood of a third-party accident occurring (for example a young child falling into an excavation area) is low, especially because construction activities will take place in a less populated area. Based on the level of construction activities taking place and the level of public access to construction areas, the significance of the impact is likely to be **minor**.

9.6.1.4. Increase in traffic accidents

Construction traffic movements (of materials and workforce), in addition to general project traffic vehicles, will result in a significant increase in traffic levels on the local roads especially for traffic to and from the construction sites and construction camp. The communities residing in the project area have settled along main transport routes and are most likely to be impacted by increased traffic with the potential increase in accidents. The overall significance of the impact is judged to be **moderate**, but this may reduce depending on the severity of accident and availability of emergency health care to deal with the increased number of incidents.

9.6.2. Long term health and safety impacts during construction and operation

9.6.2.1. Changes in water ecology, resulting in increased disease vector populations

A permanent change in water flows in the river and the creation of the reservoir can have a significant impact on disease incidences in the local region, specifically serious communicable diseases such as bilharzia, and trypanosomiasis.

Increase in bilharzia: The decreased stream flow rate in the river resulting from the impoundment of the river is expected to increase the incidence and transmission of both unary and intestinal bilharzia in the river basin. This would particularly affect school children and other users of the local streams and rivers. The significance of this impact would be **major**, and permanent.

9.6.2.2. Introduction of new communicable diseases such as HIV/AIDS due to in-migration, poverty and prostitution

The extent of disease transmission between the communities and in-migrants would depend on the level of interaction between the two, the workforce size and health status of the workforce and casual migrants, and their susceptibility to disease infection. In addition, the living conditions, access to healthcare and workforce management will determine the significance of disease transmissions.

The impact due to Acute Respiratory Infections (ARIs) is expected to be **minor**, as the symptoms are easily treated, assuming diagnosis early on and access to healthcare is sufficient. However, the significance of the impact of acute communicable diseases such as HIV/AIDS or TB – which require immediate or complex treatment, are life threatening and/or are irreversible, is considered **major**.

9.6.2.3. Increased risk from dam safety

The events that have potential to pose significant risk to downstream areas of the dam include:

A significant/catastrophic flood – of floodwaters reaching the reservoir as inflow. Where these floodwaters are not attenuated in the reservoir nor safely discharged through the spillway, it would result in an overtopping of the dam, and release of the floodwaters downstream. This can also cause erosion of the dam crest and dam break. The significance of the impact of a dam break is viewed as **major**.

Flood waves from landslides – where the sliding mass plunges into the reservoir and initiates a wave action which can propagate causing the wave height to exceed the crest elevation and therefore causing overtopping.

Flood wave from dam failure: Failure of earth dams can occur from internal erosion or crest erosion as may be caused by overtopping. Concrete dam failures are less common but can be caused by foundation seepage, sliding and overturning, concrete cracking, internal hydrostatic pressures or simply poor design and workmanship. This would result in an increasing outflow of the reservoir, causing a flood wave downstream that would have **major** adverse impacts on human life and property.

Drowning of humans and animals is also a significant risk posed by the dam in the event of unrestricted access to the reservoir.

9.6.3. Management of impacts on community health, safety and security

9.6.3.1. Construction phase management measures

Implementation of specific management plans on housekeeping, waste, air quality, traffic, health and safety and pollution prevention will ensure that community health, safety and security is enhanced. Measures should include but not limited to:

- Informing local communities of major activities in advance;
- Ensuring all dangerous construction sites are fenced off;
- Endeavour to lay pipes and backfill as soon as possible to reduce the time of hazards exposure to the public from open trenches;
- Enforcing and monitoring road safety standards;

- Identification of water sources for construction that will not deplete local water supplies and ensuring that construction minimizes its use of water;
- Implementation of measures to prevent the entry of sediment from construction areas into local waterways;
- Following best practice to prevent the creation of breeding areas for vermin;
- Spraying construction areas and roads regularly with water to suppress dust emissions;
- Ensuring that potentially disturbing construction noise is not produced outside of working hours;
- Safety training, traffic management and a high priority placement of public safety by the Contractor
- Ensuring that the workers camp(s) and construction areas are open only to formal employees;
- Developing and enforcing a strict code of conduct for workers to regulate behavior in the local communities;
- Providing awareness training to the workforce regarding the transmission of STDs, and traffic safety awareness;
- Provision of adequate facilities for workers;
- Provision of the workforce with access to healthcare.

The Contractor should also appoint a community liaison team to work with communities to manage issues or anxiety surrounding incidents and accidents and to advice on the risks and dangers associated with the project.

A series of support measures to mitigate social, health and economic impacts can be provided to local communities. These could include:

- A local employment and sourcing policy to discourage in-migration, entailing a ban on the employment of casual migrants to the site, and the recruitment of labor through offices located away from the site;
- Informing local communities of employment and procurement opportunities;
- Supporting local healthcare facilities i.e. training of local healthcare professionals, supply of regular medical supplies and updated equipment;
- A community health program including support to existing or new local programs such as mother and child, nutrition, community health awareness, HIV/AIDS awareness, hygiene and immunization, malaria control measures, campaigns to raise traffic awareness, and local Voluntary Counselling and Testing (VCT) programs;

9.6.3.2. Operation phase management measures

During project operation and maintenance, MAWASCO should appoint a community liaison officer to regularly engage the community and other stakeholders on project performance. An engagement and communication strategy should be developed that addresses:

Information: this is where the goal shall be to inform or educate the stakeholders and can take the form of continuous issuance of bulletins/letters/brochures, speeches/public presentations or advertisements.

Consultation: where the goal is to gain information and feedback from stakeholders to inform them of decisions made internally. This could entail surveys, focus groups, one-to-one meetings, public meetings and workshops. Consultation of these types offers stakeholders opportunities to reflect on issues, mobilize and respond more critically than when brought directly to workshops.

Involvement: where the goal is to work directly with stakeholders to ensure that their concerns are fully understood and considered in decision making. This can be achieved through multi-stakeholder forums, advisory panels, consensus building processes and participatory decision- making processes.

Social and Environmental Safeguards Office: where MAWASCO engages the services of a competent officer to coordinate engagement with stakeholders ensuring that the communication strategy is followed through and especially to ensure that all social and environmental safeguards proposed in the ESIA are adhered to and that stakeholders have opportunities to be properly represented in any environmental audits in the future during operation and maintenance.

A key element in the success of the engagement process is the development and implementation of a grievance mechanism. The grievance mechanism should be scaled to fit the level of risks and impacts of the

project and should follow MAWASCO's broader process of stakeholder engagement and business integrity principles, and integrate the various approaches of engagement.

