Detailed Design and Preparation of Tender Documents for Six Water Services Providers (Kwale, TAVEVO, Kilifi, Malindi, Lamu and Tana River)

CWSB/WaSSIP/CS/05/2009

DETAILED DESIGN REPORT

TANA RIVER (HOLA)

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ABBREVIATIONS

AC	Asbestos Cement
AFD	Agence Française de Développement
BPT	Break Pressure Tank
CI	Cast Iron
CWSB	Coast Water Services Board
DI	Ductile Iron
DN	Nominal Diameter
EIA	Environmental Impact Assessment
GI	Galvanised Iron
GoK	Government of Kenya
HTH	Calcium Hypochlorite
KIMAWASCO	Kilifi-Mariakani Water and Sewerage Company
KWAWASCO	Kwale Water and Sewerage Company
LAWASCO	Lamu Water and Sewerage Company
MAWASCO	Malindi Water and Sewerage Company
MDG	Millennium Development Goals
MWI	Ministry of Water and Irrigation
NGO	Non-Governmental Organisations
NWCPC	National Water Conservation and Pipeline Corporation
O&M	Operations and Maintenance
RC	Reinforced Concrete
TAVEVO	Taita Taveta Voi Water and Sewerage Company
TOR	Terms of Reference
UfW	Unaccounted for Water
uPVC	unplasticised Polyvinyl Chloride
USD	United States Dollars
WASREB	Water Services Regulatory Board
WRMA	Water Resources Management Authority
WSB	Water Services Board
WSP	Water Services Provider
WSTF	Water Services Trust Fund
WSS	Water Supply and Sanitation
WB	World Bank

UNITS

mm	millimetres
m	metres
masl	metres above sea level
m^3	cubic meters
m^3/day	cubic metres per day
m^3/hr	cubic metres per hour
km	kilometres

1 INTRODUCTION

1.1 Background and Context

The Government of the Republic of Kenya (GoK) has mainstreamed in its National Water Policy to envisage 100% access to safe water for the country's population by 2030. To achieve this target, the GoK has been implementing a far reaching sector reform program since 2002 aimed at harmonising the management of water resources and water supply and sanitation (WSS) throughout the country. This reform has been propelled by the Water Act (2002) which aims at harmonising the management of water resources and water supply and sanitation services.

Coast Water Services Board (CWSB) is a Water Services Board (WSB) created under the Water Act 2002. The Board's main responsibility is the provision of efficient and economical water and sanitation services to the people of the Coast region. This area covers 13 No. districts namely: Mombasa, Kilindini, Kilifi, Kaloleni, Kwale, Kinango, Msambweni, Tana River, Tana Delta, Taita, TAVETA, Malindi and Lamu districts. There are six Water Service Providers (WSPs) under the Board, MOWASCO, MAWASCO, KIMAWASCO, TAVEVO, LAWASCO, KWAWASCO and one being formed to serve Tana River.

The World Bank has been supporting GoK in its water sector reforms through financing of programmes towards improvement of water and sanitation services in the country. In this regard, the GoK and International Development Association (IDA) have agreed on the implementation of Water and Sanitation Service Improvement Project (WaSSIP).

1.2 Objectives of the Project

The proposed Water Supply and Sanitation Programme expects to contribute toward the achievement of the Government of Kenya's goals as defined in the Poverty Reduction Strategy Paper (PRSP) and the Economic Recovery Strategy and thus to the achievement of the Millennium Development Goals (MDG).

Under this component the rehabilitation and augmentation of water services in six WSPs in the towns of Malindi, Kilifi, Mtwapa, Voi, Kwale, Ukunda, Hola and Lamu is envisaged.

1.3 Project Area

The project area is in the Coast Province which is approximately 83,040 km^2 and covers the following towns in the six WSPs. A map indicating the locations of the project towns is included overleaf.

Water Services Provision Areas	Towns
Kilifi-Mariakani	Kilifi Mtwapa
Kwale	Kwale Ukunda
Lamu	Lamu
Malindi	Malindi
Taita Taveta	Voi
Tana River	Hola

Table 1-1: Project Towns

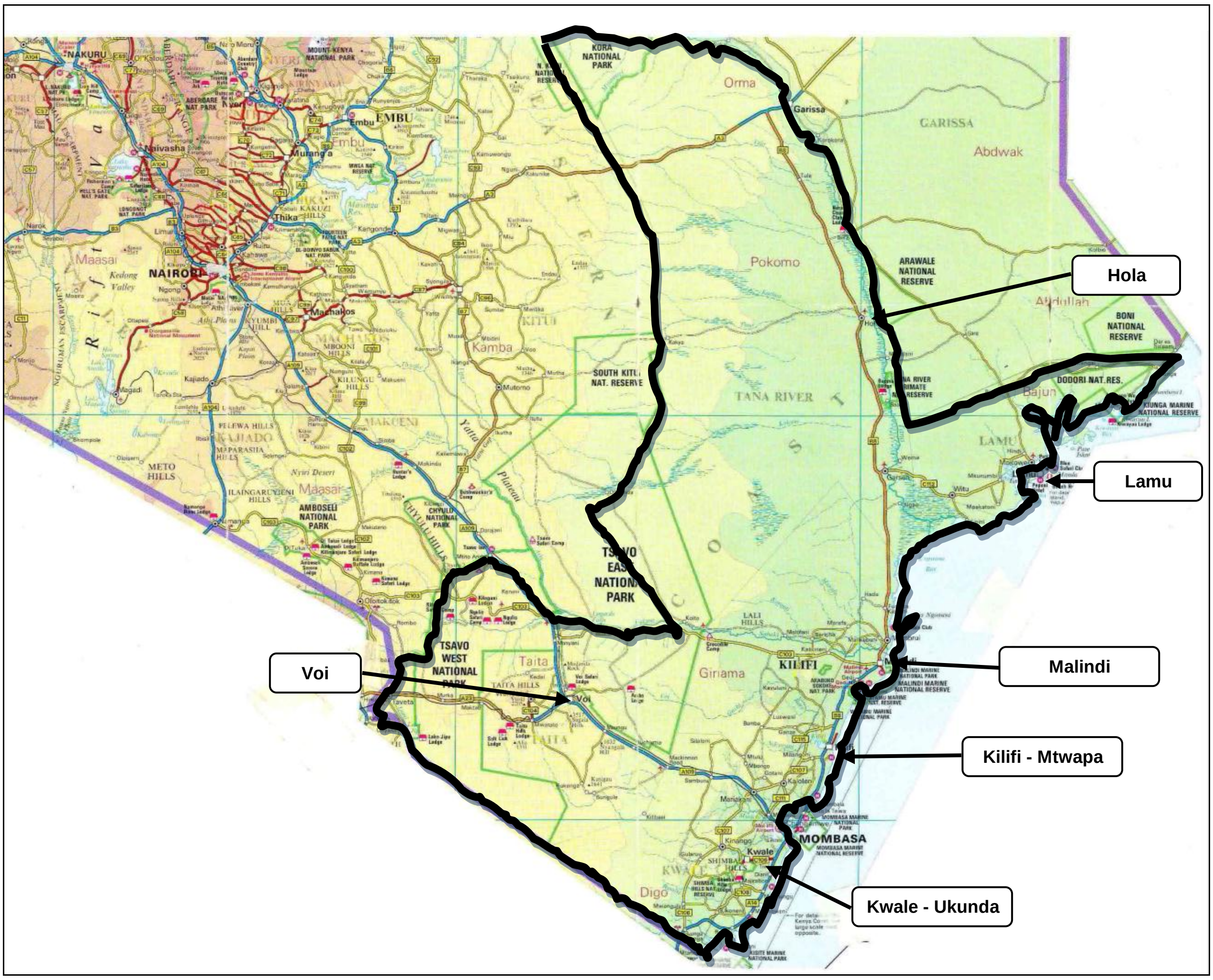

Figure 1-1: Location map

1.4 Scope of this Report

This report covers the detailed design of the rehabilitation and expansion measures for the water supply services in Hola.

