Republic of Uganda

Ministry of Water and Environment

Directorate of Water Development

Rural Water Supply and Sanitation Department

Consultancy Services for Feasibility Study and Detailed Engineering Design and Environmental Impact Assessments of Piped Water Supply and Sanitation Systems in Selected 30no Rural Growth Centres Across the Country

Lot 6: Kitenga RGC in Kaliro District, Bulange RGC in Namutumba District, Lugala RGC in Namayingo District, Bukizibu Bumwena and Nango RGCs in Mayuge District.

Contract No: **MWE/CONS/16-17/00081/6**

Detailed Design Report - Kitenga RGC

September 2020

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LIST OF ACRONYMS

AADD	Annual Average Daily Demand
CAD	Computer Aided Design
DoE	Directorate of Environment
DWD	Directorate of Water Development
DWRM	Directorate of Water Resource Management
EMP	Environmental Management Plan
ESIA	Environmental and Social Impact Assessment
FY	Financial Year
GI	Geotechnical Investigation
GIS	Geographical Information System
GoU	Government of Uganda
ISO	International Standards Organization
IT	Information Technology
LIDAR	Light Detection and Ranging
masl	Meters Above Sea Level
MWE	Ministry of Water and Environment
NDP	National Development Plan
NGOs	Non-Governmental Organisations
NRW	Non-Revenue Water
O&M	Operation and Maintenance
PACE	Performance, Autonomy and Creativity Enhancement Contract
PC	Performance Contract
PEA	Project Execution Agency
PIU	Project Implementation Unit
DIA	Diameter
SCT	Standard Conditions of Tender
ToR	Terms of Reference
UBOS	Uganda Bureau of Statistics
UWSSS	Urban Water Supply and Sanitation Sector
WATSAN	Water and Sanitation
WHO	World Health Organisation
WTP	Water Treatment Plant
EU	European Union
WSDF-E	Water and Sanitation Development Facility East

0 EXECUTIVE SUMMARY

The Ministry of Water and Environment through the Rural Water and Sanitation Department is responsible for carrying out planning and development of water supply facilities to cover communities or villages (LC1) with scattered population settlements up to 1,500 and Rural Growth Centres (RGCs) with populations between 1,500 and 5,000.

The Ministry of Water and Environment through the Rural Water Supply and Sanitation Department; **Support to Rural Water Projec**t, intends to undertake feasibility study and detailed design of piped water supply schemes in selected 30 Rural Growth Centres across the country.

This is the design report for Kitenga RGC Water Supply and Sanitation System. This report is in three volumes namely:

- Volume 1– Basic Report,
- Volume 2– Engineer's Cost Estimate,
- Volume 3– Environmental Impact Assessment (will be submitted after the approval of the basic report and the scope of works.)

0.1 Description of Project Area

Kitenga RGC is located in Bukamba Parish and partly Nangala parish, Bukamba sub-county, Kaliro District. The sub-county is bordered by the sub-counties of Kagulu and Nawaikoke to the West and South, Pallisa District to the East and Lake Kyoga in the East. The RGC is located approximately 35km by road from Kaliro district headquarters along the Kaliro-Nawaikoike-Buvuluguti road. Figure 0.1 below shows the location of Kitenga.

Figure 0.1: Location of Kitenga RGC

0.2 Summary of Feasibility Study Report

This study had been summarised as seen in Chapter 3 of this report which includes the socio economic household survey conducted, the design criteria used in the preliminary design of the system, the population projections, water demand assessment, water resources assessment, Risk assessment of the sources and the proposed institutional management analysis for the water supply project.

0.3 Detailed Design – Water Supply

The maximum day water demand for the entire system as per indicated in the feasibility study report is 1,164m^3/day for the ultimate design horizon of 2040. The water source for the piped water system is surface water from Lake Kyoga by use of an intake made of precast concrete rings. The water supply system infrastructure (intake, raw water pumping mains, storage and distribution network) has been designed for the ultimate year 2040 while the treatment plant has been designed for the intermediate year of 2030 (862.69m^3/day). The water system will be designed as follows;

a) The source of water supply is Lake Kyoga.
b) The intake system to be located in Lake Kyoga 380m off the shoreline of Nabusira village, near Kitenga landing site,
c) The raw water pumps will be sized on the basis of the water demand of 862.69m3/day (53.92m3/h at 16 hours pumping regime).
d) A raw water gravity main of DN150 ST delivers water from the intake to the aerator at the Water Treatment Plant (WTP) whose capacity is 1,223m3/d inclusive of 5% water for treatment plant works.
e) The treated water transmission system consisting of a single pipe from the WTP delivers water to the reservoir located Lwamba Beeda village, Bukamba parish, Bukamba subcounty.
f) Solar energy is the proposed means of powering the raw water and clear water pumps and augmented by 200kVA generator power since the nearest grid mains is 15km away.
g) A reservoir tank of 346m^3 representing 30% of MDD as placed on a 10m tower has been adopted.
h) A distribution network shall be of length 24.252km as shown in the table below.

Table 0-1: Distribution Network

Pipe Details	Length (m)
OD225 uPVC PN10	915
OD160 uPVC PN10	3,165
OD110 uPVC PN10	4,397
OD90 HDPE PN10	4,560
OD75 HDPE PN10	2,190
OD63 HDPE PN10	4,804
OD50 HDPE PN10	4,221
Total	**24,252**
Source: Project Estimates	

i) A total of 362 service connections have been calculated to be made in the initial year 2020. However, 400 connections have been provided for in the BoQ with the excess to cater for any requests for connections that may arise during the implementation stage. A total of 2643 connections shall be made by the ultimate year 2040.

0.4 Detailed Design – Sanitation

It is proposed to construct 2No. 6 stance water borne toilet for whose location will be proposed by the officials during construction.

0.5 Financial Analysis

0.5.1 Capital Cost Estimates

The capital investment cost estimates have been summarised in Table 0-2 below.

Table 0-2 Summary of Capital Cost Estimates

Bill No	Description	Investment Costs UShs
	GENERAL	
KIT G-1	General Items	548,400,000
KIT G-2	Method Related Charges	100,000,000
KIT G-3	Dayworks	6,944,200
	WATER SUPPLY, SANITATION AND EQUIPMENT	
KIT W-1	Intake structure works	399,393,169
KIT W-2	Raw Water Transmission Mains	247,966,652
KIT W-3	Treatment Plant Site Works	783,411,057
KIT W-4	Aerator	64,343,893
KIT W-5	Coagulator and Flocculator	200,416,898
KIT W-6	Sedimentation Tank	298,595,232
KIT W-7	Rapid Gravity Filters	405,097,937
KIT W-8	Clear Water Tank and Pump House	228,125,354
KIT W-9	Sludge Drying Beds	163,477,285
KIT W-10	Chemical House	225,109,400
KIT W-11	Laboratory and Workshop	114,772,940
KIT W-12	Clear Water Transmission Mains	341,553,440
KIT W-13	Storage Reservoir and Site Works	402,771,547
KIT W-14	Distribution Network	766,842,285
KIT W-15	Intensification Network	352,148,000
KIT W-16	Water Office Block	110,069,803
KIT ME-1	Mechanical Works	467,460,000
KIT EE-1	Electrical Works	880,555,000
KIT S-1	6 Stance Waterborne Toilet (2No.)	135,910,280
	Sub-Total 1	**7,243,364,372**
	Allow for 10% contingency	724,336,437.16
	Sub-Total 2	**7,967,700,809**
	Allow for 18% VAT	1,434,186,146
	GRAND TOTAL	**9,401,886,954**

0.5.2 Per Capita Investment Costs

The per capita investments and re-investment costs for each scenario was calculated for the initial year (2020), intermediate year (2030), and the ultimate year (2040). The computations have been based on the served population. The results are given in Table 0-3 below.

Table 0-3 Per Capita Investment & Re-investment Costs

Per Capita Investment Cost	Currency	
	(USh)	(US $)
Resident population - 2019	769,882	203
Resident population - 2020	743,426	196
Resident population - 2025	624,492	164
Resident population - 2030	524,513	138
Resident population - 2035	440,572	116
Resident population - 2040	370,009	97
Re-Investment Cost	**Currency**	
	(USh)	(US $)
Resident population - After 10 years (2030)	27,970	7
Resident population - After 20 years (2040)	19,731	5
Source: Project Estimates		

0.5.3 Summary of Financial Indicators

The results of the analyses are summarised in the Table 0-4 below.

Table 0-4 Summary of Financial Indicators

Item	Discounted Totals				
	Discounted Rate (%/year)				
	0%	**5%**	**8%**	**10%**	**12%**
Net Present Value (in USh million)	417	-3,640	-4,708	-5,136	-5,418
Dynamic Prime Cost - O & M (USh/m^3)	1,331	1,382	1,412	1,430	1,448
Dynamic Prime Cost - Total (USh/m^3)	2,416	3,647	4,585	5,285	6,036
Internal Rate of Return	**0.3%**				
Source: Project Estimates					

0.5.4 Conclusions and Recommendations from the Financial Analysis

The main conclusions are as follows:

1) The Dynamic Prime Cost (DPC) covering the Operation & Maintenance costs at the discounted rate of 5% is USh 1,382 per m3, which is less than the proposed tariff of USh 2,500 per m3. If this tariff is charged, the project will cover its O & M costs. This is mainly due to low cost of Water Production due to the use of solar as the power source.

2) The Internal Rate of Return (IRR) is (+0.3%). This means that at the tariff of USh 2,500 per m3 the system will be able to generate a surplus.

3) As with all DWD implementation projects, investment and re-investment cost recovery is not considered. If the investment and re-investment costs are to be recovered, the tariffs, at the discounted rate of 5%, would have to be at least Ush 3,647.

4) The Net Present Values (NPV) is USh -3,640 million USh at 5% discounted rate. This means that the investment is not profitable at this (5%) discounted rate however becomes profitable when the 0% (Ush, 417 million) is considered.

5) The ultimate year 2040 per capita investment costs are US$ 97. According to the 2013 MWE manual, the average per capita investment cost for 12 towns implemented during the FY

2010/11 by MWE was US$ 40. The usually accepted MWE per capita investment costs range is US$ 60 – 120 and from the analysis made, this system falls in this bracket.

In summary therefore, the investments required Kitenga RGC Water supply system are justifiable as seen from the per capita investment costs and the IRR.

0.6 Institutional Analysis

Since Umbrella has been designated as the organisation in charge of operations and maintenance of all new systems being constructed directly by Ministry of Water and Environment, and due to the fact that umbrella does not have readily available personnel to run the systems after hand over, the following should be encouraged.

- Umbrella should select its proposed staff and forward their names to the contractor for hands on training during the commissioning of the works. This would normally be one month when both the construction supervision engineer and the contractor are present on site.

- Set up a stake holder’s workshop to be attended by the major players as regards the project so as to appraise all parties of their roles in the management and operation of the water supply system.

- Ministry through DWD to conduct regular monitoring surveys to establish the performance of Umbrella, and where necessary render assistance to them.

1 INTRODUCTION

1.1 Background

The Ministry of Water and Environment through the Rural Water and Sanitation Department is responsible for carrying out planning and development of water supply facilities to cover communities or villages (LC1) with scattered population settlements up to 1,500 and Rural Growth Centres (RGCs) with populations between 1,500 and 5,000.

Water supply in rural communities is mainly via point sources, which consist of deep boreholes and shallow wells fitted with hand-pumps, springs, gravity flow schemes with public taps, and rain water harvesting tanks. The systems are community managed with support from the respective Local Governments and the Ministry of Water and Environment.

The biggest challenge facing the sector is how to serve the water stressed areas where the traditional rural water supply sources cannot easily be implemented coupled with depletion of cheaper water resources in some areas. These districts / Sub-counties are lagging behind in coverage and require more expensive technological option which cannot easily be met. It is therefore important that permanent large ground water well fields are identified, developed and water transferred in bulk to the water stressed areas for multi-purpose use. Such sources should have yields able to meet water needs for sizeable areas/centres that have population beyond 18,000 persons and are therefore economically viable to develop piped water supply systems. This approach is a high cost intervention that will enable equity in coverage especially in water scarce areas.

1.2 General

The Ministry of Water and Environment through the Rural Water Supply and Sanitation Department; **Support to Rural Water Projec**t, intends to undertake feasibility study and detailed design of piped water supply schemes in selected 30 Rural Growth Centres across the country.

1.3 Development Objective

The Development objective of the project is "Sustainable safe water supply and sanitation facilities, based on management responsibility and ownership by the users, within easy reach of 77% of the rural population by the year 2019 with and 90%-95% effective use and functionality of facilities.

1.4 Specific Objectives

The specific objectives are:

- To assist the people in the project areas to obtain safe water supply and sanitation services.
- To provide a water supply system that will be sustainably operated and maintained by the community,
- To promote better health through improved hygiene, excreta disposal and environmental management practices

1.5 Objectives of the Consultancy Contract

The services to be provided will include carrying out feasibility studies, detailed engineering design, environmental impact assessments as well as a resettlement action plan for piped water supply systems to ensure the optimal provision of water to the defined project area.

1.6 The Contract

SGI-Studio Galli Ingegneria S.r.l submitted a successful bid for the consultancy services for Lot 6 and the project details are stated as seen below.

Procurement Reference No:	**MWE/CONS/16-17/00081/6**
Subject of Procurement:	**CONSULTANCY SERVICES FOR FEASIBILITY STUDY AND DETAILED ENGINEERING DESIGN AND ENVIRONMENTAL IMPACT ASSESSMENTS OF PIPED WATER SUPPLY AND SANITATION SYSTEMS IN SELECTED 30NO RURAL GROWTH CENTRES ACROSS THE COUNTRY:** **LOT 6: KITENGA RGC IN KALIRO DISTRICT, BULANGE RGC IN NAMUTUMBA DISTRICT, LUGALA RGC IN NAMAYINGO DISTRICT, BUKIZIBU BUMWENA AND NANGO RGCS IN MAYUGE DISTRICT.**

The project is being financed by World Bank and implemented by DWD through Rural Water Supply and Sanitation Department.

1.6.1 Scope of Work

1.6.2 Introduction

The scope of services as outlined in the Statement of Requirements / Terms of Reference consisting of the following main tasks:

- Inception Report
- Feasibility Study and Preliminary Design Report,
- Final Design Report and Tender Documents
- Environmental Impact Assessment Report

1.6.3 Summary of Tasks

The summary of the tasks and sub-tasks to be undertaken under the assignment is given below.

Table 1-1: Summary of Tasks

Component	Design
1	**Mobilisation / Inception Period**
1.1	Mobilisation of the project team
1.2	Project office installation
1.3	Establishment of contact with all parties
1.4	Kick-Off meeting
1.5	Initial site visits

Component	Design
1.6	Preparation and submission of the Inception Report
2	**Feasibility Study and Draft Engineering Design**
2.1	Carry out the feasibility study of water supply system to cover the selected rural growth centres.
2.2	Establish the existing population and settlement patterns particularly at the trading centres and institutions within the sub-counties in potential supply areas.
2.3	Determine the water demand for different areas (settlements patterns) within the sub-counties based on 20 year design horizon.
2.4	Conduct a detailed baseline survey to assess the socio-economic status of the beneficiaries with a view to assess the ability to operate and manage the piped water supply system given the different social-economic activities and cultural diversity.
2.5	Assess the existing sanitation and hygiene situation in the sub-counties and propose improvements. The consultant should note that each of the settlements (trading centres, institutions and rural communities) require different assessment and approach to improve the sanitation situation.
2.6	Carry out a water resources assessment of the of the potential water sources. The consultant should note and analyse all other problems that have of recent affected water supply sources located in the project area. Possibility of exploiting groundwater for localized water supply systems should be studied as an integral part of the water resources assessment.
2.7	Develop feasible options with corresponding institutional arrangement for operation and management of the piped water supply and sanitation system. Note that different management options may be required for different settlement patterns.
2.8	Carry out Environmental Impact Assessment for the proposed water supply project, where adverse conditions are envisaged, propose mitigation measures. The EIA should be conducted independently as per NEMA guidelines. Approved EIA should be submitted to the Ministry of Water and Environment. **COST MUST BE INCLUDED IN THE FINANCIAL BID**.
2.9	Prepare and present the feasibility report and preliminary designs to the district project stakeholders.
2.10	The Output of the feasibility study should include among others the best water supply option to the beneficiaries, the energy mix recommended and the necessary distribution network. It should also include the environmental impact assessment report. The consultant should get an approval of the feasibility report in writing before proceeding to the next stage.
3	**Detailed Engineering Design**
3.1	Carry out detailed topographic surveys for the proposed sites for intakes, storage facilities, transmission mains and agreed distribution networks.
3.2	Design and document the intake works including the treatment system for the piped water supply and sanitation systems with appropriate use of energy. This should include detailed drawings indicating site levels that can be used for construction.
3.3	Prepare detailed engineering hydraulic designs for the transmission mains and distribution networks including profiles and drawings for use during construction.

Component	Design
3.4	Design of hydraulic structures for specific location and site conditions including drawings for use during construction
3.5	Prepare bills of quantities for the intake works, storage facilities, transmission mains and agreed distribution networks. Provide Engineers cost estimate based on the prices of recent bids in Uganda.
3.6	Prepare particular and general technical specifications for all the engineering works including the intake works and structures, storage facilities, transmission and distribution systems.
3.7	Prepare tender documents for construction of the works including information to bidders.
3.8	Formulate a sanitation and hygiene improvement intervention strategy for the beneficiaries of the water supply project. Propose and cost the sanitation facilities to be provided in the project area based on the ministry policy and clearly indicating the possible locations.
3.9	Formulate and develop a sustainable operation, maintenance and management strategy for the proposed water supply system. This should indicate the probable tariffs to sustain the operations and management of the systems.
3.10	Formulate Environmental Impact Assessment for the proposed water supply projects, where adverse conditions are envisaged, propose mitigation measures and environmental management and monitoring plan. The EIA should be conducted as per NEMA guidelines. Approved EIA should be submitted to the Ministry of Water and Environment
3.11	Prepare and present the design reports to the district project stakeholders.

1.7 Expected Outputs

The expected outputs from this assignment include the following:

a) Volume I Design Report,
b) Volume II Engineers Estimates
c) Volume III- Environmental Impact Assessment Report,

Bid documentation associated with this design report in regards to this Water Supply and Sanitation System is as follows:

i) Volume I- Bidding Document- Instructions to Bidders,
ii) Volume II- Bidding Forms and Bills of Quantities,
iii) Volume III- Works Requirements- Technical Specifications,
iv) Volume IV- Works Requirements- Detailed Design Drawings

This is the design report for Kitenga RGC Water Supply and Sanitation System

1.8 Design Report Contents

This is report and is made up of the following chapters:

Chapter 0 **Executive Summary** of all the crucial content in the Report.

Chapter 1 **Introduction:** detailing the project background, objectives, outputs, consultancy contract, and the report contents.

Chapter 2 **Profile of Project Area:** includes the Project Area location, climate, topography, administration and accessibility.

Chapter 3 **Summary of the Feasibility Study Report:** includes the summary of the feasibility report.

Chapter 4 **Detailed Design** of the Water Supply System for the project area which shall include Consumer Projections, Water Demand Assessment

Chapter 5 **Detailed Design** of the Sanitation Component for the project area which shall include the sanitation options considered

Chapter 6 **Financial Analysis** of the Water Supply System for the Project Area.

Chapter 7 **Institutional and Management Analysis** of the Water Supply System for the Project Area.

Chapter 8 **Annexes** of key attachments to the report.

2 PROFILE OF PROJECT AREA

2.1 Introduction

Kitenga RGC is located in Bukamba Parish and partly Nangala parish, Bukamba sub-county, Kaliro District. The sub-county is bordered by the sub-counties of Kagulu and Nawaikoke to the West and South, Pallisa District to the East and Lake Kyoga in the East. The RGC is located approximately 35km by road from Kaliro district headquarters along the Kaliro-Nawaikoike-Buvuluguti road. The coordinates of Kitenga RGC are, 577861.23 m E, 081491.16 m N. The aerial view of Kitenga is given in Picture 2.1 below.

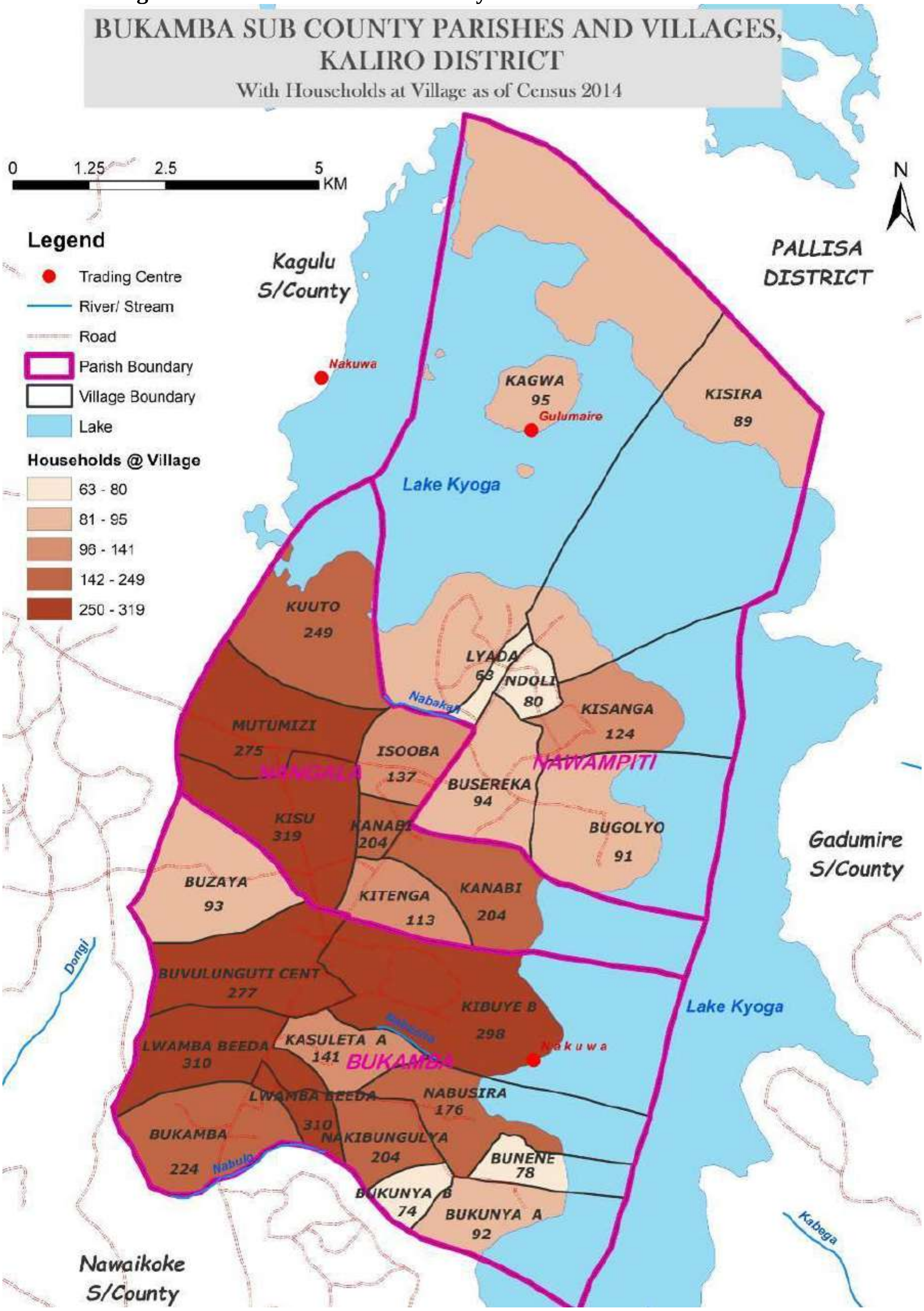
Picture 2.1: Kitenga RGC Project Area

2.2 Administrative Structure

Kitenga RGC is located in Bukamba Parish and partly Nangala parish, two of three parishes in Bukamba sub-county as seen in Figure 2.1 overleaf. The sub-county is currently headed by the Senior Assistant Secretary popularly known as the sub-county chairman. The RGC consists of three trading centres which are Kitenga, Lwamba and Buvulunguti where most of the commercial activities take place and consists mainly of shops, administrative office, a police station, health centre and schools.