Grievance procedures should be established by MAWASCO and agreed with the stakeholders. The procedures would enable the stakeholders and (especially the community) to lodge complaints or concerns, without cost, and with the assurance of a timely and satisfactory resolution of the issue(s). The procedures would be in place from the beginning of the social and environmental assessment process and exist throughout construction and operations through to the end of project life. The Grievance procedures would ideally, not replace the existing legal process but would seek to resolve issues quickly without resulting to expensive and time-consuming legal actions.

MAWASCO can also implement measures that will address the risks of bilharzia, trypanosomiasis, intestinal worm, and malaria. The measures could include community health education, and control of disease vectors/hosts, and vector breeding areas.

9.6.3.3. Dam safety management measures

Pre-construction mitigation measures to enhance dam safety can include estimations of maximum ground accelerations of probable earthquakes, probable maximum flood, as well as probable landslides into the reservoir based on the characteristics of the area. The results of these estimations should then be taken into consideration in technical decisions regarding the designs of the dam and associated structures.

Construction phase mitigation measures should include implementation of the plans developed for construction activities, review of designs and technical specifications and carrying out any additional investigations and tests deemed necessary, quality control of works, and erection of a perimeter fence around the reservoir.

Operation phase measures for dam safety should include structural dam integrity monitoring, establishment and implementation of emergency preparedness plans, maintenance of the perimeter fencing around the reservoir, and creation of awareness among the surrounding community on safety and coexistence with the dam.

Indicators for internal erosion (piping) failure which should be closely monitored include:

- wet or saturated areas along the downstream slope;
- seepage emerging on the downstream slope or from abutments and foundations
- changes in the seepage rate or in the pore pressure distribution within the dam;
- clogged drains or seepage which bypasses the drainage system;
- cracks on the crest, outer slopes or within the abutments
- increased settlement with time

With the periodic observance for these signs, internal erosion (piping) if any can be remedied and stopped before a failure occurs.

Emergency preparedness plans for the dam should include:

- Actions to be taken before a failure, such as:
  - establishment of gauging and observation stations;
  - installation of measurement and monitoring instruments;
  - preparation of maps outlining inundation zones for various conditions;
  - training of staff;
  - establishment of procedures for mobilization of emergency resources and equipment;
  - establishment of warning systems (audio and visual warning signs) in the downstream areas; and
  - establishment of procedures and access/escape routes for evacuation of potentially threatened areas
- Actions to be taken during a failure, such as:
  - evaluation data obtained from gauging and observation stations to estimate peak flood conditions, the time it would take to reach these conditions, and the length of time the whole even would last;
  - raising of alarm downstream
  - mobilization of emergency response teams with the necessary supplies and equipment
  - evacuation of affected people from the flooded area as soon as possible
- Actions to be taken after a failure, such as:

- Establishment of a committee for identification and assessment of the damages and losses due to the event
- Preparation of a report regarding the event and consequences which will serve for the improvement of the future projects and provide information for further planning.

9.7. Depression of local economy and out migration of workers and local population

Construction-related work opportunities from project components will last a limited period of time, after which the workers would need to be laid off as the project moves into operational phase. The reduction in the workforce would result in the out- migration of workers as they leave to seek job opportunities elsewhere. This may result in the depression of the local economy as the market for local goods and services declines. The significance of this impact is viewed as **moderate**.

9.8. Impact of greenhouse gas emissions

Studies have suggested that the emission of greenhouse gases (GHG) from reservoirs due to rotting vegetation and carbon inflows from the catchment may be a significant source of global GHG emissions. Greenhouse gases (carbon dioxide and methane) are released into the atmosphere from reservoirs that flood forests and other biomass, either slowly (as flooded organic matter decomposes) or rapidly (if the forest is cut and burned before reservoir filling). Reservoir releases of carbon dioxide and methane are thought to contribute an estimated seven percent of the global warming impact of all human activities.

The magnitude of the predicted climate change impact of the dam depends on the amount of biomass that is inundated by the reservoir, the total surface area of the reservoir, and the flux rate. Provided that vegetation is at least partially cleared prior to inundation, greenhouse gas emissions would be relatively low, given that the surface area of the reservoir is not large in comparison to other man-made reservoirs in Africa. The significance of this impact is considered **minor**.

A measure that can be applied to reduce greenhouse gas emissions is the selected clearance of vegetation prior to inundation.

10. Environmental management & monitoring plan (EMMP)

10.1. Overview

The measures presented here summarize the key impacts identified, the remedial measures to be taken, the responsible person(s) for execution, and the monitoring activities to be undertaken. An indication of the timing for implementation and the cost involved is also provided.

The EMMP tables can be further expanded with documented procedures and guidelines for work practices in order to be responsive to the situations that various Contract Parties will encounter. Implementation of the EMMP shall be done within the provisions of the law and for the ultimate benefit of the stakeholders in the area. The effectiveness of the EMMP should be monitored and assessed regularly through inspections and reporting throughout construction and during operations.

10.2. Construction environmental management and monitoring plans

A Construction Environmental Management and Monitoring Plan (CEMMP) is a practical and achievable plan of management to ensure that any environmental impacts during the design, planning and construction phase are minimized. Outline CEMMPs have been proposed to deal with the following issues during construction of the water supply project:

- General site management;
- Air quality;
- Noise and vibrations;
- Aesthetics (visual and landscape);
- Ecology and biodiversity (flora and fauna);
- Soil resources;
- Energy resources;
- Water resources;
- Waste management;
- Traffic Management;
- Occupational health and safety;
- Community health and safety; and
- Displacement and disruption of livelihoods

10.2.1. Contractor environmental and social management plan

The Contractor appointed for the construction of the project must develop his own ESMPs to ensure actions and mitigation necessary to protect the environment are incorporated into all site procedures. At a minimum, the contractor's ESMP must address the following:

- Policy
- Planning
- Implementation and Operation

10.2.1.1. Policy

The Contractor should develop an environmental policy that includes, as a minimum, the following:

- A commitment to comply with applicable regulations and other requirements that the construction company subscribes to;
- A commitment to provide a safe work environment;
- A commitment to provide the training and equipment necessary for employees to conduct their work safely;
- A commitment to continuously improve performance and to pollution prevention; and

- A commitment to communicate the policy to all persons working for and on behalf of the company.

10.2.1.2. Planning

Environmental issues and the legal and other requirements in construction of the water supply project have been identified in this ESIA. The Contractor must demonstrate within his plan that he has read and understood the ESIA Report and its provisions for environmental management and monitoring.

10.2.1.3. Implementation and Operation

Roles, responsibilities and authorities should be defined, documented and communicated to ensure effective environmental and social management. A specific management representative should be assigned that is responsible for ensuring that the ESMP is established, implemented and maintained and is responsible for reporting performance, reviewing the Plan and making recommendations for improvement. Documented confirmation is required that the training needs of all persons working for or on the company's behalf whose work pose significant hazards to their health and safety and/or may create a significant impact on the environment has been identified. Records of all training must be maintained.