1.5 Previous Investigations and Reports

The final design is based on the Feasibility Study done by BRL Ingenierie/GIBB Africa Ltd in 2008 and subsequent field investigations and discussions with CWSB and the respective WSP.

A list of reports and documents which have been referred to is enclosed in Annex 1.

Previous reports which have already been submitted to the Client and which should be read in conjunction with this report are:

- Inception Report (September 2009)
- Interim Report (October 2009)

2 PROJECT AREA DESCRIPTION

2.1 Location

The project location is Hola town, in Tana River district. Hola town is the administrative headquarters for Tana River District. It is located in Zubaki Location. It lies at latitude 1^{o} 30' South of the Equator and at longitude 40^{o} East of the Greenwich meridian. It is on the western bank of River Tana, Kenya's largest and longest river and it is 317 km by road from Mombasa, Kenya's second largest town.

The Tana River District borders Mutomo District to the West, Mwingi District to the Northwest, Garissa and Fafi to the North East, Ijara District to the East, Tharaka and Isiolo District to the North and Tana Delta District to the South. The district lies between latitudes 0° 1' and 2° 1' South and longitudes 38°24' and 40°08' East. The District covers a total area of 38, 782 km^2.

The District has only one local authority, namely the Tana River County Council.

2.2 Climate

Hola town lies in the semi-arid zone of Kenya. The average annual rainfall is slightly over 300 mm. Rainfall occurs during two seasons, long rains between October and December and short rains which occur in March to April. The area generally experiences drought almost every year.

The area is generally hot throughout the year. There is however a large diurnal range in temperatures with the maximum temperature during the day often being more than 10ºC higher than the minimum night temperatures.

2.3 Topography

The District mainly consists of an undulating plain which is interrupted in a few places by low lying hills. Hola town is generally flat with an altitude ranging from 60 to 70 m above mean sea level. The land slopes gently towards the Tana River which meanders as it passes through the area. The Tana River traverses the districts from Tharaka District in the North to the Indian Ocean in the South passing through Tana Delta District and covering a stretch of approximately 500km.

The area has poor drainage due to flat terrain and soils with poor infiltration characteristics. The River Tana traverses the Tana Delta district from Mnazini in the north to the Indian Ocean in the south. As the river traverses the expansive coastal hinterland, it starts to meander in its lower course forming a large basin whose width ranges between 2 to 42 km.

2.4 Geology and Soils

The soil in Hola town has been heavily influenced by the Tana River. The soil is mostly sandy silt with some areas containing clay and gravel.

The predominant geological deposits of the project area are the sands of the Quaternary era, ranging from Pleistocene to Recent. There are also some isolated pockets of fossil ferrous limestone of the Miocene age.

2.5 Vegetation

The vegetation habitat type in the project areas is mainly bush grassland dominated by acacia tree species, prosopis juliflora (mathenge), indigenous grasses, shrubs, and layanas (creepers). Other tree species include Balanites spp. and commiphora spp. The main forest products are poles, timber, gums and resins, grass, honey and herbs hence, great potential for agro forestry. Prosopis juliflora (mathenge) is a highly invasive species that is spreading very fast along the roads, towns, shopping centers, Manyattas and around homesteads. Endangered Plants Include Acacia Robusta, Ficus Sykomora and Acacia Nantalosis.

2.6 Economic Activities

Most of the people in Tana River district live in the rural areas. The main economic activities in the area are mainly centred on crop production for the agriculturalists and livestock keeping and herding for the pastoralists. There are also other cases of agro-pastrolism and the rest a small minority are in employment either locally or outside the area.

Pokomo, Munyoyaya, Malakote and Mijikenda are engaged in farming activities while the Orma, Wardei and Somalis are mainly engaged in livestock keeping. Malakote and Pokomo live in villages of approximately 500 households. Most of the villages are found along the River Tana where farming is favourable. In addition, the Malakote and Pokomo practice small -scale fishing

The pastoralist communities are mainly found in the hinterland. They live in villages called 'Manyattas' with an average village comprising 150 households. They are mainly concentrated in areas where there are watering points (dams, wells, pans and boreholes) and pasture.

3 REVIEW OF EXISTING WATER SUPPLY SYSTEM

The existing water supply facilities are reviewed in this chapter, whilst selected photographs are enclosed in Annex 2.

The Hola town water supply infrastructure is to be managed by the Tana Water and Sewerage Company Ltd. (TAWASCO).

The source works for the Hola water supply are located on the bank of the Tana River as it passes Hola Town. Water is drawn from the river using a submersible pump mounted on a floating pontoon and pumped to the nearby treatment works. The hosepipe connected to the submersible pump at the pontoon has several leakages and has several temporary repair patches. During the time of the visit the water level at Tana River was very low, so that someone had to dig a channel every morning to allow the water to reach the pontoon.

The raw water is pumped to a mixing chamber where alum is added and from there to sedimentation/ coagulation tanks.

The treatment plant consists of 3 streams. The oldest stream has a rectangular horizontal sedimentation tank, followed by 2 No vertical filter and a clear water tank. The two newer streams have a round vertical sedimentation/ coagulation tank each from where the water flows to the vertical filter and to a clear water tank shared by the two newer streams.

The condition of the treatment plant is poor and the water in the clear water tanks is turbid.

From the clear water tanks the water is pumped to elevated water towers for further distribution by gravity. One elevated tank (V=100m^3) is located at the WTP compound while the other elevated tank (V=50m^3) is located at the water offices (next to National Irrigation Board). Both tanks have been installed in 2005 and are still in good condition.

The existing water supply system can be summarised as follows:

Water sources	Tana River
Water treatment	Alum dosing & chlorination 3 No. coagulation and sedimentation tanks 4 No. vertical sand filters 2 No. clear water 50 m^3 tanks
Water pumps	Low lift: 2 no. submersible pumps (50-60 m^3/h @ 20 m) – one duty on the pontoon, one standby but not installed on the pontoon High lift: 2 pumps at pump house (37.5 kW & 18.5 kW), one duty, one standby, both in working condition
Water mains	From pontoon: Two parallel lines of DN 100 GI and DN 110 uPVC To elevated tanks: DN 150 uPVC
Water storage	1 No. 100 m^3 elevated water tank at the Treatment Works site 1 No. 50 m^3 elevated water tank at the water office site
Water distribution	1.3 km of DN 75 uPVC 2. km of DN 100 GI

	0.4 km of DN 100 AC 1.5 km of DN 150 GI 3.5 km of DN 150 uPVC 3 km of DN150 AC 500 connections of which 300 are active and 150 are metered

Table 3-1: Existing water supply overview for Hola

4 POPULATION AND WATER DEMAND

4.1 Population

Based on the official census data from the Central Bureau of Statistics for 1969, 1979, 1989 and 1999 the intercensal demographic data and intercensal growth rates, at National, Provincial, District and Town levels vary as shown in the table below.