The RGC project area will comprise the core villages of Nabusira, Nakibungulya, Lwamba Beeda, Bukamba, Kasuleta A, Buvulunguti Central, Kitenga and part of Kisu.

Figure 2.1: Bukamba Sub-county UBOS Statistical Abstract 2014



According to the National Population and Housing Census 2014, the annual population growth rate for Kaliro district is 3.55 with an average household size of 5.4. The number of Households (HH) and population in the project area is as given in Table 2-1 overleaf.

Table 2-1: Population by Villages in the Project Area

Sub County	Parish/ Ward	Village	UBOS HHs	HH size	Popn 2014	Base Year Popn 2018	Remarks
BUKAMBA	BUKAMBA	BUKAMBA A	105	5.4	567	652	60% of Population
		BUKAMBA B	119	5.4	643	739	60% of Population
		BUVULUNGUTI CENT	90	5.4	486	559	80% of Population
		KASULETA A	69	5.4	373	428	100% of Population
		KASULETA B	72	5.4	389	447	55% of Population
		LWAMBA BEEDA	310	5.4	1,674	1,925	80% of Population
		KIBUYE B	297	5.4	1,604	1,844	90% of Population
		NABUSIRA A	96	5.4	518	596	70% of Population
		NABUSIRA B	80	5.4	432	497	70% of Population
		NAKIBUNGULYA A	98	5.4	529	608	90% of Population
		NAKIBUNGULYA B	106	5.4	572	658	80% of Population
		BUVULUMGUTI WEST	61	5.4	329	379	70% of Population
		BUVULUNGUTI EAST	126	5.4	680	782	70% of Population
	NANGALA	KANABI	204	5.4	1,102	1,267	50% of Population
		KISU A	275	5.4	1,485	1,707	50% of Population
		KITENGA	113	5.4	610	702	100% of Population
TOTAL PROJECT AREA			**1,456**	**5.4**	**7,862**	**9,040**	

Source: UBOS 2014 Kaliro District, Project Estimates

2.3 Accessibility

The area is accessible via the Kaliro-Nawaikoike-Buvuluguti gravel road as seen in the Picture 2.1 below.

Picture 2.2: Access road to Kitenga RGC

2.4 Settlements

The structures in the core project area include permanent and semi-permanent structures. There are also some typically rural spatial settlements in the within the town centres and the immediate fringes (see Picture 2.3 to Picture 2.4) below.

Picture 2.3: Kitenga trading centre structures

Picture 2.4: Other structures in Kitenga Project

Picture 2.5: Lwamba trading centre structures

Picture 2.6: Buvulunguti trading centre

2.5 Power Source

Kitenga RGC is not connected to the national electricity grid and the source of power is solar energy.

Picture 2.7: Solar Panels on house top in the RGC

2.6 Telecommunications

Mobile telecommunications have eased the burden of communication significantly in Uganda since the communications sector was opened to private operator participation. All the major mobile telephone operators (MTN, Airtel and Orange) have services within the project area.

2.7 Commercial Activities

The main commercial activities are fishing, retail trade in general merchandise and agriculture (agricultural produce of crops such as Maize, Sweet Potatoes, Millet, Cassava, Groundnuts, Banana, Beans, Cotton, Rice, Sorghum, Coffee, Sesame, Onions, Peas, Irish Potatoes and Sugar cane. Other activities include; service industry (restaurants/eating places) dry processing mills, petty trade and service provision. The Picture 2.8 to Picture 2.9 below show the commercial activities carried out within the project area.

Picture 2.8: Dry Grain Processing Mills

Picture 2.9: Kitenga daily market

Picture 2.10: Eating Place in Kitenga RGC

Picture 2.11: Shops in the RGC

2.8 Institutions

The main institutions within the project area are listed in Table 2-2 and shown in Picture 2.12and Picture 2.13, shown overleaf;

Table 2-2: Main Institutions within the Project Area

Type of Institution	Institution Name	Ownership
Sub-county	Bukamba Sub-county Headquarters	Gov.
Market	Market	Trading centre
Religious	Catholic Churches	Church
Religious	Protestant Churches	Church
Religious	Mosque	Moslems
School	St. Benedict Kitenga Primary School	Gov.
School	Buvulunguti Primary School	Gov
Security	Police	Gov
Source: Field Visits		

Picture 2.12: Bukamba Sub-county Offices

Picture 2.13: Bukamba Sub-county Offices

2.9 Water Resources in the Project Area

2.9.1 Rainfall

Kaliro district experiences extreme seasonal variations in monthly rainfall, falling throughout the year in the district. The most rain falls around April 22, with an average total accumulation of 194mm. The least rain falls around February 1, with an average total accumulation of 39mm, as shown in Figure 2.2.

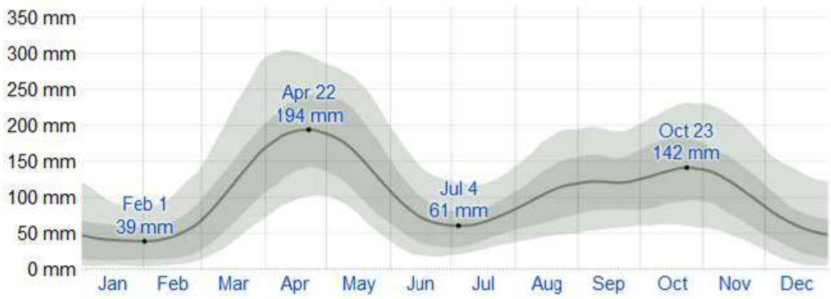


Figure 2.2: Average Monthly Rainfall for Kaliro District

2.9.2 Temperatures

According to weather spark.com, the annual average high temperature in Kaliro is 32^{o}C with the lowest being 17^{o}C as shown in Figure 2.3.

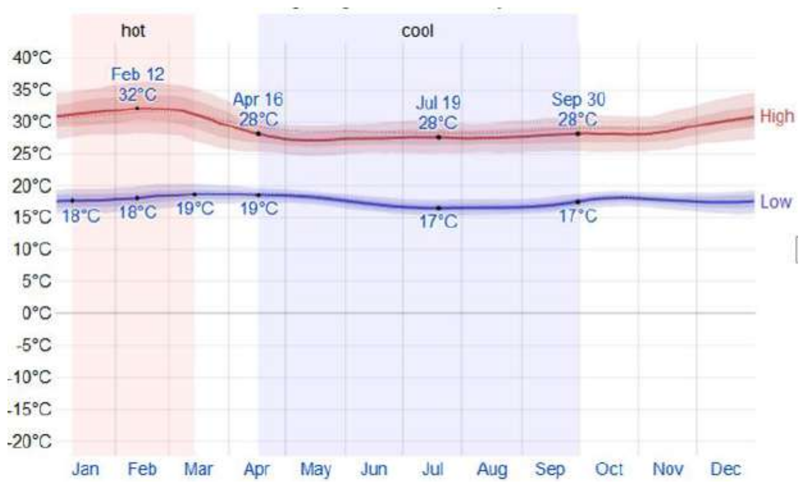


Figure 2.3: Average High and Low Temperatures for Kaliro District

2.9.3 Sun

In 2018, the shortest day in Kaliro district is December 22, with 12 hours, 4 minutes of daylight; the longest day is June 21, with 12 hours, 10 minutes of daylight as seen in Figure 2.4.

Figure 2.4: Hours of Daylight and Twilight

The earliest sunrise is on November 2, and the latest sunrise is on February 10. The earliest sunset is on November 4, and the latest sunset is on February 12 as seen in Figure 2.5.

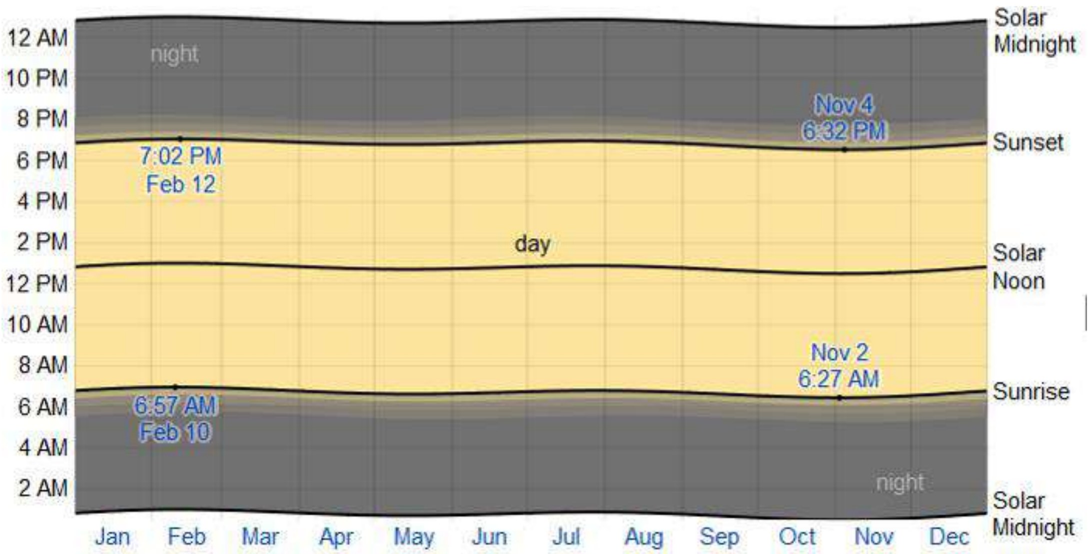


Figure 2.5: Sunrise and Sunset with Twilight

The solar day over the course of the year 2018. From bottom to top, the black lines are the previous solar midnight, sunrise, solar noon, sunset, and the next solar midnight. The day, twilights (civil, nautical, and astronomical), and night are indicated by the colour bands from yellow to grey.

2.9.4 Humidity

Kaliro district experiences extreme seasonal variation in the perceived humidity. The muggier period of the year lasts for 8.6 months, from March to November, during which time the comfort level is muggy, oppressive, or miserable at least 43% of the time. The muggiest month of the year is May, with muggy conditions 90% of the time. The least muggy month of the year is January, with muggy conditions 28% of the time as seen in Figure 2.6.

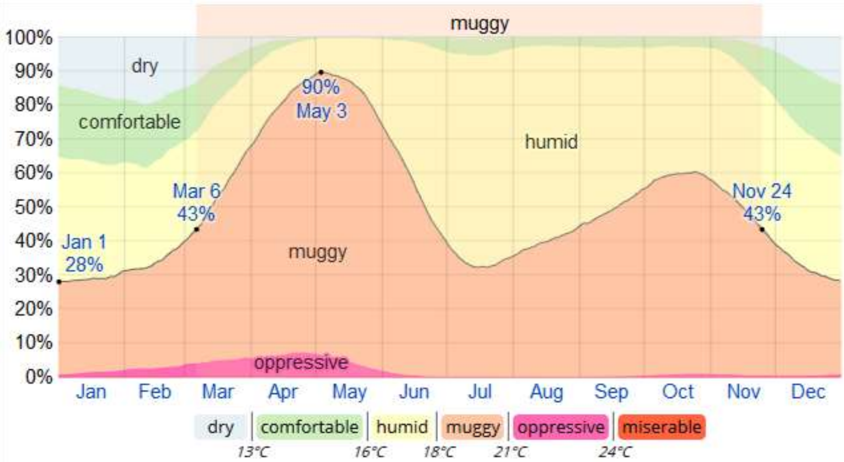


Figure 2.6: Humidity for Kaliro

2.9.5 Solar Energy

The average daily incident shortwave solar energy experiences some seasonal variation over the course of the year. The brighter period of the year lasts for 2.4 months, from January 7 to March 20, with an average daily incident shortwave energy per square meter above 6.5kWh. The brightest day of the year is February 10, with an average of 6.9kWh. The darker period of the year lasts for 2.5 months, from April 22 to July 4, with an average daily incident shortwave energy per square meter below 5.4kWh. The darkest day of the year is May 11, with an average of 5.0 kWh. Figure 2.7 below best illustrates the solar energy trend in Kaliro district.

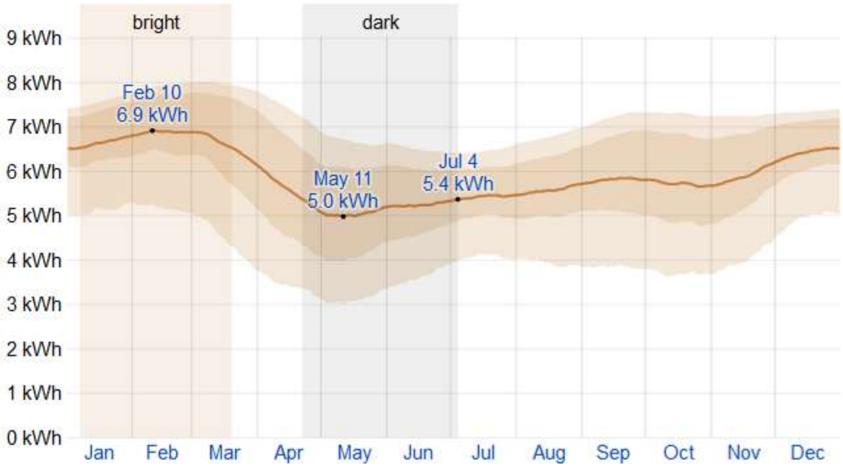


Figure 2.7: Average Incident Shortwave Solar Energy for Kaliro

2.9.6 Topography and Vegetation

The topography of Kaliro contains only modest variations in elevation, with a maximum elevation change of 65 meters and an average elevation above sea level of 1,078 meters. The area within district is covered by cropland (44%) and trees (18%), and the remaining swamps and part of Lake Kyoga.

2.9.7 Geology

The Archaean Gneissic-Granulitic Complex (AGGC) coined by Schlüter (1997) covers most of the project area and comprises high-grade metamorphic facies rocks.

2.9.8 Hydrogeology

The area is generally flat running into swamps nearby which form the water collection points. There are several boreholes being used as collection points within the project area. Ground water has been taped mainly in form of boreholes (28No.). Picture 2.14 below show some of the boreholes used in Kitenga RGC.

Picture 2.14: Borehole located in the Project Area

2.9.9 Surface Water

The major surface water bodies within or close to the project area are swamps and Lake Kyoga as seen in Picture 2.15.

Picture 2.15: Lady returning from fetching water from the Swamp

3 SUMMARY OF FEASIBILITY STUDY REPORT

3.1 Socio-Economic Household Survey

Ten villages from Bukamba, Kitenga and Nangala parishes in the project with a total household's population of 4717 will directly benefit from the planned Water Supply and Sanitation facilities. To ensure that development management is well managed so that it is both sustainable and contribute towards health improvement, rural livelihood, food security and community stability, major policy shifts will have to favour the proper assessment and understanding of community interests.

In order to achieve the objectives of this survey a number of data gathering methods were employed. The first phase focused on administering a structured socio-economic questionnaire and interview guides designed to collect both quantitative as well as qualitative data about households and institutions willingness to pay for improved water services and the current sanitation practices in the study area. Secondly, key-informant interviews (KIIs) were held with selected people in the project area. These were individuals known to be opinion leaders and/or in local authority leadership positions hence representing the views of the community. Focus group discussions (FGDs) were also conducted that involved making consultations with the local leadership, ordinary community members (men, women, children). We also had interviews with opinion leaders, institutions like health centres, religious institutions and schools since these are currently in great need of adequate water supply in order to meet the ever-increasing water demand in schools and health centres respectively.

The study adopted a mixed method approach. The mixed-method combined the detailed insights and understanding obtained from using qualitative approaches with the ability to generalize to a wider population offered by quantitative data collection.

In the household survey, 718 households representing 15.2 percent of the sample, were interviewed. These interviews gave a good insight of the situation at household level and the individual personal opinions

3.1.1 Socio-Demographic Characteristics

3.1.1.1 Age of Respondents

Table 3-1 below provides demographic structure of the households in the sample.

Table 3-1 Demographic structure of project area

Below 5 years	655
6 - 17 years	692
18+ years	876
Over 65 years	30
TOTAL	**2253**
Source: Socio-Economic Report – Kitenga, February 2019	

3.1.1.2 Sample Respondents and Household Headship by Sex

The total number of respondents as indicated by their sex in the study was 718 out of which 74 percent were males and 26% were female. Results also show that, 76.4% of the respondents were household heads.

Table 3.2: Percentage Distribution of Respondents by Sex

	Frequency	Percentage
Male	525	73.9
Female	193	26.1
Total	718	100
Source: Socio-Economic Report – Kitenga, February 2019		

The total number of respondents as indicated by their sex in the study was 718 out of which 74 percent were males and 26% were female. Results also show that, 76.4% of the respondents were household heads.

3.1.1.3 Occupation

It is important for the project to understand the occupation pattern of the target population in order to project systems sustainability and success of project implementation. Table 3.3 below depicts the current situation in Bukamba, Kitenga and Nangala/Kitenga RGCs

Table 3.3: Household Head Primary Occupation

Primary Occupation	Freq
Largescale farmer	49
Subsistence/small scale farmer	370
Informal trader	1
Bodaboda transporter	0
Formal traders/wholesales	18
Salon operator	7
Casual labourer	8
Sales attendant	33
Fisherman	9
Public officer	87
Others	15
Total	**597**
Source: Socio-Economic Report – Kitenga, February 2019	

3.1.1.4 Income

Going back to the employment categories, it was clear that a majority of the households in the sample are engaged in full time subsistence farming (62%) followed by public employment (14.6%). Results also revealed that, out of 718 sample respondents, 325 (49.6%) households reported having at least one person working while 321 (48.9%) households reported they had 2-3 members of their households as income earners

Table 3.4: Monthly Income and Savings and Seasonal Income

Income Levels	Monthly Income		Seasonal Income		Monthly savings	
	Freq	%	Freq	%	Freq	%
< 10,000	59	10.7	76	13.2	117	21.1
10,000-50,000	116	21	118	20.5	158	28.5
50,000-100,000	69	11.9	122	21.2	89	16.0
100,000-150,000	74	13.4	23	4.0	18	3.2
150,000-300,000	42	7.6	37	6.4	65	11.7
300,000-500,000	8	1.7	9	1.6	79	14.2
500,000-700,000	42	7.6	48	8.3	27	4.9

700,000-1,000,000	106	19.2	105	18.2	1	0.2
>1,000,000	39	7	38	6.6	1	0.2
	555	**100**	**576**	**100**	**555**	**100**
Source: Socio-Economic Report – Kitenga, February 2019						

Table 3.5: Average Monthly Expenditure

Average monthly Expenditure	
Number	690
Mean	269183.91
Median	209500.00
Mode	36000
Range	2299000
Minimum	1000
Maximum	2300000
Source: Socio-Economic Report – Kitenga, February 2019	

The mean monthly household expenditure is computed as shs. 269184/=. Even considering the typical under-reporting of incomes/expenditures by respondents in such surveys, it is only clear that on average the population in the area is low income earners. The per capita expenditure for the sample respondents is as low as shs 64041.6/=. This figure is lower than the national per capita income figure of Shs 3671925(US$ 1415) (Uganda's GDP per capita 2016 reported by World Bank and IMF) in the IMF World economic outlook September 2016.

3.2 Existing Water Supply and Sanitation Situation

There is no water supply system within Kitenga and all residents depend on the boreholes, swamps and Lake Kyoga for water supply for their everyday water needs. Kitenga RGC currently has no central piped sewerage facilities. The population in the centre is mainly served by privately owned pit latrines as there is no public toilet within any of the trading centres. The project area has no solid waste dump site and the rubbish is collected and burnt at household level.

3.3 Design Criteria

3.3.1 Summary of the System Design

The system has been designed as follows:

a) A design horizon of 2040 with the initial year being 2020, and ultimate year 2040.
b) To allow for increased demands during the dry season, a maximum day peak factor of 1.3 has been proposed. The Transient Population is allowed for within this maximum day factor.
c) To accommodate the peak hourly flow in the major distribution mains from the reservoir(s) to the project area, a peak hour factor of 2.0 will be considered.
d) To limit water hammer effects, the maximum flow velocities in the pipes will be maintained within the range 0.75 -2.5 m/s. For water pumping mains the flow velocities at the optimum pipe diameter shall apply.
e) The pressures in the distribution system will, as far as possible, be kept below PN6 and above PN 1.0.
f) Non-Revenue Water (NRW) / Un-accounted for Water (UfW) has been taken as 20%.

g) It is proposed to size the storage at 30% of the maximum day's demand.
h) The treatment works are assumed to operate for 24 hours per day. The distribution system is assumed to operate 24 hours per day. The pumping stations will however operate for a maximum of 16 h/d.
i) The water quality to be met is the Uganda Drinking Water Standard (US - 201: 1994).

3.3.2 Summary of Design Criteria

The summary of the water supply design criteria along with comparison details from the DWD Manual (2013) and previous studies criteria is also given in Table 3.6 below.