Management, supervisory, and employee responsibilities must be communicated to all employees through training, formal job descriptions, work experience, hiring practices, etc. Awareness training should be provided that include the importance of conforming to the policy and procedures, the significant environmental issues, and the roles and responsibilities of management and staff.

Records should be legible, identifiable and traceable to the activity. Records should be stored and maintained in such a way that they are retrievable and protected against damage, deterioration or loss.

The Contractor should establish, implement and maintain procedures to identify potential emergency situations and potential accidents that can have an impact on the environment, surrounding communities, the employees, and/or the public.

The Contractor should be prepared to respond to actual emergency situations and accidents and prevent or mitigate associated adverse environmental or social impacts. The ESMP must also address how the Contractor will receive, document and respond to external interested parties.

10.2.2. Environmental monitoring

Environmental monitoring will commence at the initiation of the construction activities for the project, and will be carried out through the construction phase to commissioning. The monitoring plan will be employed throughout the operation of the water supply infrastructure based on the implementation schedule.

10.2.2.1. Environmental monitor

An independent Environmental Monitor will be identified and contracted to perform the following:

- Verify that all project approvals and permits are in place prior to the start of construction;
- Evaluate contractor plans (e.g., ESMP, Spill Response and Waste Management Plans) and monitor implementation;
- Develop inspection checklists to ensure site inspections are focused and useful;
- Conduct environmental monitoring of construction works; the environmental monitor will ensure the protection of the environment, that mitigation measures are appropriately implemented and to facilitate communication between the Contractor, the Project Team and NEMA; and
- Prepare regular written reports to the Project Team, Contractor and, where need be, NEMA on an agreed to schedule.

Detailed CEMMP's are presented below.

Table 10-1 CEMMP - Site management

Management Plan				
Objective	**To apply best management practices in site management during construction**			
Management strategy	**To control potential pollutants at their source by good housekeeping practices**			
	Activities	**Responsibility**	**Timing**	**Estimated Costs (Kshs)**
Actions	▪ Provide training to workers to ensure that they understand the requirements of the environmental management plan as applicable to their responsibilities; ▪ Conduct drills to check on preparedness and response time to emergencies; ▪ Implement practices and procedures that promote proper handling and storage of construction materials and other stockpiles to prevent or reduce storm water pollution, injury to workers or visitors, ground water pollution, and soil contamination; ▪ Minimize or eliminate the discharge of pollutants into storm water drainage systems/natural water channels, surface water bodies or aquifer by reducing hazardous material use on site, using alternative products, and training employees in proper handling and use of construction materials ▪ Ensure protection of stockpiles to reduce the potential for air and storm water pollution originating from stockpiles of construction materials, topsoil and subsoil; ▪ Ensure measures to prevent the discharge of wastes (solid waste, sanitary/effluent waste, hazardous waste, concrete waste) into the ground or the area's surface water courses /water bodies; ▪ Institute practices and procedures to reduce or prevent leaks or spills which may be discharged into the environment; and ▪ Develop a plan that addresses the sequence of construction activities as it relates to local climate to minimise soil erosion from exposure to wind, rain, runoff and vehicle tracking.	Contractor	During construction	▪ 200,000 for worker's training ▪ 100,000 for drills ▪ 300,000 for housekeeping measures ▪ 400,000 for pollution prevention ▪ 200,000 for protection of stock piles ▪ 600,000 for waste management ▪ 300,000 for management and containment of materials to prevent spillages/leakages
Monitoring Plan				
Performance indicators	Housekeeping practices vis a vis EMP requirements; environmental pollution and H&S concerns arising during construction	Environmental Monitor	Construction Phase	No Additional Cost (NAC)
Monitoring requirements	Periodic audits (monthly)			
Reporting	Training plans and records; records of drills; construction schedule/plans			
Interface	Environmental Management and Coordination Act, 1999 and subsidiary legislation			

Table 10-2 CEMMP – Ecology and biodiversity

Management Plan				
Objective	**Conserve/protect the existing biodiversity and ecological functions in the Project area**			
Management strategy	**Institute measures to protect and conserve existing biodiversity and ecological functions**			
	Activities	**Responsibility**	**Timing**	**Estimated Costs (Kshs)**
Actions	▪ Locate all associated structures and temporary and permanent construction-related sites (e.g. the construction camp and borrow pits) as far as possible within the zone of inundation or on disturbed habitat locations to minimize overall habitat loss; ▪ Minimize the width of construction right of way for construction of new pipelines, and the width of access road(s) ▪ Avoid unnecessary removal/destruction of vegetation in site clearance; ▪ Development and implementation of a Reinstatement Plan; ▪ Re-vegetation of disturbed grounds with indigenous species; ▪ Incorporate existing vegetation into landscaping plans where possible and ensure that proper care is taken for this vegetation before and after construction; ▪ Ensure the protection of existing vegetation using any of the following methods: mark, flag or fence areas of vegetation to be preserved; designate limits of root systems (tree drip line); limit grading to within one foot of the tree drip lines if grading under the tree is necessary; and locate construction traffic routes, spoil piles etc. away from existing vegetation; ▪ Ensure the prevention of vegetation and soil contamination by hydrocarbon/chemical pollution events through development and implementation of pollution prevention plans and emergency response plans. ▪ During inundation/filling of the reservior: ✓ Provide for rescue of rare or distressed animals; ✓ Selectively harvest tall trees within the inundation area prior to impoundment to force tree-dwelling wildlife to migrate from the area prior to flooding; ✓ Begin reservoir inundation after the dry season once hibernating animals have emerged; ✓ Reduce the biomass that will be flooded by selective vegetation clearing; ✓ Implement 'nuisance' plant monitoring programme for the reservoir.	Contractor	During construction	▪ 200,000 for protection of existing vegetation ▪ 600,000 for re-vegetation and landscaping
Monitoring Plan				
Performance indicators	Extent of vegetation clearance, vegetation damage from pollution incidences	Contractor/ Environmental Monitor	Construction Phase	NAC
Monitoring requirements	Periodical inspection (weekly)			

Management Plan				
Objective	**Conserve/protect the existing biodiversity and ecological functions in the Project area**			
Management strategy	**Institute measures to protect and conserve existing biodiversity and ecological functions**			
	Activities	**Responsibility**	**Timing**	**Estimated Costs (Kshs)**
Reporting	▪ Number and species of trees cleared and planted ▪ Hydrocarbon spillages and clean-up measures taken			
Interface	Compliance with the EMP and with the EMCA, 1999			