	Indicator	1969	1979	1989	1999
1.	National Population	10,942,705	15,327,061	21,443,836	28,686,607
	Intercensal Growth Rate	-	*3.43*	*3.6%*	*2.9%*
2.	Provincial Population	944,082	1,342,000	1,829,000	2,491,100
	Intercensal Growth Rate	-	*3.6%*	*3.1%*	*3.1%*
3.	Tana River District	50,696	92,401	128,426	180,901
	Intercensal Growth Rate	-	*6.19%*	*3.35%*	*3.49%*
4.	Zubaki location	6,706	11,475	15,208	8,001 (1)
	Intercensal Growth Rate	-	*5.52%*	*2.86%*	-
5.	Hola Town		5,352	9,533	10,467
	Intercensal Growth Rate	-	-	*5.94%*	*2.35%*

Note: (1) – *Change of boundaries; Mikinduni and Kiriakungu sub locations taken out of Zubaki location*

Table 4-1: Intercensal growth rates – National, Provincial, District and Town level

In addition to the data above, preliminary data from the 2009 Census has been obtained for the project town and the growth rate was calculated for 1999 to 2009. This was found to be 1.64% for the Hola water supply area. The table overleaf shows the 1999 census data, the percentage of the population served in the different sub-locations according to the WSP and the calculated growth rates for the town areas.

The demographic trend for Hola Town reduced from 5.94% to 1.64% over the last 20 years, with a 3.6% drop from 1989 to 1999 and 0.7% drop from 1999 to 2009. A further drop, however, is not considered likely as the reduction over the last decade was only 0.7% and it is expected that the growth rate will stabilise.

The recent growth rate of 1.64% is lower than the 4.19% used in the Feasibility Study, but only slightly lower than the growth rate of 2.35% in the 1989-1999 period.

As the growth rate of 1.64% over the past decade takes into account the most recent trends in fertility, mortality (incl. HIV/ AIDS) and migration levels and patterns as well as the socio-economic development momentum, it is considered to be a plausible scenario for the future population projections up to the 2030 design year.

Hola

Sub-location	Population 1999	No. of Households 1999	Average No. of Household	Population 2009	% served	population served in 1999	population served in 2009
Currently supplied							
Kibuyu	5,535	1,220	4.5	6,994	100%	5,535	6,994
Hola	2,466	526	4.7	2,029	100%	2,466	2,029
Hola mission	2,452	502	4.9	2,702	100%	2,452	2,702
Sub Total	**10,453**	**2,248**	**4.6**	**11,725**		**10,453**	**11,725**
Future Extensions							
Lenda	1,594	282	5.7	2,178	80%	0	1,742
Mikinduni	1,934	360	5.4	2,750	90%	0	2,475
Kiarikungu	542	127	4.3	696	100%	0	696
Matanya	659	155	4.3	455	100%	0	455
Kalkacha	1,254	273	4.6	1,062	100%	0	1,062
Dayate	547	131	4.2	1,113	100%	0	1,113
Subtotal	**6,530**	**1,328**	**4.9**	**8,254**		**0**	**7,543**
Total	**16,983**	**3,576**	**4.7**	**19,979**		**10,453**	**19,268**

Growth rate	**1.64%**	overall growth rate
Growth rate	**1.15%**	currently supplied areas only

Table 4-2: Percentage of population served in 1999 and 2009 in Hola incl. future extensions

4.2 Domestic Consumer Categories

In accordance with the Ministry of Water and Irrigation (MWI) Water Practice Manual the domestic consumers in each town have been divided into the following four categories:

- High cost (i.e. low density formal housing);
- Medium cost (i.e. medium density formal housing);
- Low cost (i.e. high density formal housing); and
- Informal (receiving water from kiosks/ stand posts).

The following tables show the percentages of the population to be served by the water supply system for the different domestic consumer categories according to the WSP.

Population in	2009	
total	**19,268**	
High cost area	0	% of total
Medium cost area	30	% of total
Low cost area	50	% of total
Kiosk area (Informal)	20	% of total

Table 4-3: Percentage of consumer categories for Hola and extensions

4.3 Domestic Water Demand

In the absence of universal metering in the project towns (except Malindi) the per capita consumption as per the MWI Water Practice Manual have been adopted as shown in the following table.

It is to be noted that the per capita demand figures in the table below exclude the 20% UfW which is included in the MWI data. It is also to be noted that the per capita demand for Malindi agrees quite well with the MWI data (as was described in the design criteria in the Inception Report).

Water demand

Domestic		
High Cost	200	l/c/d
Medium Cost	120	l/c/d
Low Cost	60	l/c/d
Informal	15	l/c/d

Table 4-4: Per capita consumption (l/c/d)

These figures have been used to calculate the expected water demand up to the design horizon of 2030 using the intercensal growth rate figures.

The following tables show the calculated number of inhabitants and expected domestic water demand over the design period (m^3/day).

	Inhabitants No.					Water Demand m3/day				
YEAR	HC	MC	LC	I	Total inh.	HC	MC	LC	I	Total
2009	-	5,781	9,634	3,854	19,268	-	694	578	58	1,330
2010	-	5,875	9,792	3,917	19,584	-	705	588	59	1,352
2011	-	5,971	9,952	3,981	19,905	-	717	597	60	1,374
2012	-	6,069	10,115	4,046	20,231	-	728	607	61	1,396
2013	-	6,169	10,281	4,112	20,562	-	740	617	62	1,419
2014	-	6,270	10,449	4,180	20,899	-	752	627	63	1,442
2015	-	6,372	10,621	4,248	21,241	-	765	637	64	1,466
2016	-	6,477	10,795	4,318	21,589	-	777	648	65	1,490
2017	-	6,583	10,971	4,389	21,943	-	790	658	66	1,514
2018	-	6,691	11,151	4,460	22,302	-	803	669	67	1,539
2019	-	6,800	11,334	4,534	22,668	-	816	680	68	1,564
2020	-	6,912	11,519	4,608	23,039	-	829	691	69	1,589
2021	-	7,025	11,708	4,683	23,416	-	843	702	70	1,615
2022	-	7,140	11,900	4,760	23,800	-	857	714	71	1,642
2023	-	7,257	12,095	4,838	24,190	-	871	726	73	1,670
2024	-	7,376	12,293	4,917	24,586	-	885	738	74	1,697
2025	-	7,497	12,494	4,998	24,989	-	900	750	75	1,725
2026	-	7,619	12,699	5,080	25,398	-	914	762	76	1,752
2027	-	7,744	12,907	5,163	25,814	-	929	774	77	1,780
2028	-	7,871	13,118	5,247	26,237	-	945	787	79	1,811
2029	-	8,000	13,333	5,333	26,666	-	960	800	80	1,840
2030	-	8,131	13,552	5,421	27,103	-	976	813	81	1,870