Table 3.6: Summary of Water Supply Design Criteria

Design Criteria	Abbreviations and Dimensions	DWD Design Manual (2013)	Adopted Design Criteria
Baseline Data- Population			
Design Period	Years	NA	20
Design Horizon	Year	NA	2040
Population at Design Horizon	P [inh.]	NA	55,678
Maximum Day Demand	m^3/day	NA	2008.28
Hydraulic Criteria			
Max Day Factor		1.1 - 1.3	1.3
Peak Hour Factor		2.0	2.0
Maximum flow velocities in the pipes	m/s	-	0.75 - 2.5
Maximum Head losses in the main pipes	m/km	-	10
Operating Pressures			
Minimum in Distribution Network	bar	-	0.5
Maximum in Distribution Network	bar	-	6.0
Water Losses			
In Distribution System (UfW)	% of Total Average Day Demand	20 – 25%	20%
Intake & Treatment Plant Use	% of Maximum Day Demand	10%	10%
Pipe Material Selection			
Large Diameter (>250mm ND)			Ductile Iron or Steel
Medium Size Diameter (100-250mm ND)			uPVC
Small Size Diameter (< 90mm OD)			HDPE
Minimum Pipe Cover			
General Pipe Laying	m	0.6 -3.0	~ 0.9
Pipes laid below roads and reserves	m	0.9	1.2
Storage Capacity			
Sizing of Reservoirs- Balancing Storage	% of Maximum Day Demand	50%	30%
Sizing of Reservoirs- Emergency Storage (Firefighting)	% of Maximum Day Demand	50%	10%
Other Design Criteria			
Water Treatment Plant Operation Time	hour/day	-	16
Pumping Stations Operation Time	hour/day	-	16
Distribution System Operation Time	hour/day	-	24

Design Criteria	Abbreviations and Dimensions	DWD Design Manual (2013)	Adopted Design Criteria
Water Treatment Quality Standards- Drinking Water		Uganda (US - 201: 1994)	Uganda (US - 201: 1994)
Specific Water Demand			
Domestic Consumption			
House Connection			
High Income Housing	l/c/d	200	50
Medium Income Housing	l/c/d	100	
Yard Tap			
Multiple Households	l/c/d	50	40
Single Household	l/c/d	40	
Public Stand Post	l/c/d	20	20
Part Time Users (Urban Poor)	l/c/d		5
Institutional Consumption			
Schools			
Day			
With pit latrine	l/std/d	10	5
With water closet	l/std/d	20	10
Boarding	l/std/d	100	20
Hospitals / Health Centers			
Health Care Dispensaries	l/visitor/d	50	20
Health Centre I- No modern facilities			
In patients	l/bed/d	50	50
Out patients	l/c/d	NA	5
Non-Resident staff	l/c/d	NA	10
Resident staff	l/c/d	NA	10
Health Centre II- with maternity and pit latrine			
In patients	l/bed/d	70	70
Out patients	l/c/d	NA	10
Non-Resident staff	l/c/d	NA	10
Resident staff	l/c/d	NA	20
Health Centre III- with maternity and pit latrine			
In patients	l/bed/d	100	70
Out patients	l/c/d	NA	5
Non-Resident staff	l/c/d	NA	5
Resident staff	l/c/d	NA	20
Health Centre IV- with maternity and water closet			
In patients	l/bed/d	150	100
Out patients	l/c/d	NA	10
Non-Resident staff	l/c/d	NA	10
Resident staff	l/c/d	NA	40
Hospital, District- with surgery unit			
In patients	l/bed/d	200	100
Out patients	l/c/d	NA	10
Non-Resident staff	l/c/d	NA	10
Resident staff	l/c/d	NA	100
Hospital, Regional Referral- with surgery unit			

Design Criteria	Abbreviations and Dimensions	DWD Design Manual (2013)	Adopted Design Criteria
In patients	l/bed/d	400	150
Out patients	l/c/d	NA	10
Non-Resident staff	l/c/d	NA	10
Resident staff	l/c/d	NA	100
Administrative Offices			
With pit latrine	l/worker/d	-	5
With water closet	l/worker/d	70	40
Mosque	l/c/d	NA	20
Church	l/c/d	NA	5
Prisons	l/inmate/d	NA	50
Commercial / Industrial Consumption			
Hotels / Lodges			
High class	l/bed/d	600	600
Medium class	l/bed/d	300	300
Low class	l/bed/d	50	50
Bars / Restaurants			
High class	l/bar/d	1000	1000
Low class	l/bar/d	700	700
Shops			
Small Town	l/shop/d	150	50
Fuel Station/Washing Bays			
Small Town	Station/d	5000	5000
Markets	l/ha/d	20000	2000 l/market/day
Public Sanitation			
Small Town	l/person/d	50	20
Food Industry			
Dairy	Milk received (m^3)	2 - 5	200 l/d
Abattoir	Animals slaughtered (ton)	5 -10	200 l/abattoir/day
Butchery	l/d	NA	50
Grain millers (Dry processing mills)	Grain received (ton)	2 - 5	30 l/d
Other Industries			
Tannery	Raw skins (ton)	50 - 150	50
Cotton mill	Cotton thread (tufi)	50 - 150	50
Medium Scale (water intensive)	m^3/ha/d	40	40
Medium Scale (medium water intensive)	m^3/ha/d	15	15
Small Scale (dry)	m^3/ha/d	5	5

3.4 Design Criteria- Sanitation

3.4.1 Sanitation Needs

This section covers the design criteria and standards for Sanitation Works. Human waste consists of two basic elements – excreta and sullage. Excreta has a high solid content and is highly infected with pathogenic organisms. Sullage is wastewater from kitchens, baths, wash tubs, etc. and has a lower pathogenic content. Both excreta and sullage require satisfactory treatment and disposal.

The type of sanitation facilities will depend on the level of service for water supply as follows:

i) High water consumption (e.g. house connections) – water borne sanitation in the form of septic tank systems or central sewerage.

ii) Low water consumption (e.g. yard tap or stand tap users) – non-water borne on site sanitation facilities.

3.4.2 Water Borne Sanitation

Wastewater is closely related to the water consumption. To calculate potential wastewater flows, factors are applied to the water consumption. The following factors in **Table 3.7** have been adopted.

Table 3.7 Sanitation Technology

No.	Description of Water Consumer Category	Waste Water Production	Possible Wastewater Disposal
1	House Connection (HC)	80%	Water borne
2	Yard Tap (YT)	20%	Usually Non-Water borne
3	Public Stand Post (SP)	0%	Non-Water borne
4	Part Time Users (NS)	0%	Normally Non-Water borne
5	Institutional (Inst)	85%	Water borne
8	Commercial/Industrial (Com/Ind)	90%	Water borne
Source: Previous Studies- Sanitation Strategy and Master Plan for Kampala City			

3.4.3 On-Site Sanitation

The options for appropriate on-site sanitation are given in **Table 3.8** below.

Table 3.8 On-Site Sanitation Options

No.	On-Site Sanitation System	Household Water Service Level	Water required for Operation (l/c/d)	Operation & Maintenance
1	Simple Pit Latrine (Unlined)	Yard Tap / Stand Post	Nil	Cleaning only
2	VIP Latrine (Lined)	Yard Tap / Stand Post	nil	Cleaning only
3	Twin-Pit VIP (Lined)	Yard Tap / Stand Post	nil	Changing and emptying pit every two years
4	Latrine with Vault	Yard Tap / Stand Post	nil	Periodic tank emptying- similar to cesspit
5	Eco-San (Dehydrating Type)	Yard Tap / Stand Post	nil	Removal of faeces and Urine on regular basis
6	Pour-Flush	Yard Tap / Stand Post	5-25	Cleaning only
7	Twin-Pit Pour Flush	Yard Tap / Stand Post	20-30	Changing and emptying every 2 yrs.
8	Cesspit*	House Connection / Yard Tap	5-40	Periodic tank emptying – more frequent than for septic tanks
9	On-Site Septic Tank*	House Connection / Yard Tap	5-40	Periodic tank emptying
Source: Previous Studies				

The main improved on-site sanitation technologies, which have been separated into 2 groups: Non-Water and Water toilets.

3.4.3.1 Non-Water Toilets

Table 3.9 Single Pit Latrine

Advantages	Disadvantages

Advantages	**Disadvantages**
Relatively low capital cost. Relatively simple construction so some or all can be built by the householder. Does not need water for operation. Easily understood– residents are familiar with this solution. Can accept common degradable and non-degradable anal cleansing materials. Small land requirement (<1.5m^2) – possible on most plots	Flies and odours are usually noticeable. Emptying costs may be significant compared to capital costs. Sludge requires secondary treatment and/or appropriate discharge. Can contribute to pollution of surface water and ground water sources. Low pathogen and BOD reduction.
Source: Previous Studies / Compendium EAWAG[1]	

Table 3.10 Ventilated Improved Pit Latrines (VIP)

Advantages	**Disadvantages**
Low capital cost (though higher than for simple pit latrines) Relatively simple construction so some or all can be built by the householder Does not need water for operation Generally, easily understood – many residents familiar with this solution Effective control of flies (if kept dark) and odours Can accept common degradable and non-degradable anal cleansing materials Small land requirement (<1.5m^2) – possible on most plots.	Emptying costs may be significant compared to capital costs. Sludge requires secondary treatment and/or appropriate discharge. Can contribute to pollution of surface water and ground water sources. Low pathogen and BOD reduction.
Source: Previous Studies / Compendium EAWAG	

Table 3.11 Double Ventilated Improved Pit Latrines (Double VIP)

Advantages	**Disadvantages**
Longer life than single VIP (if maintained, indefinite) i.e. reduced reinvestment costs. Low capital cost (though higher than for simple pit latrines) Relatively simple construction so some or all can be built by the householder Does not need water for operation Generally, easily understood – many residents familiar with this solution Effective control of flies (if kept dark) and odours Can accept common degradable and non-degradable anal cleansing materials Small land requirement – possible on most plots.	Emptying costs may be significant compared to capital costs. Sludge requires secondary treatment and/or appropriate discharge. Can contribute to pollution of surface water and ground water sources. Higher capital costs than single pit latrines. Low pathogen and BOD reduction.
Source: Previous Studies / Compendium EAWAG	

Table 3.12 Fossa Alterna

Advantages	**Disadvantages**
Longer life than single VIP (if maintained, indefinite) i.e. reduced reinvestment costs. Low capital cost (cheaper than double VIP but more expensive than simple pit latrines). Emptying can be made manually with simple precautions (low or no operation cost). Potential for use of stored faecal material as soil conditioner.	Emptying costs may be significant compared to capital costs. Sludge requires secondary treatment and/or appropriate discharge. Can contribute to pollution of surface water and ground water sources. Higher capital costs than single pit

[1] Compendium of Sanitation Systems and Technologies, EAWAG 2008

Advantages	**Disadvantages**
Relatively simple construction so some or all can be built by the householder. Does not need water for operation. Generally, easily understood – many residents familiar with this solution. Effective control of flies (if kept dark) and odours (better than VIP because of the addition of soil, ash and/or leaves). Can accept common degradable anal cleansing materials. Small land requirement – possible on most plots. Significant reduction of pathogen.	latrines. Requires constant source of cover material (soil, ash, leaves, etc.). Garbage may ruin reuse opportunities of Compost
Source: Previous Studies / Compendium EAWAG	

Table 3.13 Urine Diverting Dry Toilet (Eco-San toilet)

Advantages	**Disadvantages**
Longer life than single VIP (if maintained, indefinite) i.e. reduced reinvestment costs. Low capital cost (cheaper than double VIP but usually more expensive than simple pit latrines). Good for poor soils, high groundwater or rocky ground. Effective control of flies (if kept dark) and odours (better than VIP). Emptying can be made manually with simple precautions (low or no operation cost). Urine and treated faeces can be recycled for agricultural purposes if desired. Small land requirement – possible on most plots. Significant reduction of pathogen.	**Requires acceptance!** Requires education. Use requires practice and/or skills. Careful slab washing required if faeces to remain dry. Urine may cause odour problems Moslems and others who use water for anal cleansing may find dehydrating eco-sans more complicated to use due to the need to keep water away from the faeces (however, variations of eco-sans have been traditional used in both the Yemen and Zanzibar and suitable designs exist for use by water-washing households). Requires a constant source of ash, sand or lime.
Source: Previous Studies / Compendium EAWAG	

3.4.3.2 Water Toilets

Table 3.14 Full Flush Toilet + Septic Tank + Soak Pit

Advantages	**Disadvantages**
No odour problems if used correctly. Cheaper than sewerage for medium to low population density. Septic tank can be built and repaired with locally available materials. Long service life.	Requires a constant and important source of water (usually piped water supply). High capital and operating cost compared to other on-site sanitation options. Requires sufficient area on plot for drainage field or soak pit and hence will not be suitable for high density settlements. Relatively complex construction so usually requires skilled builder. Seat cannot uneasily be built or repaired locally. Regular de-sludging required and seepage needs to be handled and treated safely. Sludge requires treatment. Requires construction of a pit – which may be difficult in areas of hard ground or high groundwater. Can contribute to pollution of surface water and ground water sources.
Source: Previous Studies / Compendium EAWAG	

Table 3.15 Pour Flush + Double Pit

Advantages	Disadvantages
Because of the alternating pit design, their life is virtually unlimited. i.e. reduced reinvestment costs. Low cost (though higher than for simple pit latrines). Excavation of humus is easier than faecal sludge (low or no operation cost). Potential use of stored material as soil conditioner. Moderate reduction in pathogens. Relatively simple construction so some or all can be built by the householder. No flies or odour problems. Lower water use.	Even if limited, a constant source of water must be available. Clogging is frequent when bulky cleansing materials are used. Requires construction of a pit – which may be difficult in areas of hard ground or high groundwater. Can contribute to pollution of surface water and ground water sources.
Source: Previous Studies / Compendium EAWAG	

3.5 Consumer Projections

The population for the Project Area was adopted from Uganda Bureau of Statistics based on The Uganda Population and Housing Census 2014. The adopted growth rate from UBOS based on Census, 2014 for Kaliro District is 3.55% p.a. and adopted for the domestic, institutional and commercial activity in the project area. The future domestic population in the project area has been projected as in Table 3-16 below.

Table 3-16: Population Projections

S/County	Parish	Village	Total Population					
			2019	2020	2025	2030	2035	2040
Bukamba	Bukamba	Bukamba A	675	699	832	991	1,180	1,405
		Bukamba B	765	792	943	1,123	1,337	1,592
		Buvulunguti Central	579	600	714	850	1,012	1,205
		Kasuleta A	444	460	548	652	776	924
		Kasuleta B	463	479	570	679	808	962
		Lwamba Beeda	1,993	2,064	2,457	2,925	3,482	4,146
		Kibuye	1,909	1,977	2,354	2,803	3,337	3,973
		Nabusira A	617	639	761	906	1,079	1,285
		Nabusira B	514	532	633	754	898	1,069
		Nakibungulya A	630	652	776	924	1,100	1,310
		Nakibungulya B	681	705	839	999	1,189	1,416
		Buvulunguti East	392	406	483	575	685	816
		Buvulunguti West	810	839	999	1,189	1,416	1,686
	Parish Total		**10,472**	**10,844**	**12,909**	**15,370**	**18,299**	**21,789**
	Nangala	Kanabi	1,312	1,359	1,618	1,926	2,293	2,730
		Kisu A	1,768	1,831	2,180	2,595	3,089	3,678
		Kitenga	726	752	895	1,066	1,269	1,511
	Parish Total		**3,806**	**3,942**	**4,693**	**5,587**	**6,651**	**7,919**
Kitenga RGC Water Supply Project Total			**14,278**	**14,786**	**17,602**	**20,957**	**24,950**	**29,708**
Source: UBOS and Project Estimates								

3.5.1 Commercial, Industrial and Institutional Population

The commercial, Industrial and institutional establishments in the towns are given in Table 3.17 below.

Table 3.17 Commercial, Industrial and Institutional Establishments

Demand Category	Unit	Population						
		2018	2019	2020	2025	2030	2035	2040
Institutions								
Education								
Day Scholars	No.	4,579	4,742	4,910	5,845	6,959	8,286	9,864
Boarding Scholars	No.	0	0	0	0	0	0	0
Commercial / Industrial								
Restaurants/Eating Places	No.	6	6	6	8	9	11	13
Shops	No.	80	83	86	102	122	145	172
Dry Processing Mills	No.	2	2	2	3	3	4	4
Markets	No.	1	1	1	1	2	2	2
Offices	No.	10	10	11	13	15	18	22
Police Posts	No.	1	1	1	1	2	2	2
Churches	No.	2	2	2	3	3	4	4
Mosques	No.	1	1	1	1	2	2	2
Source: Field Surveys and Project Estimates								

3.6 Water Demand Assessment

The unit consumption rates are related to the level of service being offered. Three services levels have been used and these include:

- House Connection (HC) - individual house connection with internal plumbing, kitchen, toilet and bathroom with shower;
- Yard Tap (YT) connection - no internal plumbing, no water borne sanitation;
- Stand Post Supply (SP) - usually offsite supply, either from a stand post or purchasing from a neighbour;

In determining the rates of consumption for the domestic water demand, a review was carried out of the rates in current use in the country. The adopted unit consumption rates are as follows.

i) House Connection (HC) - 50 l/c/d;
ii) Yard Tap (YT) connection - 40 l/c/d;
iii) Stand Post Supply (SP) - 20 l/c/d;

For the commercial, institutional and industrial demand these, rates have been adopted from the DWD design manual, 2nd Edition 2013.

The unit consumption rates, the levels of service and the consumer population figures have been used to calculate the water demand at the various tariff levels. The water demand computation has been made based on the ability to pay (5% of Income), with the consumption based on the adopted unit rates, and for the different tariffs of Ush 36, 50 and 83 per 20 litres.

A tariff of Ush 50/20 litres has been adopted. This is the proposed tariff to be charged by the operator of the system. The demands at tariffs of USh 36 and 83 have been calculated for comparative purposes only.

The computation based on ATP (5% income) at the water tariff of USh 50 per 20 litres results in the second highest demand when compared with the other tariffs. The demand at the Tariff of USh 36/20 litres gives the highest demand with that at the Tariff of USh 83/20 litres being the lowest. The details of the demand calculations projected over the design period are summarized in Table 3.18 below.

Table 3.18: Water Demand by Tariff- ATP (5% Income)

Design Year	**2019**	**2020**	**2025**	**2030**	**2035**	**2040**
Tariff - Ush 36 per 20 L (NWSC 2018 Urban PSP Tariff)						
Served Population.	10,349	10,718	12,759	15,191	18,085	21,534
Domestic Demand	333	345	411	489	582	693
Government / Institutional Demand	23	24	28	34	40	48
Commercial / Industrial Demand	10	10	12	15	18	21
UFW	92	95	113	134	160	190
Average Day Demand	**458**	**474**	**564**	**672**	**800**	**952**
Maximum Day Demand	**595**	**616**	**734**	**873**	**1,040**	**1,238**
Tariff - Ush 50 per 20 L (Umbrella Tariff)						
Served Population.	10,349	10,718	12,759	15,191	18,085	21,534
Domestic Demand	312	323	384	457	544	648
Government / Institutional Demand	23	24	28	34	40	48
Commercial / Industrial Demand	10	10	12	15	18	21
UFW	86	89	106	126	150	179
Average Day Demand	**431**	**446**	**531**	**632**	**752**	**896**
Maximum Day Demand	**560**	**580**	**690**	**822**	**978**	**1,165**
Tariff - Ush 83 per 20 L (NWSC 2018 Domestic Tariff)						
Served Population.	10,349	10,718	12,759	15,191	18,085	21,534
Domestic Demand	280	290	346	412	490	584
Government / Institutional Demand	23	24	28	34	40	48
Commercial / Industrial Demand	10	10	12	15	18	21
UFW	78	81	97	115	137	163
Average Day Demand	**392**	**406**	**483**	**575**	**685**	**815**
Maximum Day Demand	**509**	**527**	**628**	**748**	**890**	**1,060**
Source: Project Estimates						

The ranges of the maximum day total demands are given in Table 3-19 below. This is inclusive of 20% un-accounted for water. A maximum day factor of 1.3 has been applied to the average day demands.

Table 3-19: Summary of Maximum Day Demands

Basis of Computation	**Demand at Given Tariff (m^3/day)**		
	NWSC 2018 (PSP-Urban Poor)	**Umbrella Tariff (Proposed Tariff)**	**NWSC 2018 (Domestic)**
	USh 36 / 20L	USh 50/ 20L	USh 83 / 20L
ATP (5% Income)	1,238	1,165	1,060
Source: Project Estimates			

The demand at the proposed tariff of USh 50/20 litres has been adopted. The system will therefore be sized on the basis of the design demand of 1,164.68m^3/day.

3.7 Water Resources Assessment

3.7.1 Groundwater Assessment

The ultimate year (2040) maximum day demand is 1,164.68m^3/day. An analysis was carried of the borehole yield required for 16-hour pumping regime in Table 3-20 below.

Table 3-20: Available Borehole Capacity

Kitenga	Maximum Day Demand at Given Tariff (m^3/day)		
	USh 36/ 20L	USh 50/ 20L	USh 83/ 20L
Demand- m^3/hr	77.39	72.79	66.23
1 No Borehole	77.4	72.8	66.2
2 No Boreholes	38.7	36.4	33.1
3 No Boreholes	25.8	24.3	22.1
4 No Boreholes	19.3	18.2	16.6
Source: Project Estimates			

For the proposed tariff of USh 50 / 20L, two (2) boreholes each of minimum capacity 36.4m^3/hr yield are required over a 16hr pumping regime.

Analysis of the water quality test results shows that the water is saline and a desalination treatment process would be required. The treatment plant would require high capital investment and hence ground water will not be considered as a possible water source for the piped water supply system.

3.7.2 Surface Water Assessment

The reliable surface water source near Kitenga RGC is Lake Kyoga. Lake kyoga can meet the water demands of Kitenga RGC.

3.7.3 Conclusion

The surface water source of Lake Kyoga can provide the quantity of water needed for the piped water supply for Kitenga RGC.

Groundwater sources in the form of production wells are a viable sources of water for the piped water supply system however the saline nature of this water provides as seen in the water quality analysis of samples carried out on samples by NWSC laboratories in Bugolobi as shown in Annex 8.3, indicate a treatment challenge as the treatment process is costly which may lead to increase in the cost of production of water resulting to the increase of the tariffs hence this option has been ruled out.

3.8 Risk Assessment and Source Protection

The vulnerability of all potential water resources regarding different hazards and conflicts is assessed. If possible, mitigation or protection measures have been addressed accordingly.

3.9 Preliminary Design – Water Supply

In the design, the system will be sized basing on the maximum day water demand of 1164.68m^3/day in the year 2040.

3.9.1 Packaged Water Treatment Plant Development Scenario I

At least two treatment plants of 70m^3/hr yield are required to supply the piped water supply system. This development scenario will consist of the following aspects

1) Construction of an intake on Lake Kyoga in Nabusira village, near Kitenga landing site.
2) Construction of 2No Packaged Water Treatment Plants near the intake site
3) Pumping of treated water from the treatment plant to a storage reservoir located on the hill in the Project area.
4) Construction of a new Storage Reservoir for the project area.
5) Construction of a distribution network in the project area.
6) Making new Consumer Connections.

3.9.2 Conventional Water Treatment Plant Development Scenario II

This development scenario consists of Lake Kyoga as the source of water and contains the following aspects:

a) Construction of an intake on Lake Kyoga in Nabusira village, near Kitenga landing site
b) Construction of semi conventional Water Treatment Plant nearby.
c) Pumping of treated water from the treatment plant to a storage reservoir located on the hill in the Project area.
d) Construction of a new Storage Reservoir for the project area.
e) Construction of a distribution network in the project area.
f) Making new Consumer Connections.