Table 10-3 CEMMP - Energy resource management

Management Plan				
Objective	**Minimize impact on energy resources due to the construction works**			
Management strategy	**Conserve fossil fuel energy resources** **Reduce CO_2 emissions at the construction sites**			
	Activities	**Responsibility**	**Timing**	**Estimated Costs (Kshs)**
Actions	▪ Maintain equipment and machinery to manufacturers' specifications by regular servicing to maintain efficiency in combustion and reduce carbon emissions; ▪ Use environmentally friendly fuels such as low sulphur diesel; ▪ Minimise the period for machinery idling to save on fuel; and ▪ Specify and procure the most energy efficient plant options fit for purpose and avoid use of plant with unnecessary and excess capacity.	Contractor	Construction phase	▪ No additional costs (NAC)
Monitoring Plan				
Performance indicators	Evidence of energy conservation measures instituted and functional at the site.	Environmental Monitor	Construction phase	NAC
Monitoring requirements	Physical inspection (Monthly)			
Reporting	Maintenance logs, fuel consumption records			
Interface	Compliance with the Energy Act, 2006 and international best practices			

Table 10-4 CEMMP - Air quality

Management Plan				
Objective	**Maintain the air quality by avoiding air pollution**			
Management strategy	**Abate pollution of the atmosphere by reducing emissions**			
	Activities	**Responsibility**	**Timing**	**Estimated Costs (Kshs)**
Actions	▪ Minimize exposed areas through the schedule of construction activities to enable dust control; ▪ Sprinkling of active sites and other dust prone areas to lay dust; ▪ Maintain equipment and machinery to manufacturers' specifications by regular servicing to maintain efficiency in combustion and reduce carbon emissions; ▪ Use environmentally friendly fuels such as low sulphur diesel; ▪ Ensure no burning of waste on sites/non-designated areas; ▪ Minimise the period for machinery idling; ▪ Control of speed limit for construction vehicles along dusty roads; ▪ Rehabilitation of disturbed areas once completed; ▪ Use of tarpaulins to cover trucks carting away spoil using public roads. Additionally, the trucks should maintain at least two feet of freeboard; ▪ Proper planning in transportation of spoil to ensure that the number of trips done or the number of vehicles used is as minimum as possible; and ▪ Provision of appropriate Personnel Protective Equipment such as dust masks to site workers.	Contractor	Construction phase	▪ Equipment operation costs yet to be determined ▪ 100,000 for signage & other speed controls; ▪ 1,000,000 for dust suppression ▪ 600,000 for re-vegetation and landscaping ▪ 100,000 for tarpaulins ▪ 300,000 for worker PPE
Monitoring Plan				
Performance indicators	▪ Lack of complaints / Complaints; ▪ Deposition of dust on neighbouring vegetation; and ▪ Construction vehicle speeds; ▪ Truck loading levels ▪ Usage of PPE by workers	Environmental Monitor	Construction phase	600,000 for air quality measurements
Monitoring requirements	▪ Weekly site inspections; ▪ Air quality measurements if necessary;			
Reporting	Equipment maintenance records, entries in the complaints register.			
Interface	Compliance with the Environmental Management and Coordination (Air Quality) Regulations 2014,			

Table 10-5 CEMMP - Noise and vibrations

Management Plan				
Objective	**Maintain low noise levels and reduce vibrations emanating from construction activities**			
Management strategy	**Prevention of noise pollution and vibrations**			
	Activities	**Responsibility**	**Timing**	**Estimated Costs (Kshs)**
Actions	▪ Install portable hoods to shield compressors and other small stationary equipment where necessary; ▪ Endeavour to use equipment installed with noise abatement devices as much as practicable; ▪ Reduce idling time on trucks and other noisy equipment; ▪ Encourage drivers to turn off vehicle engines when not in use; ▪ Provide personal protective equipment such as ear muffs to workers at the site as necessary; and ▪ Carry out construction work during the day only.	Contractor	Construction phase	▪ 300,000 for noise abatement measures ▪ 300,000 for PPE
Monitoring Plan				
Performance indicators	▪ Complaints; ▪ Noise levels from construction works and equipment; ▪ Construction workforce habits relating to noise management ▪ Usage of PPE by construction workforce	Environmental Monitor	Construction phase	200,000 for noise measurements
Monitoring requirements	▪ Weekly site inspections; and ▪ Noise measurements at point sources.			
Reporting	▪ Noise measurement records; ▪ Entries in the complaints register; ▪ Construction schedule			
Interface	Compliance with the Environmental Management and Coordination (Noise and Excessive Vibration Pollution) (Control) Regulations, 2009; Factories and other places of Work (Noise Prevention and Control) Rules			

Table 10-6 CEMMP - Soil resource management

Management Plan				
Objective	**Protection of soil resources at the site**			
Management strategy	**Prevention of depletion of the soil resource at the site**			
	Activities	**Responsibility**	**Timing**	**Estimated Costs (Kshs)**
Actions	▪ Salvage, stockpile and ensure re-use of native topsoil during re-vegetation activities in disturbed areas; ▪ Develop and implement a reinstatement plan; ▪ Reinstatement to ensure that trench backfill material is compacted to a similar value to the surrounding soils; ▪ Ensure that clearance of vegetation is limited to the plinth of proposed structures and trench line to prevent soil erosion that would ensue after loss of vegetation; ▪ Ensure that construction vehicles use predetermined tracks at the site to reduce ground compaction; ▪ Stabilize and maintain access roads created to access project sites to minimize erosion and dust from vehicular traffic; ▪ Stabilize construction sites and camp(s) entrances/exits to reduce the amount of sediment tracked off-site by construction vehicles; ▪ Oils, fuels, paints and any hazardous materials to be stored in accordance with their respective MSDS's, and in such a manner to avoid spillages or leakages; and ▪ Seeding and planting of trees, shrubs and ground cover for temporary or permanent stabilization of soil in areas such as: cleared areas without on-going construction activity; open space and fill areas; spoil piles or temporary stockpile of fill material	Contractor	Construction phase	▪ 200,000 for protection of existing vegetation ▪ 600,000 for maintenance of accesses ▪ 300,000 for stabilization of entrances/exits ▪ 300,000 for management and containment of materials to prevent spillages/leakages ▪ 600,000 for re-vegetation and landscaping
Monitoring Plan				
Performance indicators	▪ Level of soil erosion observed at the sites; and ▪ Quantity of excavated soil carted away/re-used at the site ▪ Housekeeping practices that have impact on erosion and pollution prevention.	Environmental Monitor	Construction phase	NAC
Monitoring requirements	▪ Weekly site inspections			
Reporting	Records of soil pollution incidences; volumes of spoil disposed off-site			
Interface	Compliance with best practices in soil resource management			