Table 4-5: Current & projected population and domestic water demand for Hola & extensions

	Inhabitants No.					Water Demand m3/day				
YEAR	HC	MC	LC	I	Total inh.	HC	MC	LC	I	Total
2009	-	3,518	5,863	2,345	11,725	-	422	352	35	809
2010	-	3,558	5,930	2,372	11,860	-	427	356	36	819
2011	-	3,599	5,999	2,399	11,997	-	432	360	36	828
2012	-	3,641	6,068	2,427	12,136	-	437	364	36	837
2013	-	3,683	6,138	2,455	12,276	-	442	368	37	847
2014	-	3,725	6,209	2,484	12,418	-	447	373	37	857
2015	-	3,768	6,281	2,512	12,561	-	452	377	38	867
2016	-	3,812	6,353	2,541	12,706	-	457	381	38	876
2017	-	3,856	6,427	2,571	12,853	-	463	386	39	888
2018	-	3,900	6,501	2,600	13,002	-	468	390	39	897
2019	-	3,946	6,576	2,630	13,152	-	473	395	39	907
2020	-	3,991	6,652	2,661	13,304	-	479	399	40	918
2021	-	4,037	6,729	2,691	13,457	-	484	404	40	928
2022	-	4,084	6,806	2,723	13,613	-	490	408	41	939
2023	-	4,131	6,885	2,754	13,770	-	496	413	41	950
2024	-	4,179	6,965	2,786	13,929	-	501	418	42	961
2025	-	4,227	7,045	2,818	14,090	-	507	423	42	972
2026	-	4,276	7,126	2,851	14,253	-	513	428	43	984
2027	-	4,325	7,209	2,883	14,417	-	519	433	43	995
2028	-	4,375	7,292	2,917	14,584	-	525	438	44	1,007
2029	-	4,426	7,376	2,950	14,752	-	531	443	44	1,018
2030	-	4,477	7,461	2,985	14,923	-	537	448	45	1,030

Table 4-6: Current & projected population and domestic water demand for Hola only

4.4 Institutional/ Commercial Water Demand

Where available, the billing data for the major commercial/ industrial and institutional consumers has been obtained from the WSP and has been used in calculating their average daily consumption.

Where it was not possible to obtain billing data, basic data such as number of boarding students and day students for schools, number of beds for hospitals and high class hotels have been obtained. The tables below and overleaf show the commercial and institutional water consumption figures taken from the MWI Water Practice Manual (less the 20% losses included in the Manual), except where indicated with an asterisk.

Type of Consumer	Unit	Study Design (l/unit/d)
Hotel (low standard)	bed	42
Hotel (medium standard)	bed	250
Hotel (high standard)	bed	500
Restaurants*	seat	25
Bars	unit	417
Petrol Station*	unit	417
Commercial Area*	ha	25,000
Shops	unit	83

Administration/ Office	person	21

Table 4-7: Commercial and industrial consumption

Type of Consumer	Unit	Study Design (l/unit/d)
Clinic	bed	133
Regional Hospital	bed	333
District Hospital	bed	167
Other Hospitals	bed	83
Out patient	patient	17
Day School	pupil	21
Boarding School	boarder	42

Table 4-8: Institutional consumption

4.5 Water Losses (Non Revenue Water)

In the absence of metered data of water produced and received by the consumers, it is difficult to estimate the current water losses and to predict the future leakage. However, based on data from the WSPs, the present physical water losses are estimated at 60 to 40%.

In future it is assumed that these losses will reduce as a result of the improvement through the intended rehabilitation of the water system components (incl. installation of water meters), as well as through the introduction of improved maintenance and operations procedures.

Therefore, future network losses are assumed as 30% of the gross demand.

Losses at surface water treatment works (e.g. backwashing of filters) is dependent on the quality of the water being treated and the type of treatment. Generally, an allowance of 5% for treatment losses should be added.

4.6 Peak Factors

4.6.1 Peak Season Factor

Due to seasonal climate changes over the year the overall water production requirements are expected to be higher in the dry season, due to increased consumption and additional requirements for garden watering etc. Based on metered water consumption data from other towns (with unsuppressed demand), an increase in demand during the dry season, with a peak factor of 1.2 can be justified. The source works, pumping stations, pipelines and treatment plants are sized to meet the peak season flow.

4.6.2 Peak Hour Factor

Water demand patterns also have significant daily variations. To accommodate the peak hourly flow in the distribution mains from the reservoir(s) to the consumers, the following peak hour factors are considered:

Population	Peak Hour Factor
< 5,000	2.5
5,000 – 50,000	2
> 50,000	1.5

Table 4-9: Peak hour factors

4.7 Water Demand

Based on the above population projections and consumption figures the following water demand was calculated. Details are included in Annex 3.

Design Demands		Water Demand		
Description	Factor	(m3/day)		
		YEAR	YEAR	YEAR
		2009	2020	2030
Average daily consumption				
domestic		1,330	1,589	1,870
institutional+commercial	1.6%	88	105	124
Total consumption		1,418	1,694	1,994
Average Network Losses	30%	608	726	855
Gross Network Demand (average)		2,026	2,420	2,849
Gross Network Demand (peak season)	1.2	2,431	2,904	3,419
Average Treatment Losses	5%	107	127	150
Gross Treatment Demand (average)		2,133	2,547	2,999
Gross Treatment Demand (peak season)	1.2	2,560	3,057	3,599

Table 4-10: Gross water demand for Hola with extensions

Design Demands		Water Demand (m3/day)		
Description	Factor	YEAR 2009	YEAR 2020	YEAR 2030
Average daily consumption				
domestic		809	918	1,030
institutional+commercial	1.2%	88	100	112
Total consumption		897	1,018	1,142
Average Network Losses	30%	384	436	489
Gross Network Demand (average)		1,281	1,454	1,631
Gross Network Demand (peak season)	1.2	1,537	1,745	1,958
Average Treatment Losses	5%	67	77	86
Gross Treatment Demand (average)		1,348	1,531	1,717
Gross Treatment Demand (peak season)	1.2	1,618	1,838	2,061

Table 4-11: Gross water demand for Hola without extensions

5 PROPOSED WATER SUPPLY SCHEMES

The proposed works summarised below are based on what has been identified in the Feasibility Study, field visits and according to the priorities of the WSP.

Hola obtains its water from Tana River; from there it is pumped via a submersible pump to the water treatment plant and later distributed in town. According to Tana River WSP an average of 575 m^3/day is treated and pumped to the elevated tanks. Assuming 5 % treatment plant losses, the production from Tana River is then about 600 m^3/day. The 2009 gross water demand for Hola including proposed future extensions has been estimated to be 2,600 m^3/day, whilst the gross water demand for 2030 (peak season) is some 3,600 m^3/day.

The 2009 gross peak season water demand for Hola town excluding future extensions has been estimated to be 1,600 m^3/day, whilst the 2020 gross peak demand has been estimated to be 1,800 m^3/day (similar to the 2030 gross average demand). To meet the demand for Hola only (without future extensions), additional water supply of 1,000 m^3/day for 2009, 1,200 m^3/day for 2020 and 1,100 m^3/day for 2030 gross average and 1,400 m^3/day for 2030 gross peak is required.