3.9.3 Comparison of the two Scenarios

The components of the different water supply scenarios are summarised in Table 3-21 below

Table 3-21: Different Water Supply Scenario Components

Component	**Surface Water (MDD 1164.68m^3/day)**	**Surface Water (MDD 1164.68m^3/day)**
	Scenario I (Packaged WTP)	**Scenario II (Conventional WTP)**
Intake Capacity (m^3/day)	1,222.92	1,222.92
Raw Water Pump House / Intake Structure	1No.	1No.
Raw Water Pumping Main (m)		
OD160 uPVC PN10	600	600
Raw Water Pumps		
Head 21m, Flow 76.43m^3/hr	2No. (1No. Duty, 1No. Standby)	2No. (1No. Duty, 1No. Standby)
Water Treatment Plant Capacity (m^3/day)	1,120.00	1,164.68
Packaged Water Treatment Plant (70m^3/hr)	2No.	
Alum Dosing Unit and House		1No.
Rapid Hydraulic Mixing Tank		1No.
Aerator		1No.
Flocculator - Horizontal Flow Type		1No. Channel with 5No. Compartments 9.6mx1.2mx2.0m deep with 5 Baffels
Sedimentation Tanks		2No. Rectangular 14mx3.8mx2.5m deep
Rapid Gravity Sand Filters		4No. Rectangular 1.8mx3.2mx2.0m deep
Clear Water / Contact Tank		2No. Rectangular 9.2mx4.2mx2.0m deep

Component	**Surface Water (MDD 1164.68m³/day)**	**Surface Water (MDD 1164.68m³/day)**
	Scenario I (Packaged WTP)	**Scenario II (Conventional WTP)**
Sludge Drying Beds		1No.
Sump, Chlorine Dosing Unit and Pump House	1No.	1No.
Clear Water Pumps		
Head 120m, Flow 72.79m³/hr	2No. (1No. Duty, 1No. Standby)	2No. (1No. Duty, 1No. Standby)
Backwash Pumps		
Head 12m, Flow 4.09m³/hr		2No. (1No. Duty, 1No. Standby)
Backwash Tank		
	1No. 40m³ elevated on 10m tower	1No. 40m³ elevated on 10m tower
Air Blowers		
		2No. (1No. Duty, 1No. Standby)
Clear Water Pumping Mains (m)		
OD160 uPVC PN10	6,481	6,481
Storage Tank	346m³ Cold Pressed Steel Tank Elevated on 10m steel tower	
Distribution Network (m)	25,452	
Source: Project Estimates		

3.10 Preliminary Design - Sanitation

The proposed interventions in sanitation are centred on the construction of 2No. 6 stance water borne toilet facility, whose location will be proposed by the officials during construction.

3.11 Financial Analysis of the Water Supply Scenarios

3.11.1 Capital Cost Estimates

The preliminary capital investment costs determined for the proposed water supply and sanitation interventions as summarised in Table 3-22 below.

Table 3-22 Summary of Combined Capital Cost Estimates

Item	**Description**	**Capital Investment Costs**	
		Packaged WTP	**Conventional WTP**
		Scenario I	**Scenario II**
1.0	Preliminary and General Items	654,848,834	519,748,341
2.0	Intakes / Pump House	448,836,450	448,836,450
3.0	Treatment Plant Works	3,314,924,928	1,770,000,000
4.0	Raw Water Transmission Mains	42,582,384	42,582,384
5.0	Clear Water Transmission Mains	460,446,174	460,446,174
6.0	Storage Reservoir	389,965,000	389,965,000
7.0	Distribution Network and Service Connections	1,134,533,402	1,134,533,402
8.0	Water Office	120,000,000	120,000,000
9.0	Mechanical and Electrical for Raw Water	175,000,000	175,000,000
10.0	Mechanical and Electrical for Clear Water	221,000,000	497,000,000
11.0	Solar Items	241,200,000	159,120,000
	Sub Total 1	**7,203,337,172**	**5,717,231,752**
	Allow 10% Contingency	720,333,717	571,723,175
	Sub Total 2	**7,923,670,890**	**6,288,954,927**

Item	Description	Capital Investment Costs	
		Packaged WTP	Conventional WTP
		Scenario I	Scenario II
	Allow 18% VAT	1,426,260,760	1,132,011,887
	Grand Total	**9,349,931,650**	**7,420,966,814**
Source: Project Estimates			

3.11.2 Per Capita Investment Costs

The per capita investments and re-investment costs for each scenario was calculated for the initial year (2020), intermediate year (2030), and the ultimate year (2040). The computations have been based on the served population. The results are given in Table 3-23 below.

Table 3-23 Per Capita Investment & Re-investment Costs

Per Capita Investment Cost	Scenario I (PWTP)		Scenario II (CWTP)	
	Currency		Currency	
	(USh)	(US $)	(USh)	(US $)
Resident population - Initial year (2020)	872,394	230	692,413	182
Resident population - Intermediate year (2030)	615,506	162	488,522	129
Resident population - Ultimate year (2040)	434,198	114	344,619	91
Per Capita Re-Investment Cost	**Currency**		**Currency**	
	(USh)	(US $)	(USh)	(US $)
	(USh)	(US $)	(USh)	(US $)
Resident population - Intermediate year (2030)	56,132	15	74,359	20
Resident population - Ultimate year (2040)	39,597	10	52,455	14
Source: Project estimates.				

3.11.3 Summary of Financial Indicators

The results of the analyses are summarised in the Table 3-24 below.

Table 3-24 Summary of Financial Indicators

Item	Discounted Totals				
	Discounted Rate (%/year)				
	0%	**5%**	**8%**	**10%**	**12%**
Scenario I (Packaged Water Treatment Plant)					
Net Present Value (in USh million)	4,346	-2,510	-4,332	-5,078	-5,586
Dynamic Prime Cost - O & M (USh/m^3)	769	809	833	847	861
Dynamic Prime Cost - Total (USh/m^3)	1,821	3,315	4,485	5,367	6,320
Internal Rate of Return	**2.6%**				
Scenario II (Conventional Water Treatment Plant)					
Net Present Value (in USh million)	5,540	-925	-2,682	-3,415	-3,925
Dynamic Prime Cost - O & M (USh/m^3)	770	809	832	847	861
Dynamic Prime Cost - Total (USh/m^3)	1,644	2,902	3,887	4,628	5,429
Internal Rate of Return	**3.9%**				
Source: Project Estimates					

3.11.4 Conclusions and Recommendations from the Financial Analysis

The main conclusions are as follows:

1) The Dynamic Prime Cost (DPC) covering the Operation & Maintenance costs only is similar for both Scenarios. The DPC at the discounted rate of 5% is USh 799 per m^3, which is less than the proposed tariff of Ush 2,500 per m^3. If this tariff is charged, both Scenarios will cover their O & M costs and will generate a surplus. This is mainly due to low Energy Costs of Water Production due to the use of solar as the power source.

2) The best Internal Rate of Return (IRR) is got from the Scenario II (+4.2%) with Scenario I having an IRR of +2.8%. This means that at the tariff of USh 2,500 per m^3 both Scenarios provide a surplus hence can break even.

3) As with all DWD implementation projects, investment and re-investment cost recovery is not considered. If the investment and re-investment costs are to be recovered, the tariffs, at the discounted rate of 5%, would have to be at least USh 3,227 and USh 2,818 per cubic metre for Scenario I and II respectively.

4) The Net Present Values (NPV) are USh -2,217 million and USh -639 million (at 5% discounted rate) for Scenario I and II respectively. This means that the investment is not profitable for both the Water Scenarios at 5% discounted rate however they become profitable at 0% discount since the NPV is USh +4,538 million and USh +5,711 million for both Scenario I and II respectively.

5) The ultimate year 2040 per capita investment costs are US$ 110, and 86 for the Scenario I and II respectively. According to the 2013 MWE manual, the average per capita investment cost for 12 towns implemented during the FY 2010/11 by MWE was US$ 40. The usually accepted MWE per capita investment costs range is US$ 60 - 120. All scenarios fall in this bracket.

In summary therefore, the investments required for the proposed Kitenga water supply system are justifiable as seen from the per capita investment costs. However, the type of sustainable investment varies with the type of water production facility. Scenario II (use of conventional water treatment plant) has the best financial indicators and is the recommended water source for the piped water supply system.

3.11.5 Combined Preliminary Capital Cost Estimates

The preliminary capital investment costs determined for the proposed water supply and sanitation interventions as summarised in Table 3-25 below.

Table 3-25 Summary of Combined Capital Cost Estimates

No.	Proposed Intervention	Cost Estimates
1	Water Supply Investments	7,420,966,814
2	Sanitation Investments	271,100,000
	Total	**7,692,066,814**
Source: Project Estimates		

3.12 Environmental Impact Assessment

The environmental impact assessment will be submitted as a stand-alone report once the proposed source has been approved by the client, hence will not be elaborated upon from this point forward.

3.13 Institutional Analysis

Since Umbrella has been designated as the organisation in charge of operations and maintenance of all new systems being constructed directly by Ministry of Water and Environment, and due to the fact that umbrella does not have readily available personnel to run the systems after hand over, the following should be encouraged.

- Umbrella should select its proposed staff and forward their names to the contractor for hands on training during the commissioning of the works. This would normally be one month when both the construction supervision engineer and the contractor are present on site.

- Set up a stake holder’s workshop to be attended by the major players as regards the project so as to appraise all parties of their roles in the management and operation of the water supply system.

- Ministry through DWD to conduct regular monitoring surveys to establish the performance of Umbrella, and where necessary render assistance to them.

4 DETAILED DESIGN – WATER SUPPLY

4.1 Introduction

4.1.1 Development Strategy

Following the recommendation of the feasibility study report, the Ministry of Water and Environment agreed on the following development strategy:

a) The future water supply system will be based on surface water owing to the fact that the ground water in the project area is saline (contains ions) which is difficult and very costly to treat.

b) The water abstraction point shall be an intake on Lake Kyoga 500m off the shoreline in Nabusira village, near Kitenga landing site.

c) Provision is made in the design of the intake structure to guarantee availability of water in case of low flows/drought.

4.1.2 Basis of Design

The basic parameters for the design of the system are as below:

- The population projections from the domestic and non-domestic consumers;
- The water demand from the water use patterns of the population;
- Household incomes used to set the tariff and the Ability to Pay for water bills.

4.1.3 Design Considerations

In general, all system components have been designed for convenient operational and maintenance procedures. This includes, but is not limited to the following:

a) A convenient layout of the system components with ample space to allow repair and replacement of equipment;
b) Placing equipment to facilitate visual inspections and routine maintenance;
c) Considering vehicular access to equipment locations to allow for tool and parts transport;
d) Considering potential future expansions and make provisions for such;
e) Design of an adequate control and alarm system to enable operators to react quickly and properly in emergencies;
f) Equipment sizing and selection that facilitates a long service life, low operational costs and low maintenance requirements;
g) Keeping the system as simple as possible but as sophisticated as necessary, considering the different implications due to a rural versus an urban setting.

4.1.4 System Components

The Drawing **SGI-MWE-KIT-0.0.0** shows the layout of the proposed system.

i) The source of water supply is **Lake Kyoga**.
ii) The intake system to be located in Lake Kyoga 380m off the shoreline in Nabusira village, near Kitenga landing site,

iii) A raw water gravity main of DN150 ST delivers water from the intake to the flocculator at the Water Treatment Plant (WTP).
iv) The treated water transmission system consisting of a single pipe from the WTP delivers water to the reservoir located Lwamba Beeda village, Bukamba parish, Bukamba subcounty.
v) Distribution system to the consumers will have pipes of mainly plastic material as they are the cheapest and the easiest to lay while steel or ductile iron pipes will be used on stretches where the rock out crops cannot be removed hence will be exposed. They however require competent supervision during back filling.
vi) Pipes with dimensions less than OD 110 are proposed to be HDPE, and other dimensions will be uPVC. All HDPE pipes shall be delivered according to DIN 8074, ISO 3501 – 03 or equivalent standards. All materials in contact with the water: pipes, valves, fittings etc. shall be durable and resistant to corrosive water.

4.1.5 Design Criteria

A summary of the key design parameters is given in Table 4-1 below.

Table 4-1: Design Criteria

Design Criteria	Abbreviations and Dimensions	Adopted Design Criteria
Baseline Data- Population		
Design Horizon	Years	20
Initial Year	Year	2020
Design Year	Year	2040
Population at Design Horizon	P [inh.]	21,534
Maximum Day Demand	m^3/day	1,165
Hydraulic Criteria		
Max Day Factor		1.3
Peak Hour Factor		2.0
Maximum flow velocities range in the pipes	m/s	0.75 - 2.5
Maximum Head losses in the main pipes	m/km	10
Operating Pressures		
Minimum in Distribution Network	bar	1.0
Maximum in Distribution Network	bar	6.0
Water Losses		
In Distribution System (ufw)	% of Total Average Day Demand	20%
Intake & Treatment Plant Use	% of Maximum Day Demand	5%
Pipe Material Selection		
Large Diameter (>280mm OD)		DI or Steel
Medium Size Diameter (100-280mm OD)		uPVC
Small Size Diameter (< 90mm OD)		HDPE
Minimum Pipe Cover		
General Pipe Laying	m	~ 0.9
Pipes laid below roads and reserves	m	1.2
Storage Capacity		
Sizing of Reservoirs- Balancing Storage	% of Maximum Day Demand	30%
Sizing of Reservoirs- Emergency Storage (Firefighting)	% of Maximum Day Demand	10%
Other Design Criteria		
Water Treatment Plant Operation Time	hour/day	16
Pumping Stations Operation Time	hour/day	16
Distribution System Operation Time	hour/day	24
Water Treatment Quality Standards- Drinking Water		Uganda (US - 201: 1994)

4.1.6 Design Economic Life

Annual maintenance cost factors of the various design components have been adopted from the DWD Design Manual, 2013. Economic life has been adopted from previous studies. They are summarized in Table 4-2 below.

Table 4-2 Annual Maintenance and Economic life of Design components

Component	Economic Life (Years)	Maintenance Cost (% of Capital Cost)
Mechanical and Electrical Items	10	5%
Pipelines	30	1%
Structures and Site Works	40	1%

4.1.7 Demand

The design demand has been based upon the Ability to Pay (ATP) the tariff of UGX50/20 L. The design demand for the year 2040 is 1,165m3/d. The system capacity is presented in Table 4-3 below.

Table 4-3: Water System Capacity

Description	Quantity-2040 (m^3/d)	Quantity - 2030 (m^3/d)	Comment
Maximum Day Demand	1,164.7	821.6	Maximum Day Demand
Capacity of Intake and Treatment Works	1,222.9	862.7	Maximum Day Demand plus 5% for Treatment Plant and Surrounding Community Use
Water Treatment Plant use	58.2	41.1	5% of Maximum Day Demand
Capacity of Raw Water Transmission Main	1,222.9	862.7	Maximum Day Demand plus 5% for Treatment Plant
Capacity of Treated Water Transmission Main	1,164.7	821.6	Maximum Day Demand for Kitenga
Source: Project Estimates			

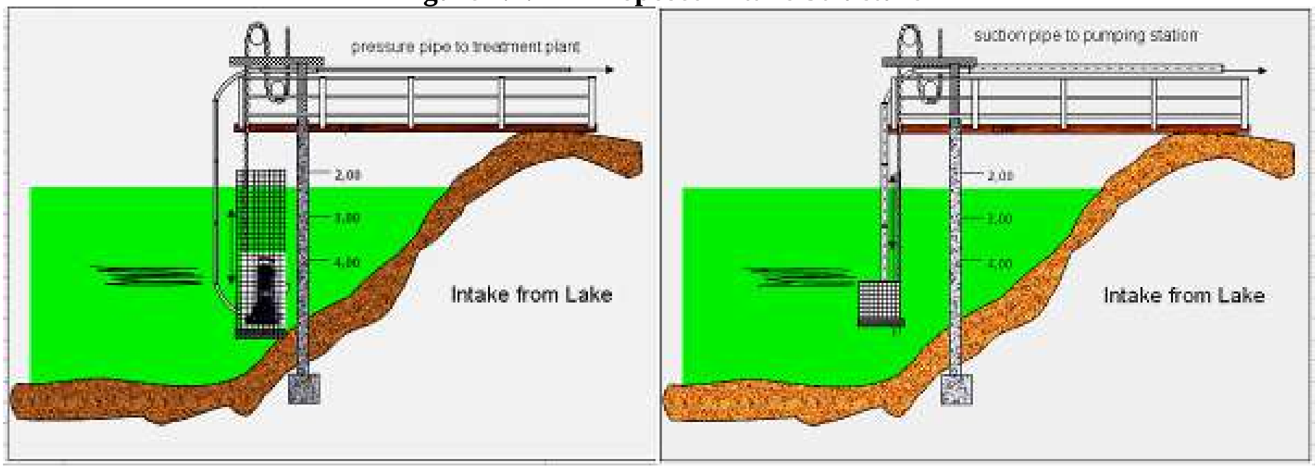
4.2 Detailed Design of Intake

4.2.1 Raw Water Intake Structure

The proposed type of intake is an Intake Well. The intake structure shall be formed from DN2000 precast reinforced concrete rings to accommodate the raw water pumps. A walkway will be provided to the intake point from the shores and will be made of steel columns and an open grid decking. A DN 150 ST raw water pumping main shall be fixed to the walkway. The electrical switchgear for the pumps will be housed in a weather proof and burglar proof console at the deck. The treatment plant will be located adjacent to the intake.

Water will be abstracted directly from the lake via a submersible pump. It is crucial that the intake is located as far from the bank as possible into the lake. If not, the bank mud that is stirred up by the waves would be sucked in by the intake pipe. To this end, we recommend constructing an access bridge extending into the lake depending on the high and low water levels as shown in Figure 4.1 overleaf, while the Intake structure layout is presented as Drawing SGI-MWE-KIT-1.1.0. The picture overleaf shows the completed intake structure in question which was recently constructed in one of the projects in the country.

Figure 4.1: Proposed Intake Structure



Picture 4.1: Intake Structure with raw water pipe on side of access bridge.

Picture 4.2: Completed structure with security cage installed

4.2.2 Raw Water Transmission Mains

The Raw Water Transmission main will be DN150 DI PN 6 from the intake to the aerators. The total length will be 1143m. The main will have the capacity to deliver 76.43m^3/hr which is the ultimate year (2040) demand.

The transmission main was designed using Hazen-Williams Formula and a spread sheet was used to design the main requirements in the ultimate design year of 2040. The formula is as follows:

Q = K*C*A*R^0.63*S^0.54

Where:	Q	=	Discharge in the section (m^3/s)
	C	=	Hazen Williams roughness coefficient (unit less)
	C	=	140
	A	=	Flow area m^2
	S	=	Friction slope (m /m)
	K	=	Constant (0.85 for SI)
	R	=	Hydraulic radius (m)
	D	=	4R
Where:	R	=	Hydraulic radius (m)

D = Diameter (m)

The design details are indicated in Table 4-4. It can be seen that the velocity is acceptable as it is within the range of 0.75-2.5 m/s and the surge pressures are also acceptable.

Table 4-4: Raw Water Transmission Design

Parameter	Raw Water Pumping Main
Demand- 2040 (m^3/day)	**1,164.68**
Treatment Plant Use (5%) (m^3/day)	**58.23**
Total Amount of Water Abstracted (m^3/day)	**1,222.92**
Hours of Pumping (hr)	16
Efficiency (%)	60.0%
Required Delivery (m^3/hr)	76.43
Required Delivery (m^3/s)	0.0212
Pump Installation Level (m amsl)	1030.000
Inlet Level (m amsl)	1043.000
Static Lift (m)	13.0
Hazen Williams Coefficient, Cwh (C)	140
Pipe Details	**DN150 ST PN6**
Pipe Diameter ND (mm)	150.00
Pipe Diameter ND (m)	0.150
Velocity (m/s)	1.201
Flow in Pipe (m^3/s)	0.0212
Length of Pipe (m)	**1520**
Friction Loss (m)	14.1
Fittings losses - 10% (m)	1.4
Total Friction Loss (m)	14.1
Total Head (m)	**28.6**
Head Used (m)	**29**
Power (kW)	**10.1**
Source: Project Estimates	

4.2.3 Raw Water Pumps

The proposed raw water pumps will be the submersible type installed in the intake water well. It is proposed to have **a single duty pump and one stand by pump**. There will be a local control point and power supply will be from the water treatment plant. Raw Water pumps have been sized for the demand of 2030 due to an economic life of only 10 years. The proposed pumping head is shown in Table 4-4.

4.3 Detailed Design of the Treatment Plant

The capacity of the treatment works is 862.69 m3/d (53.92m3/hr) inclusive of 5% plant use and is sized for the intermediate year (2030) maximum day. The plant will operate for 16 hours per day in the ultimate year of 2040.

4.3.1 Choice of Treatment Process

To evaluate the suitability of Lake Kyoga to supply safe water and to be able to design an appropriate treatment system; water samples were taken from the proposed water intake points. The water quality was analysed at the NWSC Central laboratory in Bugolobi. The raw water quality parameters that were analysed included pH, Electrical Conductivity, Apparent Colour, Turbidity, Total Suspended Solids, Total Dissolved Solids, Alkalinity (total as CaCO3), Hardness (total as CaCO3) and the Jar test.

- Alkalinity is important in determining a surface water's ability to neutralize acidic pollution
- The jar test is used to determine dosage requirements for chemicals added to remove small particulates from water.

A comparison of the analysis results against the established national standards for potable water in Uganda shows that the water samples meet the standards except the highlighted parameters presented in Table 4-5 below and the certificates of analysis are attached under Annex 8.3.

Table 4-5: Raw Water Quality Analysis Failed Parameters

Parameter	Units	Sampled Water Value	Max Acceptable Value	Possible Impact to User
pH	-	6.8	6.5-8.5	High: Taste; Low: Corrosion
Electrical Conductivity	µS/cm	223	2500	Taste
Apparent Colour	PtCo	**292**	15	Aesthetics, taste
Turbidity	NTU	**19.7**	10	Aesthetics, taste
Total Suspended Solids	mg/l	**56**	0	Aesthetics
Total Dissolved Solids	mg/l	142.7	1200	Taste, corrosion & encrustation
Alkalinity: total as $CaCO_3$	mg/l	100	500	
Hardness: total as $CaCO_3$	mg/l	58	500	Scaling of pipes and equipment
Jar Test (Flocculation pilot Experiments)	mg/l	**10**	Optimum dose	
Calcium	mg/l	12.8	75	
Magnesium	mg/l	6.24	50	
Bi Carbonate: as $CaCO_3$	mg/l	122	500	Scaling, scum formation and use of too much soap
Fluoride	mg/l	0	<1.5	Dental & Skeletal fluorisis
Iron: Total	mg/l	0.17	<1.0	Taste & colour attaining
Sulphate	mg/l	6	200	Taste & gastrointestinal irritation
Chloride	mg/l	10	250	Taste
Nitrate- N	mg/l	0.03	5	Blue Baby syndrome
Source: Project Studies				

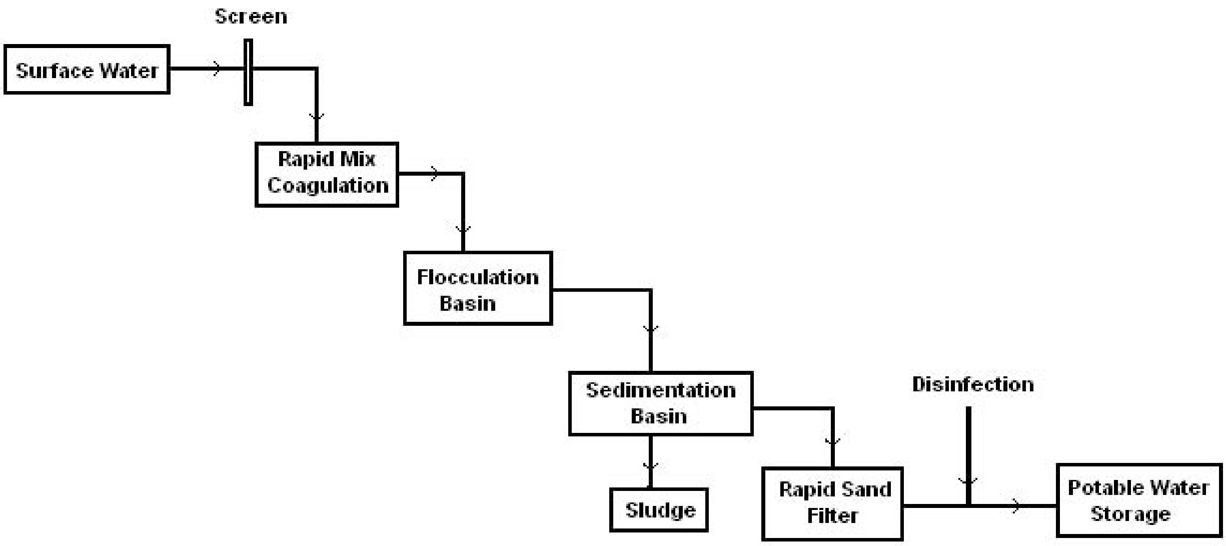
The sample displayed values above the Max Acceptable Values for the parameters **of Colour, Turbidity, and Suspended Solids.** The water treatment processes required will therefore emphasises the removal of the total suspended solids (TSS) and colour through aeration, coagulation, flocculation, sedimentation and filtration as seen in the table below.