Table 10-7 CEMMP - Water resource management

Management Plan				
Objective	**Protection of water resources in the area**			
Management strategy	**Conservative use of water at the site and prevention of water pollution by construction activities**			
	Activities	**Responsibility**	**Timing**	**Estimated Costs (Kshs)**
Actions	▪ Develop and implement a site construction waste and wastewater management plan to minimize environmental damage from construction activities; ▪ Provide appropriate sanitary facilities at construction camp and sites, worker compounds and other construction facilities; ▪ Install secondary containment measures in areas where fuels, oils, lubricants etc. are stored and loaded or unloaded, including filling points; ▪ Implement soil erosion control measures; ▪ Install and regularly empty sediment traps in surface drains around construction areas; ▪ Limit sand excavation from the riverbed to the dry season when flows are low to limit the amount of sediment transported downstream; ▪ Maintain as much riverine vegetation at the weir site and in the reservoir area as possible until inundation begins, and maintain vegetative buffer zones alongside river and drainage channels during construction; ▪ Minimize soil disturbance and excavation during wet season; ▪ obtain appropriate consents for any abstractions from, and discharges to watercourses during the construction period; ▪ Take adequate precaution in the discharge of hydro-test water to avoid erosion and deposition of sediments into watercourses ▪ Consider selected clearance of vegetation prior to inundation including commercial salvage of trees; ▪ Design implement agreed seasonal compensation flow regime during inundation	Contractor	Construction phase	▪ 200,000 for sanitary facilities at sites; ▪ 500,000 for secondary containment measures at construction camp ▪ 100,000 for silt fences and sediment traps
Monitoring Plan				
Performance indicators	▪ Water consumption levels, water pollution incidences or housekeeping practices that could cause water pollution	Environmental Monitor	Construction phase	NAC
Monitoring requirements	▪ Weekly site inspections			
Reporting	▪ Site logs of inspections and corrective actions.			
Interface	Compliance with Environmental Management and Coordination (Water Quality) Regulations 2006			

Table 10-8 CEMMP - Traffic management

Management Plan				
Objective	**Prevention of traffic nuisance by construction vehicles**			
Management strategy	**Develop and observe traffic management plans**			
	Activities	**Responsibility**	**Timing**	**Estimated Costs (Kshs)**
Actions	▪ Contractor to ensure that construction vehicles do not cause nuisance to the public through obstructions, and that speed limits are observed; ▪ Develop a traffic management plan to ensure that site vehicles do not interfere with the regular traffic along the main roads, or pose safety hazards to site workers or the public; ▪ Set up traffic control/warning signs near construction sites and road crossings informing other motorists of potential hazards; and ▪ Recruit traffic marshals to control traffic especially at road crossings where parts of the road may be closed while trenching.	Contractor	Construction phase	▪ 100,000 for signage & other speed controls
Monitoring Plan				
Performance indicators	▪ Complaints/ number of accidents/incidences ▪ Housekeeping practices impacting on traffic management at sites ▪ Adequacy and effectiveness of traffic signage on sites	Environmental Monitor	Construction phase	NAC
Monitoring requirements	▪ Weekly site inspections			
Reporting	▪ Records of traffic incidents and accidents			
Interface	Compliance with the Traffic Act, and other best practices in traffic management			

Table 10-9 CEMMP – Occupational Health and safety

Management Plan				
Objective	**Ensure a safe and healthy working environment at the site for workers**			
Management strategy	**Provide proper safety equipment, facilities and conditions that will eliminate or reduce the risk to the workers**			
	Activities	**Responsibility**	**Timing**	**Estimated Costs (Kshs)**
Actions	▪ Comply with the OSHA, 2007 and all other relevant regulations governing health and safety at workplaces; ▪ Access to the construction sites shall be controlled to prevent access by unauthorised personnel; ▪ Provide for appropriate signage and warnings in work areas; ▪ Develop and implement Safe Work Method Statements for handling and disposal of AC pipes ▪ Provide appropriate personnel protective equipment (PPE) to site workers; ▪ Provide for First Aid facilities, and ensure that workers are trained on emergency response such as first aid skills; ▪ Provide and clearly display emergency contacts on site; ▪ Provide for adequate sanitary facilities (latrines and wash water); and ▪ Develop and implement detailed and site-specific Health and Safety and Emergency Response Plans; ▪ Develop a comprehensive STDS, HIV/AIDs control programme. ▪ Provision of STDs, HIV and AIDS prevention measures to workers. ▪ Creation of awareness of STDs, HIV/AIDS in workers camps.	Contractor	Construction phase	▪ 300,000 for hoarding of construction sites ▪ 100,000 for signage ▪ 100,000 for PPE ▪ 100,000 for First Aid facilities & Training of First Aiders ▪ 60,000 for establishment of sanitary facilities ▪ 1,000,000 for the STDs, HIV/AIDS program
Monitoring plan				
Performance indicators	▪ Health and safety awareness among workers; ▪ Housekeeping practices with impact on occupational/public health and safety; ▪ Construction methodology, length and duration of open trenches and other excavations; and ▪ Frequency of incidents/accidents and fatalities.	Health and Safety Advisor	Construction phase	NAC
Monitoring requirements	▪ Daily inspection of work areas			
Reporting	Log incidents/accidents and fatalities; and minutes of Tool box meetings; records of H&S training			
Interface	Compliance with OSHA, 2007, Factories and Other Places of work Rules, and best practices in H&S at the workplace			

Table 10-10 CEMMP – Community Health, safety and security

Management Plan				
Objective	**Ensure the protection of community health, safety and security**			
Management strategy	**Establish mechanisms within contractor operations that safeguard community interests**			
	Activities	**Responsibility**	**Timing**	**Estimated Costs (Kshs)**
Actions	▪ Inform local communities of major activities in advance; ▪ Ensure all dangerous construction sites are fenced off; ▪ Endeavour to lay pipes and backfill as soon as possible to reduce the time of hazards exposure to the public from open trenches; ▪ Enforce and monitor road safety standards; ▪ Identify water sources for construction that will not deplete local water supplies and ensure that construction minimizes its use of water; ▪ Implement measures to prevent the entry of sediment from construction areas into local waterways; ▪ Follow best practice to prevent the creation of breeding areas for vermin; ▪ Spray construction areas and roads regularly with water to suppress dust emissions; ▪ Ensure that potentially disturbing construction noise is not produced outside of working hours; ▪ Provide safety training, traffic management and place a high priority on public safety ▪ Ensure that the workers camp(s) and construction areas are open only to formal employees; ▪ Develop and enforce a strict code of conduct for workers to regulate behaviour in the local communities; ▪ Provide awareness training to the workforce regarding the transmission of STDs, and traffic safety awareness;	Contractor	Construction phase	▪ 300,000 for hoarding of construction sites ▪ 300,000 for sediment traps along major waterways ▪ 2,000,000 for sprinkling of public accesses; ▪ 1,000,000 for public awareness on STDs and traffic safety
Monitoring plan				
Performance indicators	▪ Number of public awareness meetings; ▪ Housekeeping practices with impact on public health and safety; ▪ Construction methodology, length and duration of open trenches and other excavations; and ▪ Frequency of incidents/accidents and fatalities.	Health and Safety Advisor	Construction phase	NAC
Monitoring requirements	▪ Daily inspection of work areas			
Reporting	Log incidents/accidents and fatalities; and minutes of Tool box meetings; records of H&S training			
Interface	Compliance with OSHA, 2007, Factories and Other Places of work Rules, and best practices in H&S at the workplace			