In order to provide sufficient water to Hola including the proposed future extensions of Kalchacha (along Hola-Garissa Rd after Makutano), Mikinduni and Emmaus village (south of Hola), Lenda Village (south of Emmaus), Wachakone Village (north of Hola), Karikungu Village and Dayate (along Hola-Garissa road), an additional water supply of 2,000 m^3/day for 2009 and 3,000 m^3/day for the design horizon of 2030 would be required to meet the deficit.

Due to limited funds under this project, it is suggested to design the proposed works to meet the water demand for Hola town only (excluding future extensions).

During the field visit the WSP stated that the existing surface intake (pontoon) is not satisfactory and that they would prefer if water is sourced from boreholes next to the river (as was done in Baricho). A proposed location on a sandy bank some 2 km downstream of the pontoon was suggested. Consequently the Consultant undertook hydrogeological investigations including 11 vertical electrical soundings (VES) around Hola and along Tana River (see Annex 4).

Unfortunately, no suitable groundwater with adequate yield for town supply could be found and furthermore it was established that the water from existing wells showed high conductivity (indicating salinity) and high sodium, chloride and fluoride levels. Therefore, on the basis of our investigations it is not recommended to supply Hola with ground water.

In order to supply Hola with sufficient water from Tana River, it is suggested to replace the pontoon and construct a walkway, fixed at the river shore to ensure safe access to the pontoon.

Since the existing treatment plant is in a poor condition, rehabilitation of the existing structures is required. Furthermore, the capacity of the treatment plant and the pump station need to be extended to meet the average water demand of 1,800 m^3/day for the year 2030.

Due to the poor state of the water treatment plant it is recommended to rehabilitate the existing plant and to construct a new package treatment plant with an additional capacity of 1,200 m^3/day (50 m^3/h).

It was reported that the rising main to the elevated tanks has frequent bursts and therefore it should be replaced under this project. In addition, it is recommended to replace non operational fittings (mainly air valves, valves and wash outs).

Currently, Hola has a storage capacity of 150 m^3, which is not sufficient. Therefore, and if funds allow, it is suggested to construct an additional 500 m^3 elevated tank next to the existing 50 m^3 tank at the water offices (see Annex 3 last page). The tank should be 5m higher than the existing one in order to ensure sufficient water pressures during the 2020 and 2030 peak day demands.

During the field visit it was reported that out of 300 active connections, around 150 connections are not metered. Hence it is recommended to replace a minimum number of 150 domestic meters. In addition, bulk meters for monitoring the supply in various zones are recommended.

5.1 Priorities

The priorities according to the WSP are:

1. Good water source (new pontoon, rehabilitation and extension of WTP)
2. Renew rising mains to elevated tanks
3. Additional storage
4. Water meters (consumer and bulk meters)

Furthermore, an extension of the network towards the areas of Kalkacha, along Hola-Garissa road and Mikinduni and Emmaus south of Hola was proposed. The existing funds will not be sufficient for the extensions, but it may be possible to include some extensions under their ongoing project from German Agro Action (Welthungerhilfe).

5.2 Proposed Works

Due to limited funds, not all the proposed works can be implemented.

The following table shows a summary of the works proposed for Hola:

Description	**Proposed Works**	**Implemented under this project**
Water sources	Rehabilitate river intake works: construct a new pontoon and a jetty fixed on the river shore for safe access to the pontoon	Yes
Water treatment	Augment water treatment plant (additional capacity 1,200 m^3/day)	Yes
Water pumps	Rehabilitate pumps & switchgear	Yes
Water mains	Renew rising main to elevated tanks (1.5 km)	Yes
Water storage	Construct elevated storage tank V = 500 m^3 *(if funds allow)*	Yes *(As provisional item under same contract)*

Description	**Proposed Works**	**Implemented under this project**
Water distribution	Replace distribution lines *(as much as funds allow)*	Yes
Water meters	Bulk meters Consumer meters *(if funds allow)*	Yes Yes *(As provisional item under same contract)*
Sanitation	-	-

Table 5-1: Proposed Works in Hola

An overview of the Hola water supply scheme including proposed measures is given in Figure 5-1.