Table 4-6: Raw Water Treatment Process

Water quality parameter	Treatment- Process
Colour	Aeration, Clarification & Rapid Sand filtration
Turbidity	Clarification & Rapid Sand filtration
Total Suspended Solids	Coagulation, flocculation, sedimentation
Faecal coliform	Chlorination - disinfection tanks
pH	(affects the type of coagulant)

The treatment flow process is shown in Figure 4.2 overleaf.

Figure 4.2: Treatment Flow Process



4.3.2 Multiple Platform Aerator

During aeration, the water will pass over the cascades where it will be oxidised. One Multiple Platform Aerator containing three circular platforms is proposed. The Aerator will receive the raw water from the DN150mm raw water pumping main through a vertical inlet pipe and bellmouth from where it will cascade over three platforms of increasing diameters. The square collection chamber at the bottom is connected to the Rapid Mixing Chamber via a weir. The design parameters for the Aerator are given in Table 4-7 below.

Table 4-7 Aerator Design Parameters

	Units	Value
Water Flow to Treatment Plant	m^3/day	862.69
	m^3/hr	53.92
	m^3/s	0.01
Number of Trays	Nr	3
Water Fall between Trays	mm	450
Difference in Height between Trays floor and soffit of upper floor slabs	mm	300
Height of Tray Copings	mm	150
Increase in Diameter with each Tray	mm	200
Internal Wall Clearance of Collection Chamber from Bottom Tray	mm	400
Thickness of Tray Slabs	mm	150
Internal Height Clearance from Collection Chamber Floor Slab to Bottom Tray	mm	1500
Height of Aerator from Floor Slab to Bellmouth	mm	3000
Internal Diameter of Tray 1- Top Tray	mm	700
Internal Diameter of Tray 2- Middle Tray	mm	900
Internal Diameter of Tray 3- Bottom Tray	mm	1100
Internal Width of Aerator Collection Chamber	mm	3000
Internal Depth of Aerator Collection Chamber	mm	1500
Internal Diameter of Centre Column	mm	450

The Aerator pipe work sizes will be as follows:

a) Inlet - DN 150,
b) Drain - DN 100.

4.3.3 Chemical Dosing

Chemical dosing will be done in a purpose built unit as given in Drawing SGI-MWE-KIT-3.7.0 series. A chemical house of dimensions 18.7 m x 7.2 m will be constructed and will house the following: -

- Soda Ash mixing and dosing
- Alum mixing and dosing
- Chlorine mixing and dosing
- Chemical stores.

Chemical mixing will be carried out in the building. Six acid resistant ceramic tile lined reinforced concrete mixing tanks have been proposed. The volumes are as follows:

- Soda Ash mixing - 2x 500 litres
- Alum Mixing - 2x 500 litres
- Chlorine Mixing - 2x 500 litres

The jointing material for the mixing tanks shall be acid resistant, and the concrete and mortar shall be made from sulphate resistant cement. Each chemical mixing tank will have the following components;

- Make up water sufficient to fill up each tank in 30 minutes, overflow, discharge and drain pipe work and valves

- level indicator in each tank

- a GRP dissolving tray complete with stainless steel mesh suitable for use with kibbled or block chemicals

- agitation to allow rapid solution of chemicals by vertical electrically driven mixers. Mixers shall be made from corrosion resistant materials.

Three sets of dozers have been provided for in the chemical house to dose the chemical solutions from the mixing tanks. The chemicals will be dosed at locations as indicted in the process diagram. All the dozers shall be positive displacement pumps, and shall operate on a duty/standby basis, capable of handling corrosive fluids.

The chemical stores shall be well ventilated, and all the doors shall be made from corrosion resistant material, preferably timber. After the dosing of aluminium sulphate, rapid mixing will follow.

4.3.4 Rapid Mixing Chamber

Rapid mixing of Alum in the water will be effected in the mixing chamber. The mixing chamber is a horizontal flow baffled channel containing baffle walls. Movement of the water round the ends of the baffles will affect rapid mixing. The internal measurements of the mixing chamber are 4.8m x 2.00m x 1.50m deep. The concrete baffle walls which are five in number are 100mm thick x 1.325m long. The mixing channel outlet to the Flocculator is a weir across the Flocculator width.

The Rapid Mixing Chamber has been sized for full flow i.e. 862.69m3/d (53.92m3/hr.). Its design parameters are as follows:

a) Retention time - 30 Seconds,
b) Mixing Velocity - 0.2m/s,
c) Distance between Baffles - 0.45m,
d) Clear Distance at Baffle end - 0.675m.

4.3.5 Flocculation

4.3.5.1 Flocculation Process

The mixed liquor of raw water and aluminium sulphate solution will enter the flocculation chamber after rapid mixing. By forming aluminium hydroxide, the flocculants themselves produce additional solids. With such high concentrations of suspended solids, a filter system needs very high amounts of wash water. Therefore, in the present case, the suspended solids need to be removed via sedimentation. Prior to sedimentation, the micro flocs first need to coagulate to form bigger and settleable flocs. This happens in the coagulation chamber right after the flocculation where the coagulant (polyelectrolyte) is added. At the oxidation stage, ferrous iron is oxidized to iron hydroxide. The solubility of metals depends on their pH value.

The pH value of the flocculated water should be at least pH = 8 to prevent iron hydroxide from dissolving again. It would then no longer be filterable. Since adding aluminium sulphate lowers the pH value, the pH value usually needs to be slightly increased after flocculation.

$$Al_2(SO_4)_3 + 6\ H_2O \dashrightarrow 2\ Al(OH)_3 + 3\ SO_4^{2-} + 6\ H^+$$

This can be achieved by adding soda ash at the coagulation stage. The dosing depends on the buffering capacity of the water.

4.3.5.2 Sizing of the Flocculation Chamber

The Flocculator is a vertical flow baffled channel type. It contains two chambers with five baffle walls each with two weirs made of reinforced concrete and three plates made of stainless steel. Water inflow into the Flocculators is over a concrete weir while the outflow is through sluice gates separating the Flocculator and sedimentation tanks inlet channels.

The internal measurements of each Flocculator chamber are 7.6m x 1.0m x 1.5m deep. The concrete weirs are 200mm thick x 1.50m deep spanning the 1.0m width of each chamber. The stainless-steel baffle plates are 5mm thick, 2000mm deep and 1040mm wide installed in 25mm deep U Section guide channels fixed to the chamber walls. An orifice measuring 300mm deep and spanning the chamber width of 1.0m has been left at the bottom of the plate for water to flow through. Movement of the plates vertically is possible to increase the size of the orifice.

Cleaning/Drainage of the Flocculators is provided for by the construction of a sloping floor slab and 3No. 300mm wide x 100mm deep channels spanning the width the Flocculator chamber after each baffle plate section. DN 100mm drain valves and pipes to the sludge drying beds manhole system have been installed to drain each section.

The Flocculators' design parameters are as follows:

i) Retention time - 21.7 minutes,
ii) Up-flow Velocity - 27.0 m/h,
iii) Spacing of Baffles - 1.0m,

4.3.6 Sedimentation Tank

From the sludge contact chamber, the water flows to the sedimentation tank where the sludge flocs are separated from the water.

The Sedimentation Tank will be 2No. rectangular tank of the horizontal flow type. The design parameters are given in Table 4-8 below.

Table 4-8: Sedimentation Tank Design Parameters

Description	Parameter	
Flow into Sedimentation Tanks	**53.92**	m^3/hr
	862.69	m^3/day
No of Sedimentation Tanks	**2**	nr
Detention Time	**26.96**	hrs.
Sludge depth	0.5	m
Clear depth	3.0	m
Total Volume of each Sedimentation Tank	**94.36**	m^3
Outlet Over Flow Weir	*215.67*	m^3/m/day
Surface Loading Rate (SLR)- [16 hr. operating day]	16	m/day
Internal Width of each Tank	2.00	m
Internal Length of each Tank	14.00	m
Source: *Design Project Estimates*		

The tank has been sized for full flow and will result in a surface loading rate of 1m3/hr./m2. This is well within the usually acceptable range of 1-1.56 m3/hr./m2.

Water entrance into the tank is via a 600mm wide channel supplied through a weir chamber of size 300mm x 600mm deep in the Flocculator outlet chamber wall. Baffle walls with DN 150mm circular orifices have also been provided up stream of the inlets to ensure uniform distribution of water across the tank width.

Water exit from the tanks consists of flow over a V-Notch weir in each tank into the outlet channel. A reinforced concrete scum board has also been provided as per part of the outlet arrangement to minimise carryover of floccs.

The Sedimentation Tanks pipe work sizes will be as follows:

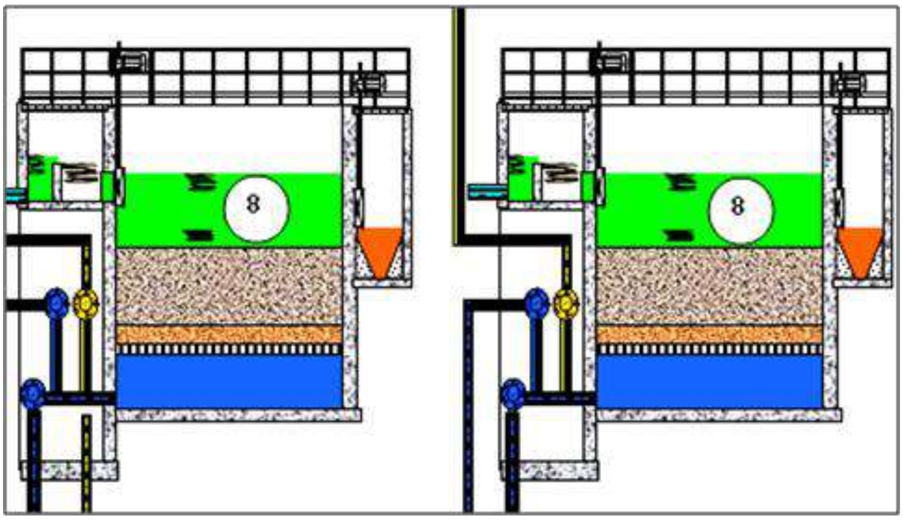
- Outlet - DN 200,
- Drain DN 150.

4.3.7 Rapid Gravity Filters

4.3.7.1 Filtration

From the sedimentation stage, the water is gravity-fed to the filter plant. The decantate has a remaining solids content of around 10mg/l. Jar tests at NWSC have shown that if flocculation/coagulation is performed correctly, colour and turbidity may even reach the value “zero”. The time between two filter cleanings is thus extended and the wash water and energy consumption reduced. The filter contains a sand layer with grain sizes between 0.7 and 1.2mm. Underneath the filter sand is a gravel layer as supporting material. The gravel (25cm to 30cm) helps to equally distribute the water above the filter bottom as seen in Figure 4.3 overleaf. This bottom is made from concrete and contains holes. Per m², around 70 – 90 filter nozzles are installed as shown in Figure 4.4 overleaf.

Figure 4.3: Concrete Filter Cells



The water flows through the filter cell from top to bottom. The filtered water is collected underneath the filter bottom and then transferred via the clear water pipe to the treated water tank. While the filter is operated, dirt is retained by the filter sand, increasing the resistance in the filter material. To overcome the loss in pressure, the water level above the filter sand rises. As soon as the water level has reached a certain height (around 2m), filter washing is required.

Figure 4.4: Filter Nozzles and Sand Bed

4.3.7.2 Sizing of the Filters

The Rapid Gravity Filters have been chosen over slow sand filters due to the fact that they occupy less space for construction. The rapid gravity filters have been designed for a flow of 53.92 m3/hr. A bank of 2No. filters has been provided each with dimensions of 3.0 m by 2.0 m and 5.8m deep.
Each filter will have the following components;

- Filter Inlet: Open channel with a DN 500 x 500 port provided with a penstock
- Filter media: Hard grain quartz or silica

- Filter bed thickness: 1.2m with 1.0m being sand
- Filter Outlet: DN 250mm connecting to a DN 150mm manifold before discharging to the clear water tank
- Wash water line: DN250 supplied from the backwash water tank
- Filter drain: DN100mm

4.3.8 Back Washing Process

4.3.8.1 Filter Washing

Filter washing shall be achieved by air scour followed by water washing. The washing conditions shall be such that the sand filters can be effectively cleaned. The rate of backwashing and air supply shall be adequate for the purpose of cleaning the bed and removing material but shall not dislodge the media layers or disturb the consistency of the bed. Facilities shall be provided for the following minimum air-scour and wash water rates:

- Air Scour - 60 m^3/m^2 per hour
- Wash Water - 23.4 m^3/m^2 per hour

The backwash water is delivered from a backwash tank. The backwash water main shall be DN 250 and shall be provided with a bulk flow meter, an electromagnetic flow meter, transmitting the flow to a panel in the filter control room and a flow control butterfly valve. The wash water shall flow over a weir into the wash water channel. A 500x 500mm outlet penstock controls the flow into the water drain channel. The penstock shall be provided with an extended spindle for operation from the filter control deck.

4.3.8.2 Sludge Water

The sludge water that results from the filter cleaning flows intermittently into a buffer and sedimentation tank where it is collected. Until the next filter washing, there is time for the suspended solids to settle. The sludge is transferred to the sludge drying bed or disposed of in the public solid waste disposal site. The calculations for checking the backwashing process for the filters are in Table 4-9 below.

Table 4-9: Backwashing Calculations

Filter Media expansion during backwashing	%	30
	mm	330
Backwash Rate (30% filter bed expansion at 20 ^{0}C)	mm/s	6.5
	$m^3/m^2/hr$	23.4
Required Backwash Flow Rate	m^3/hr	140.40
Duration of Backwashing	mins	7.0
Volume of Water required for Backwashing One Filter	m^3	16.38
No.of Filter Bed Volumes of Backwash water consumed	Nr	2.5
Backwash Frequency	hr	24
Designed Water Treatment Plant Demand	**m^3/day**	**41.08**
Estimated Community Demand- 8 hours storage of WTP Demand	m^3/day	13.69
Water Treatment Plant Use only	m^3/day	27.39
Required size of Backwash Tank(Community use, 2Nr Filters Backwash + 20% other WTP use)	m^3	53.01
Size of Backwash Tank Adopted	**m^3**	**100**
Ratio of Backwash Tank size to Water Treatment Plant & Community Demand	%	243.4%
	hrs	58.4
Maximum Velocity in Backwash Main	m/s	1.00

Cross Sectional area on Backwash Main	m^2	0.03900
Nominal Diameter of Backwash Main	mm	222.8
Backwash Delivery Main Details	**Pipe Details**	**DN250 DI**
	Nominal Diameter (mm)	**250.0**
Actual Velocity in Backwash Main	m/s	0.79
Air Cycle		30
Duration of blowing Air	mins	330
Air Loading Rate	$m^3/m^2/hr$	6.5
Air Flow Rate	Nm^3/hr	23.4
Adopted Flow Rate for Air Blower	**Nm^3/hr**	140.40
	Nm^3/min	7.0

4.3.9 Clear Water Tank and Pump Station

4.3.9.1 Chlorination

Disinfection by chlorination of the water is meant to leave a residual of 0.3-0.5 mg/l at the furthest ends of the network, which is more than 24.3 km away from the treatment plant.

4.3.9.2 Water Tank

A clear water tank has been provided and will be 5.8 m long, 5.1 m wide and 4.8 m deep. The clear water tank will have two compartments as follows:

- Chlorine contact chamber – 54 m3
- and chlorinated water storage respectively – 81 m3

The tank is in reinforced concrete. The chlorine contact tank shall be provided with internal baffle walls to eliminate short-circuiting and to provide a chlorine contact time of more than 0.5 hours. The tank also serves as a suction reservoir for back treated water pumping (chlorinated water storage). The inlet of the tank will be DN200, overflow DN250, outlet will be DN150, and the drain will be DN100 and will be provided with internal access ladders made of galvanised still for each of the compartments. Roof vents of diameter not less than DN100 shall be provided

4.3.9.3 Treated Water Pumping Station

There is one pumping station which is conjoined with the clear water tank. It shall house the following:

a) 2 No. High Lift clear water pumps (1No. duty and 1No. standby)
b) Switchgear and controls
c) All associated pipe work
d) 2 No. air scour blowers (duty and standby)
e) Floor drainage channels and cable ducts.

The Pumps will be horizontal centrifugal pumps with soft starters and will have a common DN150mm suction main and will responsible in pumping water to the reservoir tank. A Tee piece shall be installed along the transmission main from which the backwash tank shall be supplied using a DN100 pipe connected to the tap off point. A pressure reducing device shall be installed on the backwash line section after the tap off so as to reduce/shave off 90m of head. All the pumps Suction Pipes have been set at 825mm below the Bottom Water Level of the Clear Water Tank and hence will be flooded inlets to avoid the need for priming the pumps.

The Pumps will operate on a duty/standby basis and are rated as follows:

a) Flow - 51.35m^3/hr.,
b) Head - 62m.

Two Rotary Electric Air Blowers to operate on duty/standby basis will also be installed in the pump station. These will have the following operating parameters:

a) Air Loading Rate 480Nm3/hr. (60m3/m2/hr. for 15.29m2 area),
b) Maximum Pressure in Delivery Line - 10m.

4.3.10 Water Treatment Plant Buildings

4.3.10.1 Workshop and Stores

A Workshop/store building will have three rooms as follows:

i) Workshop - 42 m^2 floor space
ii) Chlorine store - 25 m^2 floor space
iii) Alum store - 65 m^2 floor space
iv) General store - 65 m^2 floor space

Vehicular access will be provided to facilitate the repair of equipment especially pumps, storage of materials/pipes/fittings/equipment, and operation of the Plant.

4.3.10.2 Operators Residence

One semi-detached type C house of combined floor area 79m^2 will be constructed in the Plant compound to house the operators of the Plant and Intake. Each house will contain a single Bedroom, a Sitting/Dining Room, Kitchen, and Bathroom/Water Borne Toilet. The houses will be fenced off from the Plant to keep non-official staff, especially children, away from the works. Water supply will be provided from the Backwash tank, electricity from the mains and a common septic tank with the Administrative Building will be constructed to collect the sewage/waste water from the residences

4.3.10.3 Sludge Drying Beds

The sludge from the sedimentation tanks will be drained into 4No. sludge drying beds each of plan area 32m2. The drying beds will be constructed just below the workshop building. The dewatering area of each bed will be 8.0m x 4.0m x 1.55m deep. Gravel of thickness 350mm and sand of 300mm thickness will be used with DN100 uPVC perforated pipes in the under-drainage. Inlet and outlet manholes as well a collection chamber will be provided. Flow into and out of each bed will be controlled by DN 100mm hand stocks. Waste water from the drying beds will be channeled through site drainage manholes to an outfall outside the Plant.

4.3.11 Water Treatment Plant Site Works

Besides the above components of the treatment process, the following auxiliary works will be considered:

1) Construction of a fence and installation of 2 No. double leaf access gates for both the plant and staff quarter entrances.
2) Supply and Installation of a 100kVA 3-Phase Generator Set for backup power options.
3) Supply and Installation of Site Lighting.
4) Supply and Installation of Surge Suppression Equipment.
5) Construction of Sludge Drainage Manholes from sedimentation tank to Sludge Drying Beds.
6) Construction of site drainage including the backwash drainage line to an outfall.
7) Construction of Site Road Works and Walkways.
8) Construction of auxiliary buildings including a workshop and stores, attendant's accommodation, Water Office

4.3.12 Interconnecting Pipework

The inter-connecting pipework shall be in ductile iron and of the sizes given in the layout drawings and will be as follows.

i) Sedimentation Tanks to Rapid Gravity Filters DN200,
ii) Rapid Gravity Filters to Clear Water Tank - DN200,
iii) Clear Water Tanks to Pumps (Suction Main) DN150.
iv) Backwash Pumping Main DN100.
v) Backwash Delivery Main DN250.
vi) Sludge Drainage Pipework DN200.

Bulk flow meters will be installed on the following mains:

a) Raw Water Gravity Main - DN 150
b) Backwash Delivery Main - DN 250.
c) Clear Water Pumping Main - DN 150
d) Backwash Pumping Main - DN 100

4.3.13 Treated Water Transmission Mains

The treated water transmission main will be OD160 uPVC PN10 delivering water from the treatment plant to the reservoir a distance of 3.5km. The main will have the capacity to deliver 73m^3/hr. the main was designed using Hazen-Williams Formula as shown in Section 4.2.2 above for the ultimate design year of 2040.

The design details are indicated in Table 4-10. It can be seen that the velocity is acceptable as it is within the range of 0.75-2.5 m/s and the surge pressures are also acceptable.

Table 4-10: Treated Water Transmission Design

Parameter	Clear Water Pumping Main
Demand- 2040 (m^3/day)	**1,164.68**
Treatment Plant Use (5%) (m^3/day)	**0.00**
Total Amount of Water Abstracted (m^3/day)	**1,164.68**
Hours of Pumping (hr)	16
Efficiency (%)	60.0%
Required Delivery (m^3/hr)	72.79
Required Delivery (m^3/s)	0.0202
Pump Installation Level (m amsl)	1043.620
Inlet Level (m amsl)	1089.210
Static Lift (m)	45.6
Hazen Williams Coefficient, Cwh (C)	140

Parameter	Clear Water Pumping Main
Pipe Details	**OD160 uPVC PN16**
Pipe Diameter ND (mm)	144.60
Pipe Diameter ND (m)	0.145
Velocity (m/s)	1.231
Flow in Pipe (m^3/s)	0.0202
Length of Pipe (m)	**5040**
Friction Loss (m)	51.2
Fittings losses - 10% (m)	5.1
Total Friction Loss (m)	51.2
Total Head (m)	**101.9**
Head Used (m)	**102**
Power (kW)	**33.7**
Source: Project Estimates	

4.3.14 Energy and Power Provision Costs

From the feasibility study report, the power supply option agreed to power the pumps and treatment plant energy requirements is solar power augmented by Generator set since the mains power (national grid is located 15km away. The characteristics of the power requirement of the pump has been calculated using the formula seen in Table 4-11 below.

Table 4-11: Pump Power Requirement Equation

P= [ρ x g x h x Q/3600]/(e1 x e2)
Where;
P is required input power (Watts)
ρ is water density (kg/m^3) = 1000
g is gravity constant (m/s^2) = 9.81
h is pump head (m)
Q is pump capacity (m^3/hr)
e1 is efficiency of pump = taken from selected pump details
e2 is efficiency of pump motor = taken from selected pump details

The pump power requirement is summarized in **Table 4-12** below.