Table 10-11 CEMMP - Solid and effluent waste management

Management Plan				
Objective	**Prevention of pollution from wastes generated at the site**			
Management strategy	**Ensure wastes generated are adequately disposed off**			
	Activities	**Responsibility**	**Timing**	**Estimated Costs (Kshs)**
Actions	▪ Isolate woody vegetation cleared and facilitate collection by neighbouring residents; ▪ Ensure excavated soil is used as much as possible in landscaping at sites or disposed appropriately in landfills to prevent nuisance; ▪ Avoid mixing excess concrete if possible. Discard excess concrete in a designated area; ▪ Concrete-coated vehicles/equipment should be washed off-site or in a designated area. The concrete wash area should be at least 50m away from natural storm drainage channels ▪ Runoff from onsite concrete wash areas should be contained in temporary pits where concrete can set; ▪ Ensure hydraulic test water is disposed in a manner not to cause erosion or is reused where the pipeline is to be tested in sections; ▪ Segregate wastes generated into inert fill materials, recyclable/reusable materials and hazardous wastes for appropriate disposal; ▪ Ensure sanitary facilities are provided at construction sites and that they are located at convenient places away from drainage facilities; and ▪ Ensure that existing AC pipes decommissioned are handled and disposed in accordance with the National Guidelines on Safe Management and Disposal of Asbestos	Contractor	Construction phase	▪ 150,000 for establishment and maintenance of concrete washout areas ▪ 100,000 for waste segregation facilities ▪ 100,000 for maintenance of sanitary facilities ▪ 2,000,000 for disposal of AC pipes
Monitoring Plan				
Performance indicators	▪ Waste management plans at the site; and ▪ Site status.	Environmental Monitor	Construction phase	NAC
Monitoring requirements	weekly inspection of sites to establish adequacy of waste management plans in place.			
Reporting	Periodical audit reports			
Interface	Compliance with the Environmental Management and Coordination (Waste Management) Regulations 2006			

Table 10-12 CEMP for displacement and livelihoods disruption

Management Plan				
Objective	**Mitigate as much as possible, adverse impacts of the schemes on livelihoods**			
Management strategy	**Adequate compensation of affected people**			
	Activities	**Responsibility**	**Timing**	**Estimated Costs (Kshs)**
Actions	▪ Cash compensation based on market value of land or provide with option of replacement land within the village if available of equivalent size and quality; ▪ Cash compensation to be provided for lost agricultural productivity during the construction period. ▪ Reinstatement of land to a least the condition it was in prior to construction ▪ Compensation for property damage and loss of amenities within the designated construction corridor; ▪ Adequate notice to be given to farmers before commencement of construction so that the farmers do not unnecessarily lose crops; ▪ Construction activities to be carried out in predetermined working areas. Any damage by construction works outside the boundaries to be appropriately compensated by the contractor; ▪ Requirement to keep within the working area to be enforced and emphasized to the workers during induction and toolbox talks; ▪ Working areas to be determined prior to construction and demarcated as necessary using fencing, marker posts or signs; ▪ Compensation for restrictions to land use be provided to land owners as set out in the Resettlement Action Plan (RAP).	Tanathi WSB	Before, during and at completion of the construction work	Costs of compensation provided in the Resettlement Action Plan
Monitoring Plan				
Performance indicators	▪ Contentment or grievances from the affected individuals / households	Tanathi WSB	Operations	NAC
Monitoring requirements	▪ RAP implementation against plans			
Reporting	▪ Periodic report on RAP implementation			
Interface	Land Act 2012, AfDB procedures on Involuntary Resettlement			

10.3. Operations phase environmental management and monitoring plans

The Operational Environmental Management and Monitoring Plans (OEMMPs) focus on sound environmental management practices that will be undertaken to minimize adverse impacts on the environment through normal operation of the water supply project.

Measures are proposed for the foreseeable impacts and cover the following aspects:

- Air quality management;
- Noise and vibrations management;
- Visual and landscape impacts management;
- Energy resources Management;
- Water resources Management
- Waste Management; and
- Health and Safety Management;

Detailed OEMMP's are presented below.

Table 10-13 OEMP for noise and vibrations

Management Plan				
Objective	**Manage activities to reduce impacts of noise on surrounding properties and comply with the laws of Kenya**			
Management strategy	**Ensure implementation of noise prevention mechanisms**			
	Activities	**Responsibility**	**Timing**	**Estimated Costs (Kshs)**
Actions	▪ Regular maintenance of pumps according to manufacturer's specifications; and ▪ Acoustic shielding if necessary following measurements and/or complaints.	MAWASCO	Operations	Nil
Monitoring Plan				
Performance indicators	▪ Noise levels at Miwongoni Treatment Works from identified point sources	MAWASCO	Operations	200,000 annually for noise measurements
Monitoring requirements	▪ Complaints; and ▪ Periodic measurements.			
Reporting	▪ Measurement records			
Interface	Compliance with the Environmental Management and Co-ordination (Noise and Excessive Vibration Pollution) (Control) Regulations, 2009			

Table 10-14 OEMMP for energy resource management

Management Plan				
Objective	**Minimize impact on energy within the Project area due to the operation of the Water Treatment Plant**			
Management strategy	**Conserve energy resources through lowering the consumption levels**			
	Activities	**Responsibility**	**Timing**	**Estimated Costs (Kshs)**
Actions	▪ Encourage staff at the WTP staff housing to conserve energy through awareness programs; ▪ Install and maintain energy efficient appliances e.g. indoor lights and outdoor security lights; and ▪ Explore use of solar energy for lighting at the WTP	MAWASCO	Operations	▪ 600,000 for energy efficient lighting
Monitoring Plan				
Performance indicators	▪ Electricity bills and changes in energy consumption levels	MAWASCO	Operations	NAC
Monitoring requirements	▪ Periodic energy audits			
Reporting	▪ Audit reports, consumption records			
Interface	Compliance with the Energy Act 2006, and international best practices			