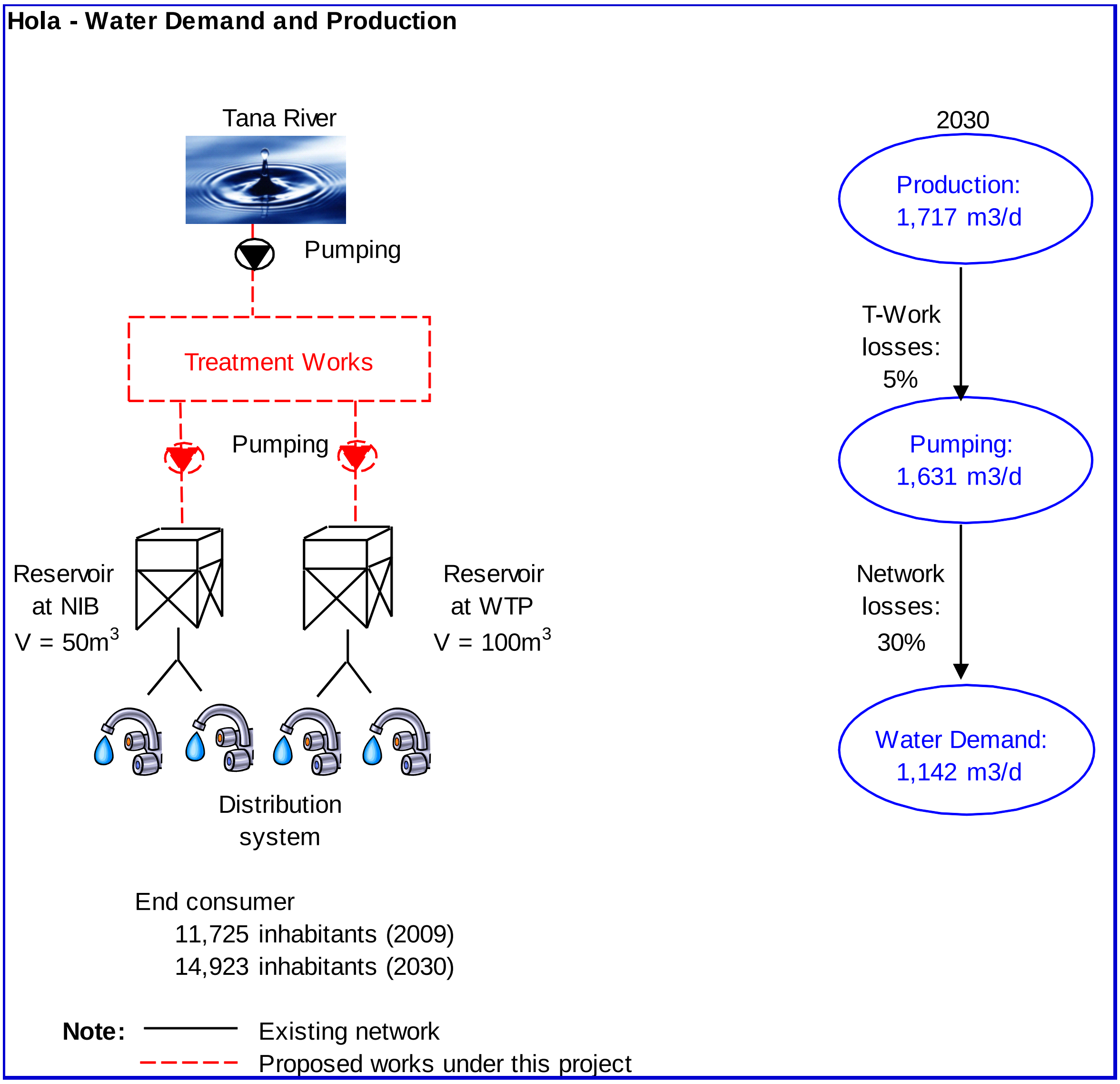

Figure 5-1: Hola water supply

6 INTAKE WORKS

Water will continue to be abstracted from the Tana river. As the existing pontoon is not in a good condition it is recommended to replace this with one shown below.

Figure 6-1: Typical surface intake pontoon

Measuring 3.5 metres in diameter, the platform will be seated on three heavy duty flotation HDPE tanks which are specifically produced for this application and allow a total load bearing capacity, including the structure, of 3 tons. It is designed to take the load of the pumping equipment and operators into account while it incorporates a lightweight construction. The platform will be built in two components to allow easy transportation as well as assembly and disassembly which allows optimum flexibility in terms of where the pontoon is used.

The submersible pump will be mounted in the centre and the rising main will be fastened to a walkway which will connect the pontoon to the river shore. The walkway bridge will ensure safe access to the pump. Steel lines will also tie the pontoon to the shore to brace it against the river flow.

Due to the potential volatility of the river it is recommended that only one pump be installed on the pontoon and that the standby pump be safely stored at the treatment plant until it is required.

7 TREATMENT PLANT

7.1 Existing Treatment Plant

The following table shows the current capacity for the treatment plant units. Detailed calculations are given in Annex 5.

Treatment Unit	No	Max capacity (m^3/d)	Max capacity (m^3/d)
Circular Coagulationand Sedimentation Tank	2	1000	**1400**
Rectangular SedimentationTank	2	400	
Round Rapid Gravity Filters	4	650	**650**
Clear water tank	2	3450	**3450**

Table 7-1: Max treatment unit capacities for Hola WTP

It can be seen that the rapid gravity filters are the limiting factor for the treatment plant with a max capacity of only 650 m^3/day, whilst the combined capacity of the sedimentation/ coagulation tanks is 1,400 m^3/day and the capacity for the 2 No. clear water tanks is 3,450 m^3/day.

Rehabilitation works at the existing treatment plant will include:

- Rehabilitation of office/mixing chamber building including replacement of broken windows
- Construction of aluminium mixing chamber c/w pipework
- Painting of all buildings and structures including repair of surface cracks
- Rehabilitation of pipework at treatment plant where required
- Cleaning of sedimentation tanks, filters and clear water tanks
- Replacement of filter sand
- Construction of chlorine dosing structure c/w pipework, mixing chambers and dosers
- Provide and install tank level recorder.

7.2 Package Treatment Plant

It is proposed to provide the additional required 1,200 m^3/day (50 m^3/h) through a containerised package water treatment plant such as the one shown in the figure overleaf. The plant combines coagulation, flocculation, sedimentation and filtration and the main benefits are its relatively low cost, the small size and fast installation.

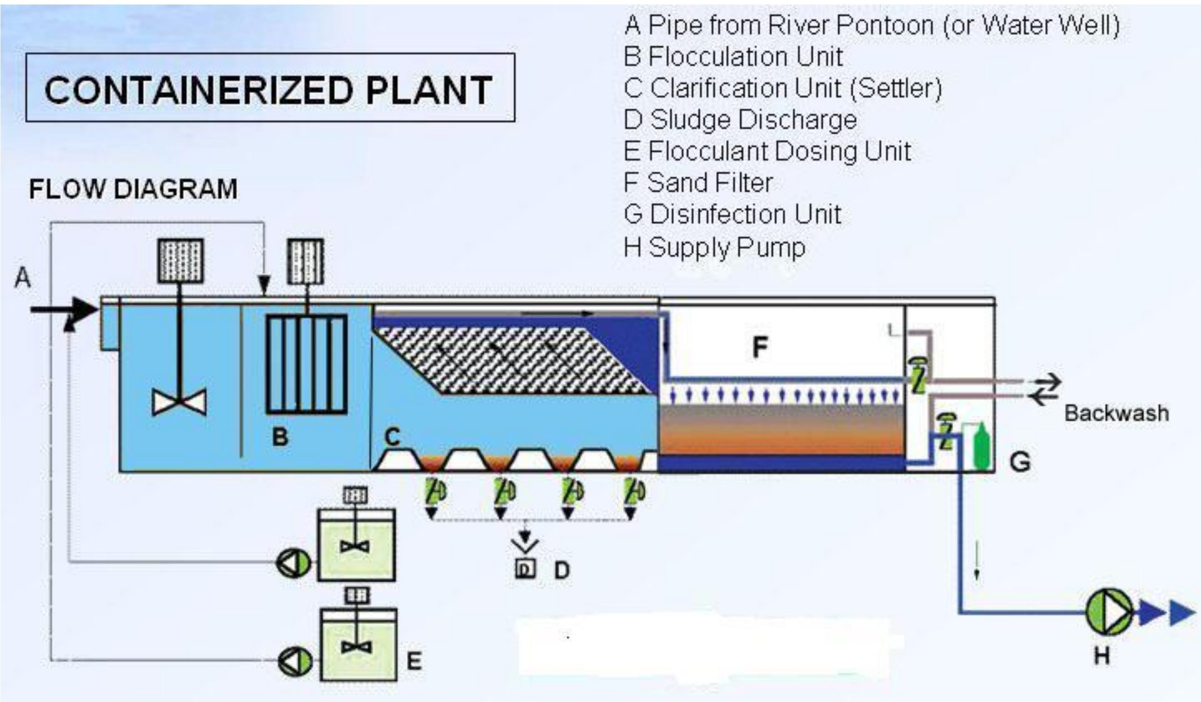

Figure 7-1: Typical package plant

Typical design details for such a compact plant are given in the table below.