Table 4-12: Pumps and Power Requirements

Location	PARAMETERS								
	Head (m)	Flow (m^3/hr)	Power (kW)	Required Motor Size KW	Available Motor (kW)	kVA	Total power (KVA)	Amperage (A)	Starting KVA
Raw Water Pumps	26	76.4	6	7.3	8.0	10.00	10.00	13.91	10.00
Backwash Pump	16	29.1	1.5	1.7	2.0	2.50	2.50	3.48	3.00
Clear Water Pump	76	72.8	17.7	20.4	21.0	26.25	26.25	36.52	27.00
Source: Project Estimates									

Table 4-13: Solar Power

Location	SOLAR POWER OPTION	
	Solar Panels No. (1x280pW)	Solar Panels area (m2)
Raw Water Pumps	32	19.39
Backwash Pump	8	4.85
Clear Water Pump	83	50.30
Other WTP Pumps and Structures	57	34.56
Source: Project Estimates		

The power requirement for the pumps and other water treatment plant structures includes the supply of and installation of 180No. of mono crystalline PV Solar panels rated at 280pW 12 Volts DC, including: PV solar panel support structure (solar array) for mounting solar panels; all electrical accessories; complete as per specifications. These will be used for a maximum of 8 hrs after which the generator set will kick in to power for supply the days demand for the next 4 hrs until 2030 where the generator set will now have to operate for 8hrs so that the pumps can supply the required demand. The Generator power will include the, supply and installation of 200kVA, 3 phase generator set and all accessories.

4.3.15 Disinfection Facilities

Final disinfection of the treated water from the Lake at the treatment plant will be effected by the installation of chemical dozers at the chemical house to feed into the contact tank.

4.4 Detailed Design of Other Facilities

4.4.1 Storage Reservoir

The required storage capacity has been computed as 30% of the 2040 maximum day demand and is therefore 349m^3. A 346m^3 main reservoir has been adopted since the 349m3 tank size does not exist in the market. This new tank represents a storage capacity of 30% in the ultimate year maximum day demand. The reservoir's storage capacity at various stages of the design period is reflected in Table 4-14 below.

Table 4-14: Reservoir Storage Capacity

Item	Kitenga RGC Storage					
	2019	2020	2025	2030	2035	2040
MD Demand- m^3/day	560	580	690	822	978	1,165
Storage Capacity (m^3)	346	346	346	346	346	346
Hours of Storage	15	14	12	10	8	7
Storage Capacity (%)	62%	60%	50%	42%	35%	30%
Source: Project Estimates						

Due to the topography of the project area and the high pressures experienced in the far reaches of the distribution network, it is recommended to place the reservoir tank on a 10m high steel tower. The reservoir will be made of square cold pressed steel panels of length 1.22m and shall be provided with inlet, overflow, outlet, and drain pipe work. The following fittings shall also be provided for the reservoir;

a) Internal ladder of galvanised steel,
b) Wall mounted level indicator,
c) Vents on the tank roof,
d) Roof level access cover of galvanised steel.

The access covers shall be at least 100 mm above the finished level of the roof and shall be lockable. The roof vents shall be similarly set out and shall be fitted with vermin proofing and mosquito proofing fabric. The overall internal dimensions of the reservoir (346m^3) are as follows:-

- Length - 8.54m,
- Width - 8.54m,
- Depth - 4.88m.

The pipe work (rated PN10) of the reservoir shall be in Epoxy Coated Steel Pipe work as follows;

- Inlet - DN 150,
- Outlet - DN 200,
- Overflow - DN 150,
- Drain - DN 100.

4.4.2 Main Reservoir Site Works

The site works at the reservoir consists of the following:

a) The general earthworks,
b) The site pipe work,
c) The site drainage,
d) Miscellaneous works.

The outlet from the main reservoir shall be fitted with new bulk flow meters. The site layout drawings for the respective reservoir is given in drawing SGI-MWE-KIT-5.0.0, in Annex 8.4

4.4.3 Distribution Network

The downstream of the distribution system reservoirs has been modelled using EPANET 2.0. A peak hour factor of 2.0 was used. The smallest size of pipe chosen is OD 50 HDPE. Pipes smaller than OD50, will be laid as Network Intensification lines. Table 4-15 overleaf shows the estimated sizes and length of the distribution pipes while Figure 4.5 shows the Epanet Model whose details are attached in Annex 8.3.

Figure 4.5: Kitenga RGC Epanet Distribution Network Model

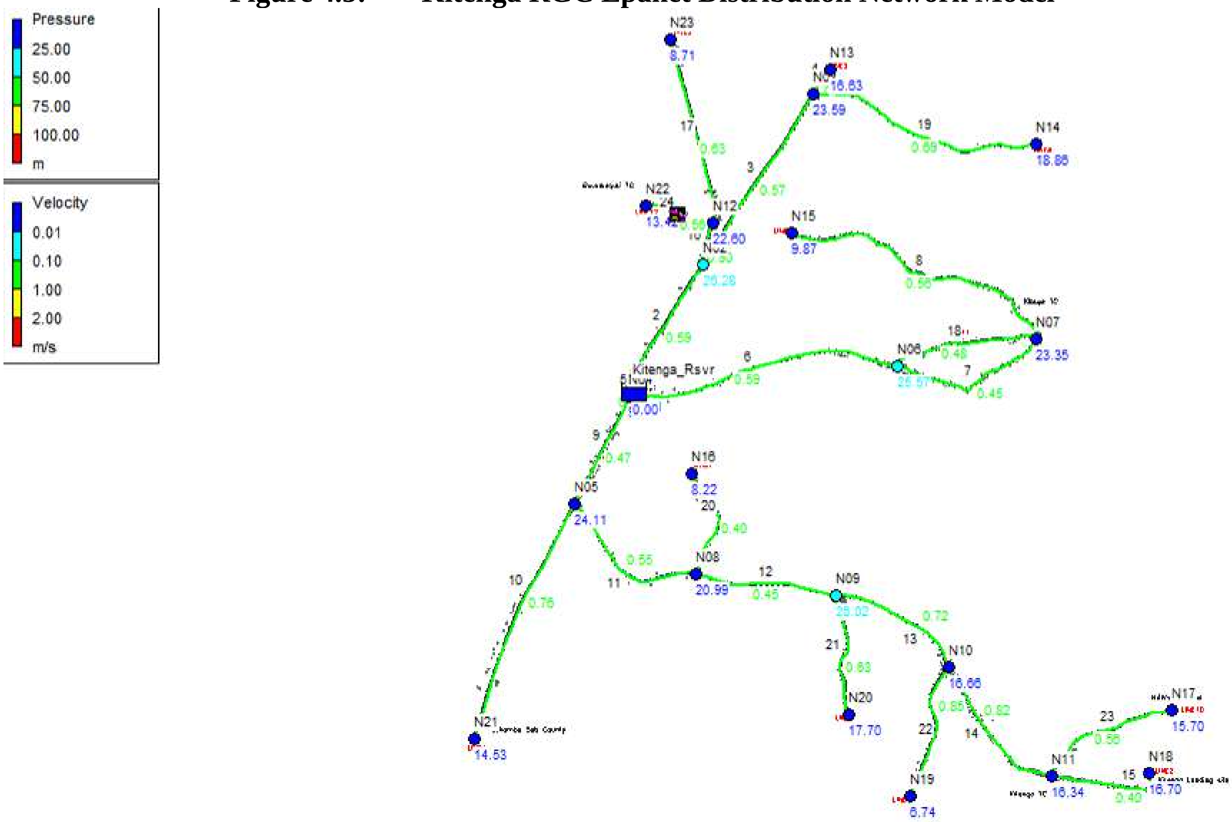


Table 4-15: Distribution Mains

Pipe Details	Length (m)
OD225 uPVC PN10	915
OD160 uPVC PN10	3,165
OD110 uPVC PN10	4,397
OD90 HDPE PN10	4,560
OD75 HDPE PN10	2,190
OD63 HDPE PN10	4,804
OD50 HDPE PN10	4,221
Total	**24,252**
Source: Project Estimates	

4.4.4 Air Valves

Air valves have been allowed for at all high points at significant changes in downward slope. Even in flat areas an air valve at every 600 m to 1000m is necessary as air bubbles form as water pressures fall. The following factors have been considered;

- To help prevent the formation of air pockets, minimum slopes are 0.3% for DN ≤ 200 mm and 0.2% for DN > 200 mm.
- Air valves are required to vent any air bubbles that are conveyed or formed in the water as the development of air pockets at high points can greatly reduce or even stop the flow of water.
- They are also required to vent large quantities of air when pipelines are filled and as noted above to help deal with the problems associated with surge.
- Suitably sized air valves will be located at upturned tees at all high points fitted with an isolating valve.
- The air valve tee is designed as an air accumulator tee with the initial tee branch 0.6 times the main pipe diameter

4.4.5 Washouts

Washouts are required at low points so as to be able to periodically flush out the pipeline to help remove any matter that tends to accumulate at such points.

4.4.6 Service Connections

The location of the service pipes will not be known until applications for connections are received. At this stage, only an estimate of the sizes, quantities and costs can be given. On the basis of the population to be served at the tariff of USh 50/20 litres, the total number of connections required in the ultimate 2040 has been estimated as in Table 4-16 below. The criteria used to determine the number of service connections for each served population category is as follows.

Table 4-16: Population per Category Criteria

Category	Population Served	Source of Criteria
House Connection	5 persons per household	Socio-Economic Study Data
Yard Taps	2 Households per yard tap	Project Estimates
Standpipes	250 persons Per Standpipe	Maximum Number- DWD Water Manual 2013
Urban Poor	250 persons per Standpipe	Standpipe coverage

The required number of service connections is given below.

Table 4-17: Required Service Connections

Kitenga RGC	House Conn	Yard Tap	Stand Pipe	No Supply	Total
2020	332	2	28	0	**362**
2025	396	2	33	0	**431**
2030	471	2	39	0	**512**
2035	561	3	47	0	**611**
2040	668	3	56	0	**727**
Total	**2,428**	**12**	**203**	**0**	**2,643**
Source: Project Estimates					

A total of 2,643 No. service connections are to be made in Kitenga RGC in the ultimate year 2040 as seen in Table 4-17 above while 362 will be made in the initial year 2020. However, 400 connections have been allowed for in the initial year to cater for the increase in demand for connections which normally happens during the implementation stage. It has been assumed that the connection materials will be supplied by the project on the payment of the connection fees. The number and location of the public stand posts will be determined during the construction period.

4.4.7 Network Intensification

There are some parts of the proposed water supply areas where the trunk mains are adequate but the mains are too far away for the customers to be able to connect at reasonable cost. As a measure to increase the densification of the distribution networks as a drive to increase the customer base, and allow a neater layout of the service connection pipes, some pipe work intensification will be required.

The intensification lines will be demand-driven, and installed where there are adequate applications for connections. Estimated quantities for this item have thus been included in the Bills of Quantities to cater for this.

4.4.8 O&M Tools and Equipment

Part of the investment will be used to supply new O & M tools and equipment. Equipment will be supplied for the running the water supply system and well as equipping the water office. These will include;

i) Plumbing Tools and Equipment,
ii) Mechanical Tools and Equipment,
iii) Electrical Tools and Equipment,
iv) Miscellaneous Tools,
v) Chemical Equipment and Chemicals.

The proposed tools and equipment are listed in Table 4-18 below.

Table 4-18: Tools and Equipment

Item	Description	Unit	Quantity
	ADMINISTRATION/WORKSHOP/STORE		
1	**Office Equipment**		
1.1	Writing desk, length and width 1,560x780mm, height 750mm with 4 lockable drawers.	No.	4
1.2	Steel office chairs with padded seat and back in black rexine.	No.	8
1.3	Steel cabinet double lockable doors, 4 shelves, height, width and depth 1,950 x 950 x 420 mm, Colour: grey.	No.	1

Item	Description	Unit	Quantity
1.4	Lockable steel filing cabinet with 4 drawers.	No.	1
1.5	Wall safe with a number combination lock, and cash box, minimum outside measurement of safe 1,100 x 900 x 750mm.	No.	1
1.6	Hardwood bookshelf 1.5 x 1.5 x 0.35m.	No.	2
1.7	Desk Top Computer with latest CPU - 15in LED screen, A4 Laser Jet Printer -, UPS -, Stabiliser plus consumables with E-Guard protection from radiation attached to the main frame.	No.	2
1.8	Photocopier A4 size complete with 2 spare drums, 2 toner cartridges and 6 packets of toner, 10 reams of photocopying paper.	No.	1
1.9	Typing desk and chair.	No.	1
2	**Workshop Equipment**		
2.1	Workbenches with dimensions about 2.0 x 1.0 and 0.9m high overall made of heavy gauge steel sheet, having built in tool containers with sliding lockable drawers. The top of the workbench shall be covered with plywood min. 40mm thick.	No.	2
2.2	Steel chairs with plastic seat cover;	No.	6
2.3	Portable grinding machine, electric motor driven, flexible shaft type 120mm fine grained grinding wheel, complete with guard;	No.	1
2.4	Electrically operated hand drilling machines with three-jaw chuck 13mm running on two speeds, left and right, minimum 650 W, equipped with steel brackets to secure the machine for vertical use, complete with all accessories in steel box;	No.	2
2.5	Sets of high speed drills 1 - 10mm, in 0.5 mm grading and 2 sets of 10-24mm HSS drills in 1.0mm grading;	No.	1
2.6	Portable disc grinder 750W electric motor driven for disc diameter of approximate 20cm, including all accessories in steel box, 20Nos, spare discs shall be provided for steel and 20Nos. suitable for concrete/stone cutting.	No.	1
2.7	One lifting tackle (differential trolley hoist) for lifting, dismantling, inspection and maintenance of the pumps capable of lifting a minimum load of 500kg. A suitable cart of the same load capacity shall be provided for the transport of machinery.	No.	1
2.8	20 - 180 Amps portable AC welder with input of 240 V complete with cables, welding helmet and goggles and 4 packets of welding rods (2 - 4 mm dia).	Set	1
2.9	Bench double sided grinding machine as FLOTT type TS 200 or equal complete with four sets of spare carborundum wheels and eye shields.	No.	1
2.10	Blacksmith anvil 100kg with 2 horns as Peddinghaus type 14161 or equal.	No.	1
2.11	Vice with parallel jaw 100mm as Peddinghaus, Matador 10203 for bench mounting.	No.	2
2.12	Bench yoke pipe vice with self locking jaw hook for pipes up to 100 mm dia as Peddinghaus, Pioneer 11054.	No.	1
2.13	Steel lockable cabinets for storage of Tools. 1,200mm x 1,000mm x 400mm, with shelves.	No.	2
3	**Mechanical fitter's Tools and Equipment**		
3.1	0.5kg axe	No.	1
3.2	Brushes, wire type	No.	2
3.3	Calliper, precision slide type, metric unit,	No.	1
3.4	Carpenter chisel from 6.4mm to 25.4mm bevelled edge,	Set	1
3.5	Mason chisel from 25.4mm to 50mm wide blade,	Set	1
3.6	Carpenter's screw clamps, 250mm opening	No.	2
3.7	Ditto but 500mm opening	No.	2
3.8	Square set, metric unit	No.	1
3.9	Crowbars, small, medium, large	Set	1
3.10	Gasket cutter, 600mm	No.	1

Item	Description	Unit	Quantity
3.11	Dividers,	Set	1
3.12	Six assorted files, half round, 250mm, including handle	Set	1
3.13	Spare file handles, 100 x 27mm	No.	5
3.14	3 suitable feelers, in tenths of millimetre and 150mm long	Set	1
3.15	Mechanic's hammer, 1/5, 1/2, 1 and 2 kg	No.	3
3.16	Carpenter's claws 1/5, 1/2. 1 and 2kg	No.	3
.3.17	Sledge hammer, 3kg	No.	3
3.18	Rubber mallet, 1/5, 1/2, 1 and 2kg	No.	4
3.19	Hooks to remove pickings	No.	4
3.20	Metal precision spirit level approx. 600 x 30 x 75 mm overall, 0.025mm/m accuracy	No.	1
3.21	Grease gun, 200ml minimum	No.	1
3.22	Oiler, approx. 200ml capacity, trigger operated, 150mm long flexible spout	No.	1
3.23	Carpenter's pincers, 200mm jointer's shouldered type	No.	2
3.24	Pliers (combination), 150 mm and 200mm wide	Set	1
3.25	Side cutting pliers, 150 mm,	No.	1
3.26	Adjustable pliers, 300mm and 400mm	Set	1
3.27	Round nose pliers, 150mm	No.	1
3.28	Puller set, inside-outside, to suit bearings and couplings incorporated in the equipment	No.	1
3.29	Punches, 1 - 10mm	Set	1
3.30	Reamer, 7 - 17mm	Set	1
3.31	Hack Saw, adjustable tubular frame, length 250-300mm, including 20 Nos. of spare blades,	No.	1
3.32	Sockets, numbers ranging from 2 to 38, with ratchets and handles	Set	1
3.33	Scraper spoon, flat and triangular type	Set	1
3.34	Screw drivers, steel, non-inflammable plastic handle, hammer proof,	Set	1
3.35	Watch maker's screw drivers,	No.	1
3.36	Snips, tin plate cutter, 300mm	No.	1
3.37	Shears, universal, 200mm	No.	1
3.38	Wrench, chain 16 to 100mm capacity	No.	1
3.39	Wrench, pipe 300/400/600/900mm	No.	4
3.40	Wrench, Allen set, numbers ranging from 2 to 38,	No.	1
3.41	Vice, to be fixed to work bench	No.	1
3.42	Open ended spanner, 6-24mm, metric size	Set	1
3.43	Ring spanners, 6-24mm, metric size	Set	1
3.44	Hexagon nut drive spanners, 2-14mm, metric size	Set	1
4	**Plumber's Tools and Equipment**		
4.1	Blowlamp. Pump action, pressure type, approx. 0.5 litre capacity, complete with wind proof nozzle and one set of replacement parts,	No.	2
4.2	Brushes, wire type for cleaning parts, 300mm long, 3 rows of approximately15 tufts with 25mm long steel bristles,	No.	3
4.3	Crowbar	No.	3
4.4	File, flat machinist's, length 250 mm, second cut,	No.	1
4.5	Ditto but smooth cut,	No.	1

Item	Description	Unit	Quantity
4.6	Ditto, but bastard cut,	No.	1
4.7	File, half-round machinist's, length 250 mm, smooth cut,	No.	1
4.8	Ditto, but bastard cut,	No.	1
4.9	File handles, 100 x 27 mm	No.	2
4.10	Hammer, mechanic's, 200 & tempered forged steel head, ash or white hickory handle, polished face,	No.	2
4.11	Level, plumb and spirit, approximately 300 x 25 x 75mm, varnished beech wood or aluminium, class of accuracy 0.025mm/m,	No.	2
4.12	Mattocks,	No.	2
4.13	Pliers, arc joint, minimum 5 adjustments, 240mm long,	No.	1
4.14	Saw, plumber's, 400 mm, fine tooth edge for cutting metal and coarse teeth for cutting wood, complete with blades,	No.	3
4.15	Screw drivers, assorted, hammer-proof, non-inflammable plastic handle	Set	1
4.16	Shovels,	No.	5
4.17	Tape measure, steel, metric units, 5m	No.	5
4.18	Vice, portable type, with tripod stand	No.	1
5	**Electrician's Tools and Equipment**		
5.1	AVO Meter, portable type, as AVO 8, model 8 mk 7 by Megger Instrument Ltd, 0-10 A, 0-300 V AC/DC,	No.	1
5.2	AVO Meter, tongs type, 0-500 A, 0-300 V AC,	No.	1
5.3	AVO Megger Earth Tester	No.	1
5.4	Pliers, combination, 200 mm long, capacity 30mm, with burner hole, side and joint cutters, insulated	No.	1
5.5	Hand lamp 100 W, 220 V with 20m cable	No.	1
5.6	Pliers, electrician's, 150mm long with wire cutter, insulated	No.	1
5.7	Screwdrivers, for electrical/radio work, non-inflammable plastic handle	Set	1
5.8	Screwdriver, for light/phase testing	No.	2
5.9	Screwdriver, Phillips, 75/100/150mm	Set	1
5.10	Soldering iron, 50W electric, including at least one kg of soldering material	No.	1
5.11	Tape measure, steel, metric units; 5m as Stanley	No.	2
5.12	Wire stripper, pliers type for cutting and removing insulation from cable ends up t 10mm2,	No.	2
5.13	Wrenches, Allen, for Nos. 4,6,8, and 10 screws, chrome vanadium alloy steel	Set	1
6	Store Shelving		
6.1	Hardwood shelving about 1,800m high with 4 shelves free standing or fixed against wall for storage of spares and equipment complete.	M	15
7	**Laboratory Equipment - Water Supply**		
7.1	HACH DR 4000 Spectrophotometer.	Set	1
7.2	WTW - Meters for Temperature, pH, EC, TDS and Salinity.	Set	1
7.3	Chlorine Colorimeter, ELE pocket type.	No	1
7.4	Floc Tester with 6 #1No beakers	No	1
7.5	Electronic Laboratory Top Pan Balance as ELE EL 22-5401/01 310 g x 0.001g.	No	1
7.6	Gellenkamp oven with temperature regulation and digital temp read out 150 litre capacity.	No	1
7.7	DO WTW meter plus probe and spare membranes	No	1

Item	Description	Unit	Quantity
7.8	2 plate table top electric heating range.	No	1
7.9	Dixon's Surgical type Autoclave 14 litre capacity.	No	1
7.10	Bacteriological testing equipment	Set	1
8	**Chemical Store**		
8.1	Equipment		
8.1.1	Platform/beam type weighing machine as made by AVERY or equivalent to weigh up to 200 kg with a resolution of 100 gm with a chemical resistant finish complete with all accessories.	No.	1
8.1.2	Stainless steel graduated (metric) buckets (10 litres).	No.	2
8.1.3	Stainless steel scoops for scooping chemicals - 1 kg capacity.	No.	2
8.1.4	Wheelbarrow for transporting chemicals.	No.	2
8.2	Chemicals		
8.2.1	Calcium Hypo chlorite (HTH) 60-70% content of Chlorine in 50 kg barrels	No.	50
8.2.2	Soda Ash in 50kg bags	No.	50
8.2.3	Aluminium Sulphate in 50kg bags	No.	50
9	Miscellaneous Tools		
10.1	Contractor's pick axe with point and chisel steel end, length 800 mm.	No.	4
9.2	Steel hoe, blade width 200 mm, 1.5 kg complete with good wooden handle.	No.	10
9.3	Steel axes 1.5 kg complete with good wooden handle.	No.	4
9.4	Galvanised steel buckets standard round, 20 l.	No.	4
9.5	Seamless pressed tray wheelbarrow, steel frame, with pneumatic wheels, 80 1.	No.	5
9.6	Steel slasher	No.	5
9.7	Steel pangas (machetes)	No.	5
9.8	Steel rakes	No.	5
9.9	Motorised Lawn Mower Heavy duty.	No.	1

5 DETAILED DESIGN – SANITATION

5.1 Background

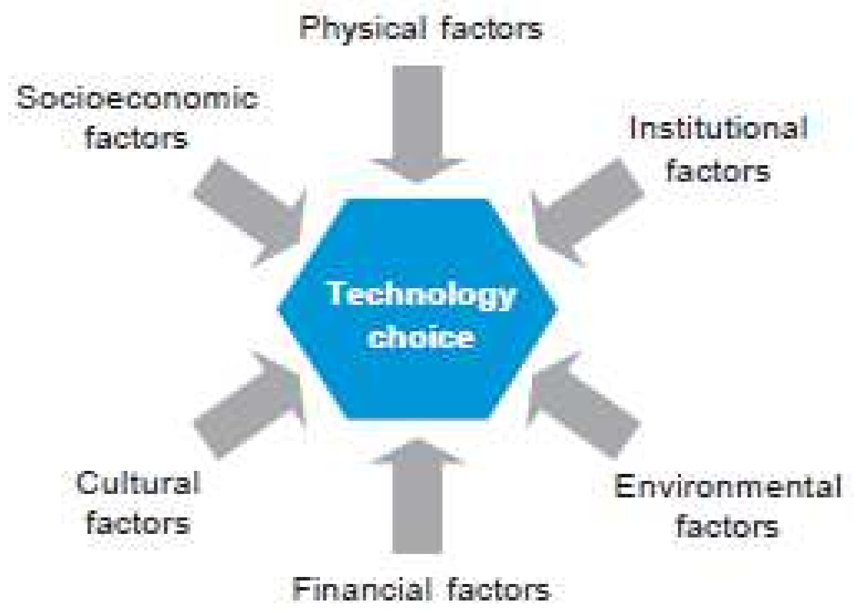
From the SEHS, 98.8% of the households sampled in the RGC claimed to have access to toilet facilities. The types of toilet facilities used by the households and their usage are as follows;

i. Public latrine 36%
ii. Private latrine 62.6%
iii. Dig a hole and bury 1.2%

5.2 Design Objectives

A number of factors have been considered to come up with the technology options. These are presented in Table 5-1 below.