Table 10-15 OEMMP for water resource management

Management Plan				
Objective	**Minimize impact on water resources within the Project area due to the operation of the water supply project**			
Management strategy	**Protect the ecological functions of the river through catchment protection and abstraction management**			
	Activities	**Responsibility**	**Timing**	**Estimated Costs (Kshs)**
Actions	▪ Design and implement agreed seasonal compensation flow regime during operation; ▪ Manage operations to avoid rapid fluctuations in downstream flow; ▪ Undertake regular (preferably continuous) flow monitoring downstream; ▪ Undertake regular water quality monitoring in reservoir, to include dissolved oxygen, nutrients (N & P), pesticides and nuisance plants; ▪ Seek an abstraction license from WRMA and adhere to the conditions of the license; ▪ Cooperate with WRMA in implementing the catchment abstraction management strategy to allow for adjustments/variation in licensing conditions which may be necessary following resource assessments; ▪ Recycling of filter backwash water which is a significant amount (expected to be about 5% of the volumes abstracted). ▪ Establish stock proof wire or live perimeter fencing around the dam and reservoir impoundment areas; ▪ Provide controlled access to water draw-off points; ▪ Provide convenient livestock or animal troughs downstream of the dam supplied by a gravity pipeline from the reservoir; ▪ Establish a tree nursery nearby to be used for afforestation of the catchment area as a sustainable long-term measure by community or local administration; ▪ Provide an appropriate scour pipe or siphon with effective inlet, outlet and outfall /flushing systems; ▪ Construction and maintenance of silt check dams, traps and vegetation (capable of thriving in waterlogged conditions) at and upstream of the tail of the reservoir, along and across the valley; ▪ Planting and maintaining suitable grass cover on the embankment to reduce rainfall erosive effects on embankment slopes; and ▪ Provide and maintain riprap stone pitching down the upstream slope to prevent water wave erosion.	MAWASCO	Operations	▪ Costs of river flow and reservoir water quality monitoring to be established during project operations ▪ 10,000,000 for construction and maintenance of perimeter fence around reservoir
Monitoring Plan				
Performance indicators	▪ River flows against expected levels ▪ Reservoir water quality ▪ Trespass by human and livestock through fenced off area around the reservoir	MAWASCO	Operations	100,000 monthly for water quality analysis and other measurements
Monitoring requirements	▪ Daily, weekly and monthly monitoring schedule of identified parameters.			
Reporting	▪ Water sampling, river flow monitoring reports.			
Interface	Compliance with the Water Act 2016, Environmental Management and Co-ordination (Water Quality) Regulations, 2006, Water Resource Management Rules 2007, and international best practices			

Table 10-16 OEMMP for waste management

Management Plan				
Objective	**Eliminate impact on public health due to poor waste management at the WTP**			
Management strategy	**Removal of agents of environmental pollution and proper disposal of wastes while complying with the laws of Kenya.**			
	Activities	**Responsibility**	**Timing**	**Estimated Costs (Kshs)**
Actions	▪ Ensure recycling of backwash water; ▪ Proper sludge management by composting or overland application or disposal through the existing sewerage system; ▪ Encourage dwellers in staff houses to implement waste minimisation at source principles e.g. zero generation, reduction, re-use and/or recycling; ▪ Provide mechanisms to segregate wastes at source, and provide waste disposal facilities such as compost pit and incinerator; and ▪ Ensure regular maintenance of foul water drainage works at the premises to prevent clogging, and fore-stall breakdowns	MAWASCO	Operations	▪ 500,000 for installation of waste collection and segregation and disposal facilities ▪ 50,000 per annum (p.a.) for maintenance of facilities ▪ 200,000 p.a. for periodic maintenance of drainage works
Monitoring Plan				
Performance indicators	▪ Appropriateness and adequacy of waste management practices at the WTP		Operations	NAC
Monitoring requirements	▪ Periodical inspection	MAWASCO		
Reporting	▪ Environmental Audits and other Statutory and non-statutory reports			
Interface	Compliance with the Environmental Management and Co-ordination (Waste Management) Regulations, 2006			

Table 10-17 OEMP for occupational and public safety and health management

Management Plan				
Objective	**Prevent the occurrence of accidents from conditions and activities at the reservoir and WTP sites, and other installations**			
Management strategy	**Establishment and implementation of health and safety plans**			
	Activities	**Responsibility**	**Timing**	**Estimated Costs (Kshs)**
Actions	▪ Develop and implement operating procedures cognisant of the health and safety hazards at the reservoir and WTP; ▪ Provide training to staff at the facilities and ensure they have appropriate PPE for work at the sites ▪ Secure the reservoir and WTPs with chain-link perimeter fencing and guards to prevent unauthorised entry ▪ Establishment of dam safety measures including: ✓ Structural dam integrity monitoring; ✓ Establishment and implementation of emergency preparedness plans; ✓ maintenance of the perimeter fencing around the reservoir; and ✓ Creation of awareness among the surrounding community on safety and coexistence with the dam.	MAWASCO	Operations	Nil costs for implementation of procedures Cost of securing the facilities are part of construction costs
Monitoring Plan				
Performance indicators	Health and safety measures in place at the reservoir and WTP	MAWASCO	Operations	NAC
Monitoring requirements	▪ Records of incidents and accidents; and ▪ Annual health and safety audits.			

Reporting	▪ Occupational Health and Safety Audit Report			
Interface	Compliance with the Occupational Safety and Health Act, 2007			

10.4. Project decommissioning guidelines

10.4.1. Overview

Once Tanathi WSB has decided to proceed with decommissioning –of the entire or some components of the Water Supply project, a Project Decommissioning Plan shall be prepared and submitted to NEMA for approval. Only after NEMA's approval and after Tanathi has completed any precursor activities, and a decommissioning schedule shall the decommissioning process begin.

The following steps would be followed in the decommissioning process.

10.4.1.1. Scoping

This is a consultative process to discuss the scope of the decommissioning action for all project components, including the schedule, budget, risks and approach for performing the work.

10.4.1.2. Facility walk-down

Site personnel would perform a facility walk down to obtain the information necessary to prepare the hazard assessment and the Reconnaissance Level Characterization Report (RLCR). Safety and physical hazards at the sites would be identified as part of the initial project reconnaissance. The safety and physical hazard assessment would help site personnel determine the possible risks to workers, the public and the environment during decommissioning.

To identify and control hazards, an Integrated Safety Management (ISM) process description and implementation plan would be followed. The ISM integrates the identification, analysis and control of hazards and provides feedback for improvement. The ISM would consist of five core safety management functions which include:

- Definition of the scope of work;
- Identification and analysis of hazards associated with the work;
- Development and implementation of hazard controls;
- Performance of the work within such controls; and
- Provision of feedback on the adequacy of the controls.