Compact Water Treatment Plant	
Type	1-Stream Compact Plant
Components	Flocculation Sedimentation Gravity sandfilter
Rated capacity	50 m³/h
Flocculation	
Length	2.5 m
Width	2.4 m
Height	2.3 m
Volume	13.8 m³
Retention time	0.28 h = 16.5 min
Sedimentation	
Length	3.0 m
Width	2.4 m
Height	2.3 m
Volume	16.6 m³
Retention time	0.33 h = 19.9 min
Lamella plates/tubes	28 m , uPVC

Angle of inclination	60°
Normal Surface area	3*2.4 = 7.2 m²
Surface loading / app. Upward flow velocity	50 m³/h/7.2 m² = 6.9 m/h (normal for sedimentation with lamella plates)
Sandfiltration	
Length	5.0 m
Width	2.4 m
Surface area	10.0 m²
Filter Material (from bottom to top)	Layer 1 (200 mm) size 8.0-16.0mm, vol.=2.2 m^3 Layer 2 (100 mm) size 5.6-8.0mm, vol.=1.1 m^3 Layer 3 (100 mm) size 3.15-5.6mm, vol.=1.1 m^3 Layer 4 (500 mm) size 0.71-1.25mm, vol.=5.5 m^3
Surface Load/ Filtration Rate	50 m³/h/10 m² = 5 m/h (standard)

Table 7-2: Typical design details for a package plant

An alternative option to the package plant would be to construct one new filter of 1,400 m^3/day throughput to match the sedimentation tanks, but then the construction period will need to be lengthened (see Chapter 12). The combined five number filters will then be able to treat some 2,000 m^3/day, but an additional sedimentation tank of 400 m^3/day would be needed to meet the 2020 peak season demand (1,800 m^3/day). This would also meet the 2030 gross average demand. For the 2030 peak season demand of 2,000 m^3/day it is recommended that the filter capacity of the existing plant be increased by 200 m^3/day.

8 ELECTRICAL AND MECHANICAL

Design is carried out in accordance with the following documents:

- The current edition of the Regulations for the Electrical Equipment of Buildings issued by the Institution of Electrical Engineers of Great Britain
- The local Electricity Supply Authority (Kenya Power & Lighting Company Limited)
- British Standard Specification & Codes of Practice by the British Institution
- Regulations of the Government of Kenya

Hola water supply scheme abstracts raw water from a pontoon on a river. The existing pontoon is dilapidated and requires to be replaced. One duty submersible pump is used for abstracting raw water and its starter is in the main pump house.

The high lift pump is situated in the main pump house. Both these pumps are operational. The particulars are:

- Low Lift Pumps – Q = 75 m^3/h; H = 13.3 m
- High Lift Pumps – Q = 84 m^3/h; H = 29 m

The following works are recommended:

- Provision of one distribution board with MCCB, 100 A
- Provision of 2 LL pumps (1 duty, 1 standby) – each Q = 80 m^3/h; H = 19 m
- Provision of 1 HL pump (as standby) – Q = 80 m^3/h; H = 33 m;
- Relocation of the LL pump starter to near the pontoon;
- Supply of one star delta starter
- Replacement of the 6 mm^2 cables with 10 mm^2 cables
- Alum dosing pumps, 1 D, 1 SB, complete with mixing tanks
- PF improvement: kVAR = 6

9 TRANSMISSION PIPELINES

9.1 General

The raw water rising main will convey water from the river to the intake chamber at the treatment plant, whilst the treated water pumping main will transport water from the clear water reservoirs at the treatment plant to the elevated tanks at the plant and at the office.

9.2 Route Alignment

The pipelines will follow the existing pipelines and generally be along existing roads and within the road wayleaves.

9.3 Selected Pipe Material

Protected lined ferrous pipes, or equivalent approved are proposed to be used for construction of transmission mains. Steel pipes are recommended to discourage illegal connections along the alignment and also enhance the life of the pipelines. The pipelines will be epoxy coated and lined and joints will be spigot and socket.

9.4 Hydraulic Design

The raw water rising main is designed to transmit a flow of 2,060 m^3/day (i.e. 86 m^3/h) and according to the optimisation calculations will comprise a DN 200 steel pipe with epoxy coating and lining.

The new treated water rising main from the plant to the elevated tanks is designed for a throughput of 1,960 m^3/day (i.e. 82 m^3/h) and according to the optimisation calculations will comprise a DN 200 steel pipe with epoxy coating and lining.

The Colebrook-White equation is used to calculate frictional losses by taking the value of factor ‘k’ as 0.2mm for the raw water main and 0.1mm for the treated water main. Detailed hydraulic calculations are presented in Annex 5.

9.5 Installation of Pipes

Pipes are jointed and embedded in trenches. The pipe trench will be backfilled mostly by the excavated material. The minimum depth of cover is taken as 1m above the crown of the pipe.

At road crossings pipes will be laid within sleeves or below concrete load spreader beams. Where the pipeline runs along roads or crosses roads, the pipe crown levels have been designed to be at a depth of at least 1.2m below the road level in order to avoid exposure or re-aligning of pipeline when road expansion is done at a later date and protection against traffic loads.

Provision has been made to have thrust blocks at horizontal and vertical bends to contain thrust forces of water at such places. For pipes laid at steep gradients adequate traverse supports have been provided to hold pipe in place as per details on drawings.

10 DISTRIBUTION SYSTEM

10.1 Design

Headlosses are calculated using the Colebrook-White formula. Following the DVGW paper W302 of 1981 (amended in 1985), for the calculation of head losses, a roughness factor of k=1 mm is applied for distribution pipes (this takes into account the junctions and fittings). For pipelines of DN 150 and larger the roughness factor was taken as 0.4 mm.

Alignments of pipelines will follow existing or planned roads as much as possible to minimise compensation costs and facilitate easy access to the lines and fittings. The minimum cover to the pipes shall be 0.9 m, but where the pipe is subjected to vehicular traffic the minimum cover shall be 1.2 m. If shallower depths are encountered due to natural ground profiles, concrete protection for pipes shall be provided. Maximum cover to uPVC pipes shall not exceed 3 m.

Whenever a pipeline changes direction horizontally or vertically or changes size, concrete thrust blocks shall be provided to resist the force in the piping system.

The existing and new pipelines have been modelled using STANET computer modelling software. The minimum residual nodal pressure at peak hour demand should be 10 m head, whilst the maximum pressure in the network should not exceed 60 m, and only in isolated cases 90 m head. All distribution pipework will be to PN 10 (100 m head).

Regarding pipe materials, this depends on the nature of the ground in which the pipes are to be laid, overburden soil pressure, surge pressures, traffic load and cost of pipe. Generally, the most economical pipe materials available for choice are:

- Ferrous (DI or steel) for pipes of diameter larger than DN 300
- PVC for pipes of diameter DN 63 to DN 300
- HDPE for pipes of DN 20 to DN 50 (mainly used for consumer connections)

The table below gives an overview of the proposed (replaced and new) pipe lengths for the various diameters.

	Length (m)		
DN	New	Replaced	Total
63 uPVC	0	1,000	1,000
90 uPVC	0	1,434	1,434
110 uPVC	0	530	530
160 uPVC	0	991	991
200 uPVC	0	30	30
Total	**0**	**3,985**	**3,985**

Table 10-1: Distribution pipelines for Hola

For Hola the network has been initially sized for 3,075 m^3/d (for the 2009 peak day demand). With reference to the modelling printouts in Annex 5, it can be seen that the pressures in the whole system exceed 10 m (1 bar), except for a few outlying areas which are marginally below 1 bar.

During the 2020 peak day demand (3,490 m^3/d) a few more areas will have pressures marginally below 1 bar and a higher elevated reservoir is recommended. However, most areas, especially the town centre, will still have pressures above 1 bar.

During the 2030 peak day demand (3,916 m^3/d) most of the town centre will have pressures below 1 bar and a higher elevated reservoir (5m higher than existing) is recommended.