Figure 5.1: Factors affecting the Sanitation Technology Choice



5.2.1 Institutional Factors

These factors are related to the effective O&M arrangements that could be put in place given the financial and human resources available

5.2.2 Physical Factors

Refer to the location, space and ground conditions related to the percolation of the effluent. Population density provides an indicator of the amount of open space for the construction of latrines and treatment systems. In very dense informal settlements, narrow roads may be a constraint for desludging equipment. Other space constraints include

- Insufficient space to store faecal waste – this is more likely to be a problem for vaults that are normally raised above floor level than for pits and tanks which can be located below floor level.

- Insufficient space to allow absorption of waste water into the ground – this is mainly a problem for cistern flush toilets discharging to septic tanks followed by soak aways. Another factor to be taken into account is that seepage from soak pits and soak aways sited close to buildings can cause damp problems in buildings and result in structural damage although damp proof can be used.

Ground conditions include the soil type. The soil type affects the operation of soak aways due to the infiltration capacity of the soil. The table below provides guidance on the maximum volume of waste water that can be infiltrated on-site for different soil types. The last column calculates the maximum theoretical infiltration capacity for a 1m3 (wetted area of 5m3) assuming that there is no constraint due to clogging or water logging. In areas where the ground is rocky, it will be difficult and expensive to install latrines, septic tanks and sewers. In such situations, dry sanitation systems with chambers constructed partially or fully above the ground level may provide a feasible sanitation technology.

Table 5-1: Infiltration Capacities of Different soils

Soil Type	Infiltration Rate		
	mm/hr	m^2/day	Maximum capacity for a 1m^3 pit (litres/ day)
Silt Clay	0-1	0-24	0-120
Sandy Clay	1-4	24-96	120-400
Silt	4-8	96-192	400-1,000
Sand	8-12	192-288	>1,000

5.2.3 Environmental Factors

These factors are concerned with the source of water. Where the community is dependent on boreholes for their drinking water, the possibility of ground water contamination must be considered as this is a potential problem mainly for on-site technologies.

A minimum distance of 10m should be allowed between a soak pit and a shallow well, but this standard will almost be impossible to achieve in most urban settings.

Where the groundwater table is more than 1.5m below the bottom of the pit, the most likely contamination route will be along the side of the well. This suggests that, if off-site technologies are not feasible, the focus then should be on blocking the potential contamination route along the side of the well for instance by using a puddle clay layer.

5.2.4 Socioeconomic Factors

These factors include the level of water supply service (i.e. house connections are feasible with a sewerage system) and the population/ housing density (i.e. onsite systems are more appropriate for less densely populated rural areas).

The total quantity of wastewater produced will depend on water consumption (see Table 5-2), which in turn will depend on the location of the water source and the length of time for which water is available each day. When per capita consumption is relatively low (<30l/c/d) then, depending on ground conditions and population density, it should be possible to deal with all the waste water on-site. When per capita consumption is higher, on–site disposal of black water is still possible, but sullage water will need to be disposed of off-site. Off-site disposal of al waste water will be required if black water and sullage water flows are combined on-site to produce sewage.

Table 5-2: Relationship between Water Use and Wastewater Disposal

Waste water	Level of water use		
	Low (<30 lpcd)	Medium (30-30 lpcd)	High (>80 lpcd)
Black water	Discharge waste water to soak pit on or close to the plot	Soak pit disposal possible if kept separate from sullage. Otherwise sewerage and treatment is required	Soak pit disposal possible if kept separate from sullage. Otherwise sewerage and treatment is required
Sullage (Grey water)	Discharge to soak away or used for garden watering	Soak away disposal may be possible in permeable soils, but off-plot disposal via a drain or sewer will be required	Off –plot disposal, sewerage or drainage required
Source: Urban Sanitation Options			

5.2.5 Cultural Factors

Cultural factors are related to the cultural norms and practices of the community especially as regards, anal cleansing, faecal disposal and the general hygiene practises.

Sanitation systems, even when they are properly designed, may not be appropriate when social and cultural factors affecting sanitation and hygienic practices of the community members are not considered. For instance, technologies involving re-use of excreta are unfeasible in communities where sight or handling of waste is culturally and socially unacceptable. In the same way, dry technologies are inappropriate for communities which prefer water for toilet hygiene. In communities that require a high level of privacy, the design of communal facilities should provide for these requirements.

5.2.6 Financial Factors

The financial factors include the operation and maintenance costs together with the capital costs of the proposed technology option. The costs of the land too where the facility would be located have to be considered.

5.3 Basic Technology Options

As a general rule:

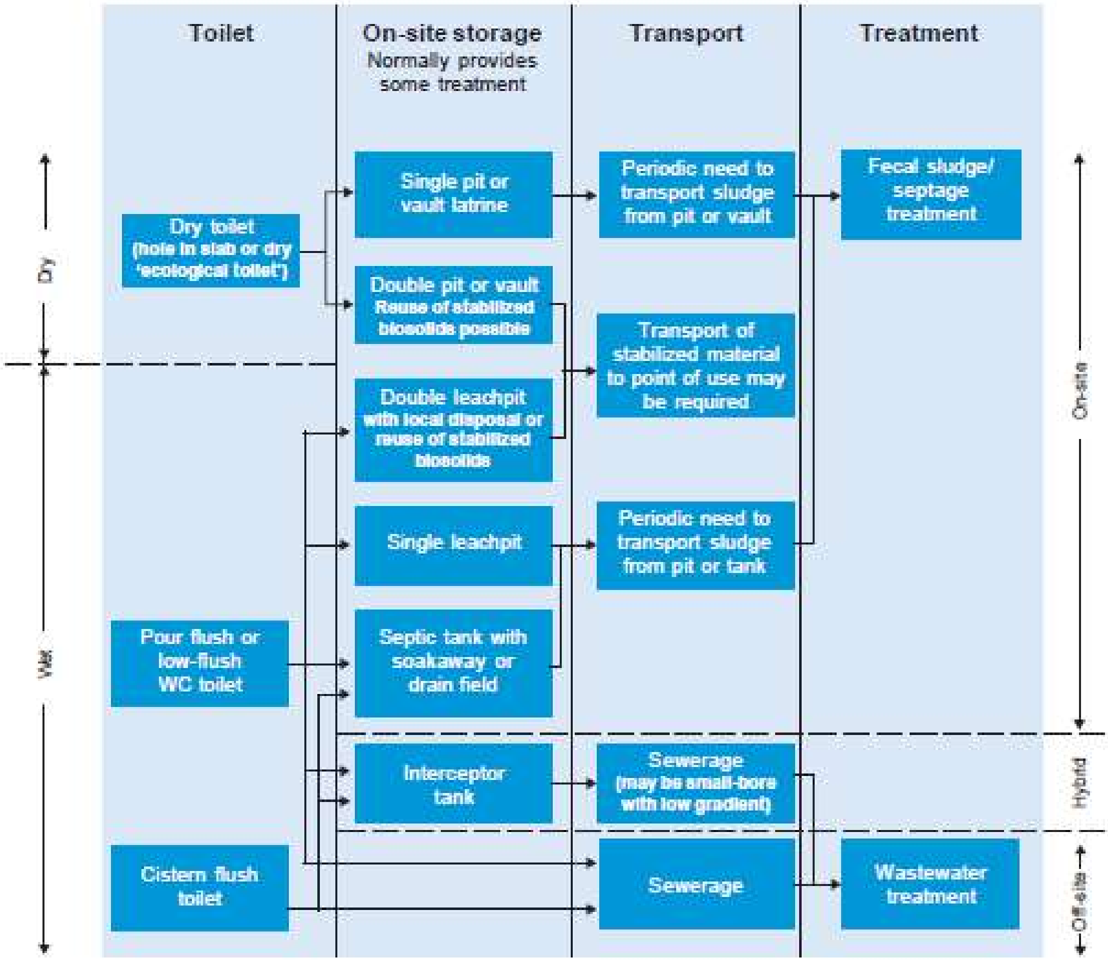
- On-site options will be most appropriate in areas of low-density housing (typically less than 40 housing units per hectare), relatively low water consumption, and ground conditions that allow the absorption of wastewater without harm to an aquifer

- Off-site options will be most appropriate where housing density is high (>40 houses per hectare), there is a reliable water supply on or close to the plot and sufficient fall is available to transport solids through the sewer without pumping.

- On-site disposal of black water via soak pits, with off-site disposal of sullage water may be possible, even for relatively high-density areas and relatively high-water consumption, provided that ground conditions allow that and there is no problem of contaminating water supplies

- Hybrid systems may be appropriate in medium- to high-density areas with a flat topography, particularly where the water table is high.

Figure 5.2: Menu of Technological Options



5.4 Sanitation Assessment

The assessment entails a more detailed analysis of the current situation to reveal what types of improvements are needed and where they will have the most beneficial impact. It gives a further assessment of the existing services from the user's point of view. This will be a guide to knowing the inadequacies in the current systems.

5.5 Proposed Improved Sanitation System Options

As one of the matters arising from the feasibility study, it is proposed to construct 2No. 6 stance water borne toilet for whose location will be proposed by the officials during construction.

5.5.1 Operation and Maintenance of the Proposed Toilets

The public toilet can only be properly maintained when the users are paying a fee set by the local authorities. This can be in the form of;

- A monthly fee being charged to the residents within the locality of the public toilet who would wish to use it, while the non-residents paying and fee for every time, they use the toilet or,
- A standard user fee is charged for using the toilet at any one time.

5.5.2 Faecal Sludge Disposal

When the sanitation facilities are filled up, they have to be emptied and faecal sludge disposed off. This sludge is to be disposed somewhere and according to the Ministry of Water and Environment (National faecal sludge assessment for small towns, 2013). The Ministry proposed that faecal sludge treatment plants should be constructed in selected towns within the country. The towns under WSDF-E that were considered were ranked and Clustered as seen in Table 5-3 below.

Table 5-3: Proposed Small Town Clusters for Faecal Sludge in WSDF-East

Cluster	Proposed Location of treatment/ disposal facility	Potential Towns to be served	Population in Town Cluster
Cluster 1	Busia	Busia, Masafu, Lumino	57,027
Cluster 2	Pallisa	Pallisa, Kibuku, Tirinyi, Kibale,Kadama	54,323
Cluster 3	Kamuli	Kamuli, Kasambirwa, Namwendwa, Bulopa	38,510
Cluster 4	Kumi	Kumi, Bukedea, Ngora,Nyero	50,200
Cluster 5	Sironko	Sironko, Budadiri, Bulengeni, Mutufu	40,949
Cluster 6	Kapchorwa	Kapchorwa, Sipi, Binyiny	29,300
Cluster 7	Kotido	Kotido	24,400
Cluster 8	Nakapiripirit	Nakapiripirit T.C, Amudat T.C, Namalu T.B	14,591
Cluster 9	Mayuge	Mayuge, Buggadde, Bwondha	21,257
Cluster 10	Mbale (NWSC)	Kachumbala, Budaka, Busiu, Ikiki,Butaleja	52,683
Cluster 11	**Iganga (NWSC)**	**Busembatia, Namutumba, Kaliro, Bugiri, Idudi, Namungalwe**	**78,475**
Cluster 12	Tororo (NWSC)	Busolwe, Nagongera	20,471
Cluster 13	Jinja (NWSC)	Lubani-Namagera, Kagoma, Iziru	28,990
Total			**511,175**
Source: MWE 2013; National Faecal Sludge Assessment for Small Towns in Uganda			

Kitenga RGC is located in Bukamba sub-county and is placed in cluster 11 which consists of Busembatia, Namutumba, Kaliro, Bugiri, Idudi, Namungalwe as seen in Table 5-3 above. The waste stabilisation ponds in Iganga constructed in 2008 by Spencon Services are to be used as the proposed treatment facility.

6 FINANCIAL ANALYSIS

6.1 Introduction

The objective of the financial analysis is to show to what extent the cost regarding the implementation and operation of the water supply system, accruing to the operating entity, will be covered by the commercial revenues. The Water Supply system was subjected to a financial analysis to determine their financial viability for Kitenga RGC water supply. The following parameters have been used to evaluate the financial viability of the project:

a) Dynamic Prime Cost (DPC),
b) Internal Rate of Return (IRR),
c) Net Present Value (NPV),
d) Per Capita Investment Costs.

The proposed water supply tariff, of USh 2,500 per cubic metre (US 50/ 20 litres consumed), has been used for the financial analysis of the water supply system and the main inputs into the financial analysis are as follows:

i) Capital Investment Costs.
ii) Capital Reinvestment Costs.
iii) Operation & Maintenance Costs which include: Personnel, Office Running, Energy, Chemical, and Maintenance Costs.
iv) Residual Values of the Assets.

6.2 Capital Investment Cost Estimates

The capital costs are detailed in the Engineer's Estimates in a separate volume (Basis Design Report-Volume 2). They are summarized in Table 6-1 below. All the costs are entirely in Uganda Shillings and have been derived from first principals while others from a combination of the current market prices and from running and previous projects.

Table 6-1: Capital Investment Cost Estimates

Bill No	Description	Investment Costs UShs
	GENERAL	
KIT G-1	General Items	548,400,000
KIT G-2	Method Related Charges	100,000,000
KIT G-3	Dayworks	6,944,200
	WATER SUPPLY, SANITATION AND EQUIPMENT	
KIT W-1	Intake structure works	399,393,169
KIT W-2	Raw Water Transmission Mains	247,966,652
KIT W-3	Treatment Plant Site Works	783,411,057
KIT W-4	Aerator	64,343,893
KIT W-5	Coagulator and Flocculator	200,416,898
KIT W-6	Sedimentation Tank	298,595,232
KIT W-7	Rapid Gravity Filters	405,097,937
KIT W-8	Clear Water Tank and Pump House	228,125,354
KIT W-9	Sludge Drying Beds	163,477,285
KIT W-10	Chemical House	225,109,400
KIT W-11	Laboratory and Workshop	114,772,940
KIT W-12	Clear Water Transmission Mains	341,553,440

KIT W-13	Storage Reservoir and Site Works	402,771,547
KIT W-14	Distribution Network	766,842,285
KIT W-15	Intensification Network	352,148,000
KIT W-16	Water Office Block	110,069,803
KIT ME-1	Mechanical Works	467,460,000
KIT EE-1	Electrical Works	880,555,000
KIT S-1	6 Stance Waterborne Toilet (2No.)	135,910,280
	Sub-Total 1	**7,243,364,372**
	Allow for 10% contingency	724,336,437.16
	Sub-Total 2	**7,967,700,809**
	Allow for 18% VAT	1,434,186,146
	GRAND TOTAL	**9,401,886,954**

6.3 Capital Reinvestment Cost Estimates

The M&E equipment has a usage life of 10 years after which they will need replacing. Re-investment costs for the project have thus been calculated for the replacement of the borehole pumps, MCC Panels, chemical dozers, and mixers in the year 2030. The re-investment costs, are presented in Table 6-2 below.

Table 6-2 Capital Reinvestment Cost Estimates

Bill No	Description	Re-Investment Costs UShs
KIT ME-1	Mechanical Works	352,260,000
KIT EE-1	Electrical Works	34,000,000
	Sub-Total 1	**386,260,000**
	Allow for 10% contingency	38,626,000.00
	Sub-Total 2	**424,886,000**
	Allow for 18% VAT	76,479,480
	GRAND TOTAL	**501,365,480**

6.4 Operation & Maintenance Costs

6.4.1 Personnel Costs

Personnel are required in the project area to operate the water supply system by.

- Operating the system in accordance with the service standards.
- Maintaining the system.
- Developing the system.
- Billing the consumers.
- Collecting revenue.
- Receiving applications for and making new connections.
- Making extensions to the system or assets.
- Attending to all customers.
- Keeping records of the operations of the system.
- Writing status reports for the operations of the system.

The level of personnel and personnel costs are presented in Table 6-3 overleaf.

Table 6-3 Personnel Schedule and Costs

Position	Total Salary	Staff Required	Total Staff Costs
	('000 USh/month)	(No.)	(Mio. USh /year)
Manager	1,000	1	12.0
Accounts Officer	650	1	7.8
Secretary	500	1	6.0
Plumber / Technician	600	3	21.6
Meter Readers	200	4	9.6
Attendant / Guard	180	6	13.0
Total		**16**	**70**
Source: Project Estimates			

6.4.2 Running Costs

The office running costs include stationary, utilities, cleaning and general office costs. They are summarised in Table 6-4 below. These are derived from the levels and costs in similar small towns.

Table 6-4 Office Running Costs

Item	Amount (USh '000/month)	Amount (USh '000/year)
Stationary	50	600
Office Supplies	100	1,200
Transport Costs	100	1,200
Office and Utilities	100	1,200
Cleaning Services	50	600
Total		**4,800**
Source: Project Estimates.		

6.4.3 Chemical Costs

The unit chemical costs are given in Table 6-5 while the annual chemical costs are given in Table 6-7 below. The unit costs are the costs of dosing hypochlorite and alum per m^3 of water produced. These are calculated from the selected dosing rates and market prices of the chemicals.

Table 6-5 Chemical Costs

Chemical	Dosage rate per litre (mg/l)	Dosage rate per cubic metre (g/m^3)	Actual dosage rate per cubic metre (g/m^3)	Cost of chemical per kg (USh)	Cost of chemical for kg/m^3 (USh)
Chlorine	4	4	5.7	6,000	34.3
Alum	10	10	10	2,000	20
Source: Project Estimates					

6.4.4 Energy Costs

The system has been designed to operate for 12 hours daily until 2030 after which operation will increase to 16 hrs. However, the solar power option can provide energy for only 8 hours. Thus, a diesel generator has been provided to augment operation of the system at full capacity. The energy costs summarized below represent the energy required to run the system for 4 hours as the other 8 hours shall be run by solar which has zero (0) energy costs. The unit pumping power costs as seen in Table 6.6

overleaf are based on the cost of running the respective generator sets whose consumption is also shown

Table 6.6: Unit Energy Costs (USh/m^3)

Pump	Generator rating KVA	Average Consumption (l/hr)	Energy (kWh/m^3)	Cost (USh/m^3)
Raw Water Pump	30	6.4	0.10	79.38
Backwash Pump	10	2.6	0.06	83.35
Clear Water Tank	100	21.4	0.30	164.58
Totals			**0.17**	**327.32**

The summary of the annual chemical and energy costs are given in Table 6-7. These are derived from the unit costs above and the annual water production.

Table 6-7 Water Volumes (In '000 m3), Annual Energy & Chemical Costs

Item	2020	2025	2030	2035	2040
Water Produced (in '000 m^3 / year)	211.6	251.9	299.9	357.1	425.1
Losses (in '000 m^3 / year)	42.3	50.4	60.0	71.4	85.0
Water Sold (in '000 m^3 / year)	169.3	201.5	239.9	285.6	340.1
Energy Costs (USh mio. / year)	69.3	82.5	98.2	116.9	139.1
Chemical Costs (USh mio. / year)	7.3	8.6	10.3	12.2	14.6
Maximum Day Demand (in m^3/day)	579.7	690.1	821.6	978.2	1,164.7
Supply hours per day	8.0	9.5	11.3	13.4	16.0
Cost of Water Produced (in USh/m^3)	0	1,231	1,092	975	877
Source: Project Estimates					

6.4.5 Maintenance Costs

The annual maintenance costs are taken as a percentage of the investment costs as given in Table 6-9 below. Since the reinvestment costs include item replacement, their maintenance costs are covered in the maintenance costs derived from the investment costs. The categorized capital investment and reinvestment cost estimates are given in Table 6-8 below.

Table 6-8 Investment & Reinvestment Cost Categories

Item	Estimates (million Ush)
Civil Works	
Structures and Siteworks	4,271.07
Pipelines	2,066.31
Subtotal	**6,337.38**
Mechanical and Electrical Works	
Mechanical and Electrical Works	1,630.32
Subtotal	**1,630.32**
Total	**7,967.70**
Re-Investment Cost Estimates	
Mechanical and Electrical Works	424.89
Total Re-investment Costs	**424.89**
Notes: Preliminaries and Contingencies has been distributed *pro rata* across all items. M&E Re-investment is after 10 years for Pumps, Blowers, Dozers, Mixers, and Surge Compressors.	
Source: Project Estimates	

The annual maintenance costs would therefore be as given in the **Table 6-9** below.

Table 6-9 Annual Maintenance Costs

Item	**Maintenance Cost** (% of Capital Cost)
Structures and Site works	1.0%
Pipe work	1.0%
Mechanical and Electrical Works	5.0%
Solar Items	1.0%
Total	
Source: Project Estimates	

6.5 Residual Values of the Assets

Residual values for the capital investment and reinvestment cost assets were calculated on the basis of the estimated technical-economic service lifetime of each cost item. They are accounted for as negative investment cost occurring in the ultimate design year, 2040.

Residual values are the expected sale value of an asset at the end of its estimated service lifetime. For the M&E items replaced after 10 years a salvage value of 10% was considered as the residual value even though they had reached the end of their estimated service lifetime. Table 6-10 contains residual values of the assets for the water supply system. Table 6-11 contains a recapitulation of the investment capital, re-investment, and operation costs. The cash flows that have been used for the financial analysis are given in Table 6-12 overleaf.

Table 6-10: Residual Value of Assets

Item	**As-New Value year 2020** (million USh)	**As-New Value year 2030** (million USh)	**Theoretical Life span** (years)	**Year of Construction**	**Remaining Value in year 2040** (million USh)
Civil Works					
Structures and Siteworks	4,271.1	-	40	2020	2,135.5
Pipelines	2,066.3	-	30	2020	688.8
Subtotal	**6,337.4**	-			**2,824.3**
Mechanical and Electrical Works					
Mechanical and Electrical Works[a, b]	1,630.3	-	10	2020	163.0
Mechanical and Electrical Works Re-Investment	-	424.9	10	2030	0.0
Subtotal	**1,630.3**	**424.9**			**163.0**
Total	**7,967.7**	**424.9**			**2,987.3**

Notes

a] The mechanical and electrical items have been given a lifespan of 10 years after which re-Investment in their replacement will be carried out.

b] Although the mechanical and electrical items will have attained their theoretical lifespan in 2030, they have been given a salvage value of 10% of their Initial cost.