10.4.1.3. Reconnaissance level characterization

The Reconnaissance Level Characterization produces an overall assessment of the hazards, and other conditions associated with each structure/facility to be decommissioned. The physical condition of the structures/facilities would be assessed in order to identify hazards, as well as physical obstacles or other conditions that could affect decommissioning activities. The Reconnaissance Level Characterization would include a detailed review of hazards that require special work controls to complete decommissioning safely. In all cases, the team performing the RLC would check the historic information against current observed conditions.

10.4.1.4. Prepare reconnaissance level characterization report (RLCR)

Based on the Reconnaissance Level Characterization, Tanathi WSB would prepare a report for review and approval by NEMA. The report summarizes the results of the Reconnaissance Level Characterization and provides an analysis of the risks presented by the project. The RLCR would also contain sufficient detail including analysis of analytic information to establish the basis for decommissioning activities.

The project points of contact and staff would use the RLCR to provide input to the preparation of the health and safety analysis, the determination of the engineering support requirements, and the determination of appropriate milestones.

10.4.1.5. Perform physical work of disposition operations

These activities include, for example, excavation, dismantling, demolition and removal of components. After demonstration that the structure/facility meets the established criteria, it would be demolished or excavated. The requirements and procedures set out in the ISM plans would be followed by workers performing decommissioning.

10.4.1.6. Perform and validate final characterization

At the end of the decommissioning, site personnel would confirm that their activities have achieved the standard required in the completion of disposition for structures/facilities that are demolished such that only environmental restoration activities remain.

After the structure/facility is demolished, the final characterization would occur. The demolition survey would be conducted in accordance with the Site's characterization protocols, and would provide sufficient data to demonstrate that the Site has successfully completed decommissioning in conformance with the set regulation requirements.

The post-demolition survey may result in a loop of activity for Site decommissioning personnel, because if the survey reveals insufficient decommissioning to meet the requirements of the regulations, additional action would have to be taken. Only at such time as the Site project point of contact is satisfied that the post-demolition survey shows that decommissioning is complete, would the survey be deemed final.

10.4.1.7. Environmental restoration

Environmental Restoration constitutes those activities necessary to characterize, assess and remediate contamination in soils, sediments, surface and ground water from past activities at the site. It may also entail reinstatement and re-vegetation of the site(s) through planting of indigenous trees and shrubs. Re-vegetation would be carried out to the extent determined by the proposed future use of the sites.

11. Conclusions and recommendations

An environmental and social impact assessment (ESIA) has been carried out for the proposed Machakos Water Supply Project, and an ESIA Study Report prepared outlining the potential positive and adverse impacts of the project.

The project is a positive and necessary intervention because, while the urban and peri-urban areas of Machakos Town have experienced rapid population growth, most of the existing water supply infrastructure is old and dilapidated and requires rehabilitation and augmentation to meet the present and future demands of the fast-growing population.

The study has identified both positive and adverse impacts of the water supply project, assessed their significance, and presented mitigation measures for the anticipated adverse environmental impacts.

Beneficial impacts identified in the assessment include: improved access to clean water for the population in the target area, and creation of employment and business opportunities during construction and operation phases of the project.

Adverse impacts identified include displacement and/or disturbance of members of the community with potential loss of livelihoods, the potential increase in noise pollution, air pollution, soil and water resources pollution, and increased health and safety hazards during construction phase of the project. The risk of changes in river flow regime from impoundment, over abstraction and dam safety are some of the significant impacts during operations, with potential to adversely affect aquatic ecology, and downstream users of the river.

Mitigation measures proposed during construction include implementation of a resettlement action plan for the expected displacement/disturbance to communities, institution of noise management mechanisms on machinery at the sites, dust control around construction areas and stockpiles, soil and water pollution prevention through proper management of construction wastewater, storage and use of hazardous chemicals, and implementation of health and safety and traffic management plans.

During project operations, measures proposed include dam safety monitoring, water resource conservation measures such as recycling of filter backwash wastewater, catchment protection, and cooperation with WRMA in the implementation of a catchment abstraction management strategy.

From the foregoing, no adverse environmental impacts are anticipated that cannot be mitigated. An environmental audit is recommended upon the completion of construction works to corroborate the implementation of the proposed mitigation measures. Any unforeseen project impacts shall be identified and addressed through annual environmental audits.

In conclusion, the Consultant proposes that project approval and an Environmental Impact Assessment license be issued by NEMA based on the environmental management measures contained in this ESIA Study Report.

12. References

African Development Bank Group. (2013). *Integrated Safeguards System: Policy Statement and OperatIonal Safeguards. Safeguards and Sustainability Series Volume 1 - Issue 1 (Dec - 2013).*

Anglican Development Services-Eastern. (2017). *ADS-Eastern*. Retrieved from ADS-Eastern website: http://www.adseastern.org

BirdLife International. (2017). *Important Bird Areas factsheet: Machakos valleys*. Retrieved from BirdLife International: http://datazone.birdlife.org

BirdLife International. (2018, January 27). *Important Bird Areas factsheet: Machakos valleys*. Retrieved from Birdlife International Data Zone: http://www.birdlife.org

County Government of Machakos. (2015). *Machakos County Integrated Development Plan.*

Critchley, W. (1991). *Looking After Our Land - Soil, and Water Conservation in Dryland Africa.* Oxfam on behalf of the Arid Lands Information Network and the International Institute for Environment and Development.

Department of Environmental Protection. (2015). *Asbestos Cement Pipe Guidance Document and Conditional Enforcement Discretion .* Commonwealth of Massachusetts - Executive Office of Energy and Environmental Affairs.

GoK. (2016). *Kenya National Adaptation Plan 2015-2030.* Ministry of Environment and Natural Resources.

Howard Humphreys. (2009). *Feasibility Study for Machakos Water Supply and Sanitation project: Environmental and Social Impact Assessment Project Report.*

International Rivers. (2018, January 31). *International Rivers*. Retrieved from Dam Removal : www.internationalrivers.org

International Rivers. (2018, March 13). *Itaipú Dam Reservoir Changing Microclimates in Brazil*. Retrieved from International Rivers Web Site: https://www.internationalrivers.org/resources/itaip%C3%BA-dam-reservoir-changing-microclimates-in-brazil-7652

Moore, T. R. (1979). "Land Use and Erosion in the Machakos Hills" Annals of the Association of American Geographers, Vol. 69, no. 3, . *JSTOR*, 419–431.

NEMA. (2013). *National Guidelines on Safe Management and Disposal of Asbestos.* National Environment Management Authority.

State Government of Victoria. (2016). *Decommissioning dams: A guide for dam owners.* The State of Victoria Department of Environment, Land, Water and Planning.

The World Bank Group. (2018, March 19). *Climate Change Knowledge Portal :Kenya Dashboard - Climate Future*. Retrieved from http://sdwebx.worldbank.org/climateportal