10.2 Consumer Connections

In order to manage water consumption and prevent wastage, all consumer connections should be metered. Under a separate procurement contract it is recommended to provide DN 15 (1/2") and DN 20 (3/4") meters and the connection fittings. It is further recommended that meters be supplied complete with isolating valve, strainer, non-return valve and in a UV resistant plastic meter box with the necessary fittings for rapid connection and use.

Furthermore, for the consumer connections it is recommended that pipe saddles (which can clamp over the PVC pipes) and limited lengths of DN 20 HDPE pipes (about 20 m per connection) be procured as significant water losses can be experienced here. The connections to the existing consumers can be done under a project or otherwise by the WSP once the meters have been supplied.

11 ENVIRONMENTAL IMPACT ASSESSMENT

An environmental impact assessment was undertaken and a separate report has been submitted and the conclusions are given below.

Improved clean water supply to the area will lead to improved public health and quality of life through reduced risk of waterborne and water-related diseases; and increased public satisfaction with the urban environment. The completion of the project will not only enhance economic growth at the local level but also contribute to the national economy due to the growth of the tourism industry and regional integration.

The integration of environmental concerns in the implementation strategy of the Tana River Water Project will enhance environmental practices amongst all stakeholders. This will ultimately enhance sustainable development in the region.

The EIA Study Project Report concludes that the construction and rehabilitation of the Hola Water Project should be undertaken and makes the following key recommendations:

- The development is undertaken since the project is not out of character with its surroundings
- The EIA has not identified any significant negative impacts related to the project that cannot be mitigated.
- The identified mitigating measures to be incorporated into the detailed design and tender documents. The implementing agency should address and implement all the proposed mitigation measures; as laid out in the proposed EMP.
- During the implementation of the project, positive impacts such as labour sourcing from the local community where possible should be enforced to not only improve economic gains and local skills but also alleviate poverty.
- Capacity building, creating awareness, implementing proposed mitigation measures and monitoring are essential to the effective implementation of the Environmental Management Plan. To achieve this, key target groups, such as project-affected people will need to be trained to ensure effective and timely implementation of the EMP

12 ESTIMATED PROJECT COSTS AND WORK PLAN

12.1 Cost Estimate

Estimated costs are presented in Kenya Shilling (KES) and US Dollars (USD) and are based on:

- General price level in Kenya known from other projects
- Quotations received from suppliers and contractors in Kenya
- Rate of exchange 1 USD = 80 KES
- Costs exclude Kenyan taxes and duties

The estimated project costs are given in the table below. The budget as per the CWSB Procurement Plan is USD 0.61 million.

Bill No.	Description	KES	USD
1	Preliminary & General Works	15,000,000	187,500
2A	Source Works & Treatment Plant	21,000,000	262,500
2B	E&M Works	6,000,000	75,000
2C	Transmission Mains	10,000,000	125,000
2D	Distribution	11,000,000	137,500
	Sub-Total	**63,000,000**	**787,500**
	Add 10% Contingencies	6,300,000	78,750
	Total	**69,300,000**	**866,250**

Table 12-1: Cost Estimate

12.2 Work Plan

The work plan for construction works is divided into three main time frames.

1. Bidding and Award of Contract – 4 Months
2. Mobilisation and Construction Period – 9 Months
3. Defects Liability Period – 12 Months

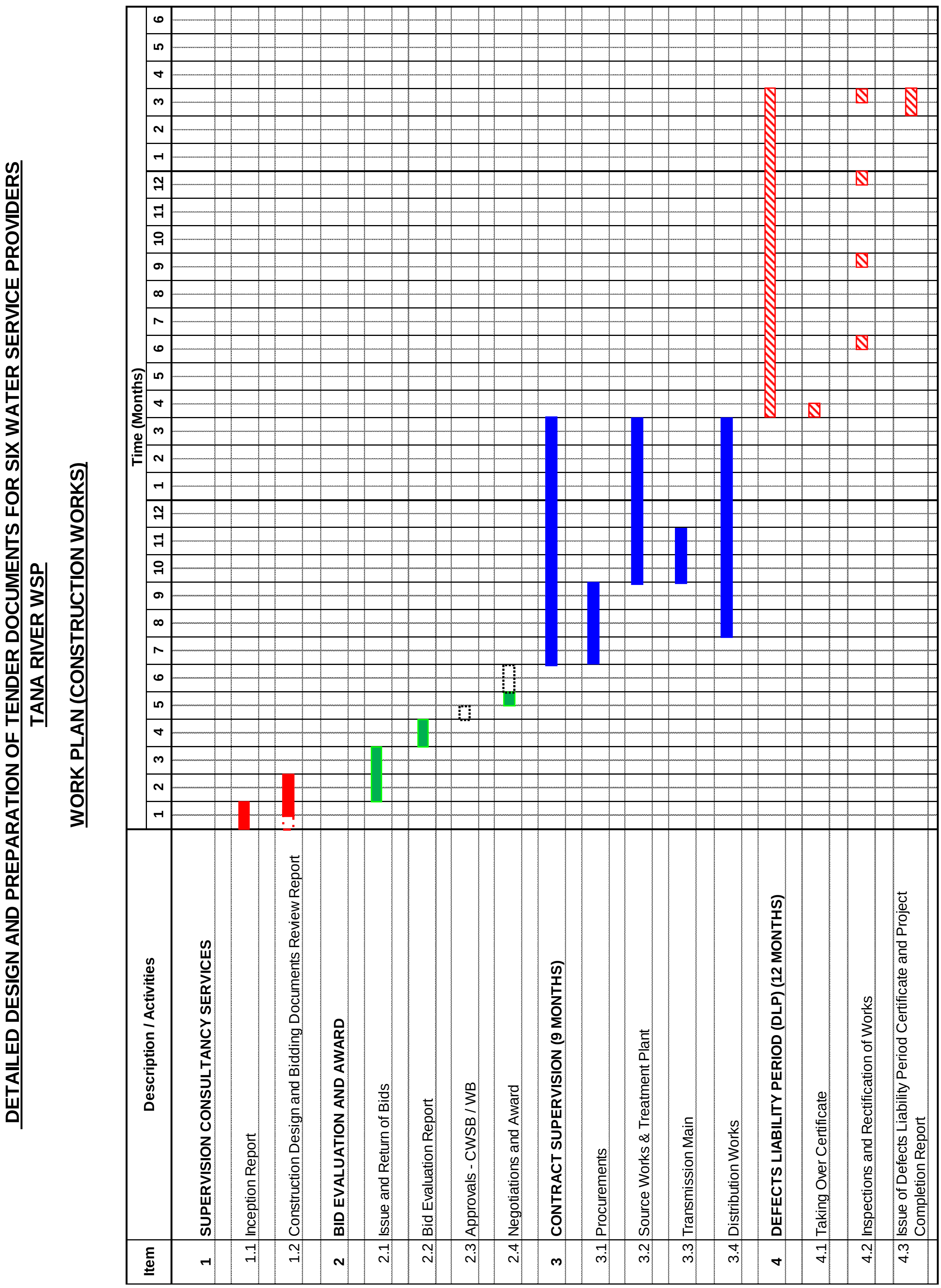

Figure 12-1: Estimated Work Plan