Source: Project Estimates

Table 6-11: Recapitulation of Capital & Maintenance Costs (USh million)

Item	2020	2025	2030	2035	2040	Total
Capital Costs						
Civil Works	6,337.4					6,337.4
Mechanical / Electrical Items	1,630.3					1,630.3
Total Project Costs	**7,967.7**					**7,967.7**
Reinvestment Costs						

Structures and Siteworks						0
Pipe work						0
Mechanical and Electrical Works			424.9			425
Total Reinvestment Costs	**-**	**-**	**424.9**	**-**	**-**	**424.9**
Operation Costs						
Energy Costs		82.5	98.2	116.9	139.1	**2,038.5**
Chemical Costs		8.6	10.3	12.2	14.6	**213.5**
Maintenance Costs		144.9	144.9	144.9	144.9	**2,897.8**
Personnel Costs		70.0	70.0	70.0	70.0	**1,399.2**
Office Running Costs		4.2	4.2	4.2	4.2	**84.0**
Total Operation Costs		**310.1**	**327.5**	**348.2**	**372.8**	**6,633.1**
Residual Values					**-2,987.3**	**-2,987.3**
Grand Total	**7,967.7**	**310.1**	**752.4**	**348.2**	**-2,614.6**	**12,038.3**
Source: Project Estimates						

6.6 Results of the Analyses

6.6.1 Dynamic Prime Cost

The Dynamic Prime Cost (DPC) of the water supply services has been used as a basis for determining the financial viability of the project. The DPC of a water supply or sanitation project are obtained by dividing the sum of discounted project investment, re-investment and operation costs by the sum of discounted project outputs both considered over the length of the evaluation period. This in effect gives the tariff necessary for the system to operate without subsidy.

In keeping with the practice in DWD, the water supply undertaking is only expected to meet its operation and maintenance costs. In this analysis, both the total DPC (i.e. with both investment, re-investment, and O & M costs considered) and the operation and maintenance DPC have been calculated. Only the latter will be used for project evaluation.

The objective of the Dynamic Unit Cost analysis is to determine the average tariff level necessary in order to recover cost over the evaluation period. According to standard practice, the calculation of Dynamic Unit Cost is based on a present value analysis, according to which the present value of the cost cash flow of the project is to be divided by the present value of the corresponding flow of water consumption over the determined evaluation period.

The main assumptions underlying the calculation of the DPC are:

i) Evaluation period of 10 years of full system operation with the base year 2020,

ii) Main discount rate applied is 5%, which is generally assumed as investment return for social infrastructure projects. In addition rates of 0%, 8%, 10% and 12% are applied.

iii) Unit rates are in USh,

iv) VAT and taxes are excluded,

v) Physical contingencies of 10% are included, and

vi) Cost categories considered are investment cost, reinvestment cost, residual cost, as well as operation and maintenance cost.

The sequence of work steps for the calculation of the Dynamic Prime Cost are as follows:

i) Allocation of project investment cost, respective re-investment cost, indicating a tentative split between civil works, M&E and other equipment;

ii) Estimation and allocation of annual recurrent operation and maintenance costs,

iii) Present value analysis, i.e. calculation of dynamic prime cost per m³ of water consumed adequate to recover costs.

The detailed values of the Dynamic Prime Cost are given in Table 6-12 below.

Table 6-12 Dynamic Prime Costs

Item	Discounted Totals					Dynamic Prime Costs (USh/m^3 consumed)				
	Discounted Rate (%/year)					Discounted Rate (%/year)				
	0%	5%	8%	10%	12%	0%	5%	8%	10%	12%
Total Water Consumed ('000 m^3/year)	**3,987**	**2,236**	**1,660**	**1,386**	**1,173**					
Capital Costs (USh million)										
Project Investments	6,919	6,590	6,407	6,290	6,178	1,735	2,947	3,860	4,539	5,268
Project Re-investments	456	434	422	415	407	114	194	254	299	347
Residual Values	-3,370	-1,876	-1,338	-1,074	-865	-845	-839	-806	-775	-738
Total	**4,006**	**5,148**	**5,491**	**5,631**	**5,720**	**1,005**	**2,302**	**3,308**	**4,063**	**4,878**
Operation Costs (USh million)										
Pumping Costs	1,266	710	527	440	372	318	318	318	318	318
Chemical Costs	171	96	71	59	50	43	43	43	43	43
Maintenance Costs	2,635	1,564	1,198	1,020	879	661	699	722	736	749
Personnel Costs	1,399	830	636	541	467	351	371	383	391	398
Office Running Costs	84	50	38	33	28	21	22	23	23	24
Total	**5,555**	**3,250**	**2,470**	**2,093**	**1,796**	**1,393**	**1,453**	**1,488**	**1,510**	**1,531**
Grand Total	**9,561**	**8,398**	**7,961**	**7,724**	**7,516**	**2,398**	**3,755**	**4,796**	**5,574**	**6,409**
Source: Project Estimates										

6.6.2 Net Present Value

Net present value (NPV) is the present value of an investment's expected cash inflows (water sale revenues and residual values of assets) minus the costs of acquiring and operating the investment (Investment and reinvestment costs, and O&M costs). It compares the present value of money in the initial year 2020 to the present value of money in the ultimate year 2040, taking inflation and returns into account.

If NPV > 0; It means the investment is profitable.

NPV < 0; It means the investment is not profitable.

NPV = 0; It means the investment is neither profitable nor unprofitable.

The detailed values of the Net Present Value are given in Table 6-13 below.

6.6.3 Internal Rate of Return

Internal rate of return (IRR) is the discount/interest rate at which the net present value of an investment becomes zero. In other words, IRR is the discount rate which equates the present value of the future cash flows (positive and negative) of an investment with the initial investment. Using IRR to obtain net present value is known as the discounted cash flow method of financial analysis. The detailed values of the Internal Rate of Return are given in Table 6-13 below.

Table 6-13: Cash Flow Projections, Net Present Values, and Internal Rate of Return

Cash Flows (in USh million)	2020	2025	2030	2035	2040	Net Present Values (USh mio.)				
						0%	5%	8%	10%	12%
Investment	-7,967.7									
Total Operation and Maintenance Costs		-310	-327	-348	-373					
Re-Investment			-425							
Residual Value					2,987					
Revenues (Water)		504	600	714	850					
Net Cash Flows	**-7,967.7**	**194**	**-153**	**366**	**3,465**	**417**	**-3,640**	**-4,708**	**-5,136**	**-5,418**
IRR										**0.3%**
Source: Project Estimates										

6.6.4 Per Capita Investment Costs

The per capita investments and re-investment costs were calculated for the initial year (2020), intermediate year (2030), and the ultimate year (2040). The computations have been based on the served population. The results are given in Table 6-14 below.

Table 6-14 Per Capita Investment & Re-investment Costs

Per Capita Investment Cost	Currency	
	(USh)	(US $)
Resident population - 2019	769,882	203
Resident population - 2020	743,426	196
Resident population - 2025	624,492	164
Resident population - 2030	524,513	138
Resident population - 2035	440,572	116
Resident population - 2040	370,009	97
Re-Investment Cost	**Currency**	
	(USh)	(US $)
Resident population - After 10 years (2030)	27,970	7
Resident population - After 20 years (2040)	19,731	5
Source: Project Estimates		

6.6.5 Summary of Financial Indicators

The results of the analyses are summarised in the Table 6-15 below

Table 6-15 Summary of Financial Indicators

Item	Discounted Totals				
	Discounted Rate (%/year)				
	0%	**5%**	**8%**	**10%**	**12%**
Net Present Value (in USh million)	417	-3,640	-4,708	-5,136	-5,418
Dynamic Prime Cost - O & M (USh/m^3)	1,331	1,382	1,412	1,430	1,448
Dynamic Prime Cost - Total (USh/m^3)	2,416	3,647	4,585	5,285	6,036
Internal Rate of Return	**0.3%**				
Source: Project Estimates					

6.7 Conclusions and Recommendations from the Financial Analysis

6.7.1 Conclusions

The main conclusions are as follows:

1) The Dynamic Prime Cost (DPC) covering the Operation & Maintenance costs at the discounted rate of 5% is USh 1,382 per m^3, which is less than the proposed tariff of USh 2,500 per m^3. If this tariff is charged, the project will cover its O & M costs. This is mainly due to low cost of Water Production due to the use of solar as the power source.

2) The Internal Rate of Return (IRR) is (+0.3%). This means that at the tariff of USh 2,500 per m^3 the system will be able to generate a surplus.

3) As with all DWD implementation projects, investment and re-investment cost recovery is not considered. If the investment and re-investment costs are to be recovered, the tariffs, at the discounted rate of 5%, would have to be at least Ush 3,647.

4) The Net Present Values (NPV) is USh -3,640 million USh at 5% discounted rate. This means that the investment is not profitable at this (5%) discounted rate however becomes profitable when the 0% (Ush, 417 million) is considered.

5) The ultimate year 2040 per capita investment costs are US$ 97. According to the 2013 MWE manual, the average per capita investment cost for 12 towns implemented during the FY 2010/11 by MWE was US$ 40. The usually accepted MWE per capita investment costs range is US$ 60 – 120 and from the analysis made, this system falls in this bracket.

6.7.2 Recommendation

In summary therefore, the investments required Kitenga RGC water supply system are justifiable as seen from the per capita investment costs and the IRR.

7 INSTITUTIONAL AND MANAGEMENT ANALYSIS

7.1 Introduction

The Umbrella organisation (Eastern, Western, Central and Northern) was gazetted by the Ministry of water and Environment to operate and maintain all the water supply and sanitation systems within their regions of operation.

7.2 Umbrella Organisations

For the case of Kitenga RGC Water Supply and Sanitation System, Eastern Umbrella is designated as the proposed Water Authority and Operator for this System due to the fact that the project lies in its area of jurisdiction. The roles of the stakeholder as regards this system are as follows

7.3 The Operator (Eastern Umbrella)

The Operator (Eastern Umbrella) manages the water supply and sanitation system, including:

i) Operating the system in accordance with the set guidelines
ii) Maintaining the system,
iii) Developing the system,
iv) Billing the consumers,
v) Collecting revenue,
vi) Receiving applications for and making new connections,
vii) Making extensions to the system or assets,
viii) Attend to all customers,
ix) Prepare draft business plans for the authority,
x) Prepare regular status reports for the operations of the system,
xi) Maintain regular accounts for submission to the Ministry.
xii) To operate a Management Information System (MIS) as provided by the Ministry.
xiii) Keep records of the operation of the water supply system - both physical and technical,
xiv) Ensures that all accounts are audited,
xv) Set and publish Tariff & Charges

7.4 The Consumer

The consumer has the following obligations:

i) Pay on time for the water used, services provided, and penalties imposed,
ii) Ensure the security of the meter.

7.5 Recommendations

Since the Umbrella has been designated as the organisation in charge of operations and maintenance of all new systems being constructed directly by Ministry of Water and Environment, and due to the fact that umbrella does not have readily available personnel to run the systems after hand over, the following should be encouraged.

- Umbrella should select its proposed staff and forward their names to the contractor for hands on training during the commissioning of the works. This would normally be one month when both the construction supervision engineer and the contractor are present on site.

- Set up a stake holder's workshop to be attended by the major players as regards the project so as to appraise all parties of their roles in the management and operation of the water supply system.

- Ministry through DWD to conduct regular monitoring surveys to establish the performance of Umbrella, and where necessary render assistance to them.

8 ANNEXES

Annex 8.1: Demography
Annex 8.2: Water Demand Calculations
Annex 8.3: Water Supply Design Calculations
Annex 8.4: Design Drawings

Annex 8.1

Demography

Table 8-1: Population Projections

S/County	Parish	Village	Base Population	Population Growth Rates			Total Population					
			2014	2014-2020	2020-2030	2030-2040	2019	2020	2025	2030	2035	2040
Bukamba	Bukamba	Bukamba A	567	3.6%	3.6%	3.6%	675	699	832	991	1,180	1,405
		Bukamba B	643	3.6%	3.6%	3.6%	765	792	943	1,123	1,337	1,592
		Buvulunguti Central	486	3.6%	3.6%	3.6%	579	600	714	850	1,012	1,205
		Kasuleta A	373	3.6%	3.6%	3.6%	444	460	548	652	776	924
		Kasuleta B	389	3.6%	3.6%	3.6%	463	479	570	679	808	962
		Lwamba Beeda	1,674	3.6%	3.6%	3.6%	1,993	2,064	2,457	2,925	3,482	4,146
		Kibuye	1,604	3.6%	3.6%	3.6%	1,909	1,977	2,354	2,803	3,337	3,973
		Nabusira A	518	3.6%	3.6%	3.6%	617	639	761	906	1,079	1,285
		Nabusira B	432	3.6%	3.6%	3.6%	514	532	633	754	898	1,069
		Nakibungulya A	529	3.6%	3.6%	3.6%	630	652	776	924	1,100	1,310
		Nakibungulya B	572	3.6%	3.6%	3.6%	681	705	839	999	1,189	1,416
		Buvulunguti East	329	3.6%	3.6%	3.6%	392	406	483	575	685	816
		Buvulunguti West	680	3.6%	3.6%	3.6%	810	839	999	1,189	1,416	1,686
		Parish Total	**8,797**	**3.5%**	**3.5%**	**3.6%**	**10,472**	**10,844**	**12,909**	**15,370**	**18,299**	**21,789**
	Nangala	Kanabi	1,102	3.6%	3.6%	3.6%	1,312	1,359	1,618	1,926	2,293	2,730
		Kisu A	1,485	3.6%	3.6%	3.6%	1,768	1,831	2,180	2,595	3,089	3,678
		Kitenga	610	3.6%	3.6%	3.6%	726	752	895	1,066	1,269	1,511
		Parish Total	**3,197**	**3.6%**	**3.5%**	**3.5%**	**3,806**	**3,942**	**4,693**	**5,587**	**6,651**	**7,919**
Kitenga RGC Water Supply Project Total			**11,993**	**3.6%**	**3.5%**	**3.6%**	**14,278**	**14,786**	**17,602**	**20,957**	**24,950**	**29,708**

Source: Project Estimates

Table 8-2: Served Population

Parish	Village	% Population Served	Served Population 2019	2020	2025	2030	2035	2040
Bukamba	Bukamba A	60%	405	419	499	595	708	843
	Bukamba B	60%	459	475	566	674	802	955
	Buvulunguti Central	80%	463	480	571	680	810	964
	Kasuleta A	100%	444	460	548	652	776	924
	Kasuleta B	55%	255	263	314	373	444	529
	Lwamba Beeda	80%	1,594	1,651	1,966	2,340	2,786	3,317
	Kibuye	90%	1,718	1,779	2,119	2,523	3,003	3,576
	Nabusira A	70%	432	447	533	634	755	900
	Nabusira B	70%	360	372	443	528	629	748
	Nakibungulya A	90%	567	587	698	832	990	1,179
	Nakibungulya B	80%	545	564	671	799	951	1,133
	Buvulunguti East	70%	274	284	338	403	480	571
	Buvulunguti West	70%	567	587	699	832	991	1,180
	Parish Total	**77%**	**8,083**	**8,371**	**9,965**	**11,864**	**14,125**	**16,819**
Nangala	Kanabi	50%	656	680	809	963	1,147	1,365
	Kisu A	50%	884	916	1,090	1,298	1,545	1,839
	Kitenga	100%	726	752	895	1,066	1,269	1,511
	Parish Total	**60%**	**2,266**	**2,347**	**2,794**	**3,327**	**3,960**	**4,715**
Kitenga RGC Water Supply Project Total		**72%**	**10,349**	**10,718**	**12,759**	**15,191**	**18,085**	**21,534**

Source: Project Estimates

Table 8-3: Institutional Population

Demand Category	Unit	Population						
		2018	2019	2020	2025	2030	2035	2040
Institutions								
Education								
Day Scholars	No.	4,579	4,742	4,910	5,845	6,959	8,286	9,864
Boarding Scholars	No.	0	0	0	0	0	0	0
Commercial / Industrial								
Restaurants/Eating Places	No.	6	6	6	8	9	11	13
Shops	No.	80	83	86	102	122	145	172
Dry Processing Mills	No.	2	2	2	3	3	4	4
Markets	No.	1	1	1	1	2	2	2
Offices	No.	10	10	11	13	15	18	22
Police Posts	No.	1	1	1	1	2	2	2
Churches	No.	2	2	2	3	3	4	4
Mosques	No.	1	1	1	1	2	2	2
Source: Field Surveys and Project Estimates								

Annex 8.2

Water Demand Calculations

Table 8-4: Demand by Enumeration (2019 & 2020)

Parish	Village	Demand Year 2019 (m^3/d)						Demand Year 2020 (m^3/d)					
		Domestic	**Institutions**	**Industrial / Commercial**	**UFW**	**Total Demand**	**Max Day Demand**	**Domestic**	**Institutions**	**Industrial / Commercial**	**UFW**	**Total Demand**	**Max Day Demand**
Bukamba	Bukamba A	12.2	1.6	5.0	4.7	23.6	30.6	12.6	1.7	5.2	4.9	24.4	31.7
	Bukamba B	13.8	1.6	5.0	5.1	25.6	33.3	14.3	1.7	5.2	5.3	26.5	34.5
	Buvulunguti Central	13.9	5.4	0.0	4.8	24.2	31.4	14.4	5.6	0.0	5.0	25.1	32.6
	Kasuleta A	13.4	0.0	0.0	3.3	16.7	21.7	13.8	0.0	0.0	3.5	17.3	22.5
	Kasuleta B	7.7	0.0	0.0	1.9	9.6	12.5	7.9	0.0	0.0	2.0	9.9	12.9
	Lwamba Beeda	48.0	0.0	0.0	12.0	60.0	78.0	49.7	0.0	0.0	12.4	62.1	80.8
	Kibuye	51.7	0.0	0.0	12.9	64.6	84.0	53.6	0.0	0.0	13.4	66.9	87.0
	Nabusira A	13.0	0.0	0.0	3.3	16.3	21.1	13.5	0.0	0.0	3.4	16.8	21.9
	Nabusira B	10.8	0.0	0.0	2.7	13.5	17.6	11.2	0.0	0.0	2.8	14.0	18.2
	Nakibungulya A	17.1	0.7	0.0	4.4	22.2	28.8	17.7	0.7	0.0	4.6	23.0	29.9
	Nakibungulya B	16.4	0.7	0.0	4.3	21.4	27.8	17.0	0.7	0.0	4.4	22.1	28.7
	Buvulunguti East	8.3	0.0	0.0	2.1	10.3	13.4	8.6	0.0	0.0	2.1	10.7	13.9
	Buvulunguti West	17.1	0.0	0.0	4.3	21.3	27.7	17.7	0.0	0.0	4.4	22.1	28.7
	Parish Total	**243**	**10**	**10**	**66**	**329**	**428**	**252**	**10**	**10**	**68**	**341**	**443**
Nangala	Kanabi	19.7	2.4	0.0	5.5	27.7	36.0	20.5	2.5	0.0	5.7	28.7	37.3
	Kisu A	26.6	2.4	0.0	7.3	36.3	47.2	27.6	2.5	0.0	7.5	37.6	48.9
	Kitenga	21.9	8.0	0.0	7.5	37.3	48.5	22.6	8.3	0.0	7.7	38.6	50.2
	Parish Total	**68.2**	**12.8**	**0.0**	**20**	**101**	**132**	**70.6**	**13.3**	**0.0**	**21**	**105**	**136**
Kitenga RGC Water Supply Project Total		**312**	**23**	**10**	**86**	**431**	**560**	**323**	**24**	**10**	**89**	**446**	**580**

Source: Project Estimates

Table 8-5: Demand by Enumeration (2025 & 2030)

Parish	Village	Demand Year 2025 (m^3/d)						Demand Year 2030 (m^3/d)					
		Domestic	Institutions	Industrial / Commercial	UFW	Total Demand	Max Day Demand	Domestic	Institutions	Industrial / Commercial	UFW	Total Demand	Max Day Demand
Bukamba	Bukamba A	15.0	2.0	6.2	5.8	29.1	37.8	17.9	2.4	7.4	6.9	34.6	45.0
	Bukamba B	17.0	2.0	6.2	6.3	31.6	41.0	20.3	2.4	7.4	7.5	37.6	48.9
	Buvulunguti Central	17.2	6.7	0.0	6.0	29.8	38.8	20.5	7.9	0.0	7.1	35.5	46.2
	Kasuleta A	16.5	0.0	0.0	4.1	20.6	26.8	19.6	0.0	0.0	4.9	24.5	31.9
	Kasuleta B	9.4	0.0	0.0	2.4	11.8	15.3	11.2	0.0	0.0	2.8	14.1	18.3
	Lwamba Beeda	59.2	0.0	0.0	14.8	74.0	96.1	70.4	0.0	0.0	17.6	88.0	114.5
	Kibuye	63.8	0.0	0.0	15.9	79.7	103.6	75.9	0.0	0.0	19.0	94.9	123.4
	Nabusira A	16.0	0.0	0.0	4.0	20.0	26.1	19.1	0.0	0.0	4.8	23.9	31.0
	Nabusira B	13.3	0.0	0.0	3.3	16.7	21.7	15.9	0.0	0.0	4.0	19.9	25.8
	Nakibungulya A	21.0	0.8	0.0	5.5	27.3	35.5	25.0	1.0	0.0	6.5	32.5	42.3
	Nakibungulya B	20.2	0.8	0.0	5.3	26.3	34.2	24.1	1.0	0.0	6.3	31.3	40.7
	Buvulunguti East	10.2	0.0	0.0	2.5	12.7	16.5	12.1	0.0	0.0	3.0	15.1	19.7
	Buvulunguti West	21.0	0.0	0.0	5.3	26.3	34.2	25.1	0.0	0.0	6.3	31.3	40.7
	Parish Total	**300**	**12**	**12**	**81**	**406**	**528**	**357**	**15**	**15**	**97**	**483**	**628**
Nangala	Kanabi	24.4	3.0	0.0	6.8	34.2	44.4	29.0	3.6	0.0	8.1	40.7	52.9
	Kisu A	32.8	3.0	0.0	9.0	44.8	58.2	39.1	3.6	0.0	10.7	53.3	69.3
	Kitenga	26.9	9.8	0.0	9.2	46.0	59.8	32.1	11.7	0.0	10.9	54.7	71.2
	Parish Total	**84.1**	**15.8**	**0.0**	**25**	**125**	**162**	**100.1**	**18.9**	**0.0**	**30**	**149**	**193**
Kitenga RGC Water Supply Project Total		**384**	**28**	**12**	**106**	**531**	**690**	**457**	**34**	**15**	**126**	**632**	**822**

Source: Project Estimates

Table 8-6: Demand by Enumeration (2030 & 2040)

Parish	Village	Demand Year 2035 (m^3/d)						Demand Year 2040 (m^3/d)					
		Domestic	Institutions	Industrial / Commercial	UFW	Total Demand	Max Day Demand	Domestic	Institutions	Industrial / Commercial	UFW	Total Demand	Max Day Demand
Bukamba	Bukamba A	21.3	2.9	8.8	8.2	41.2	53.6	25.4	3.4	10.5	9.8	49.0	63.8
	Bukamba B	24.1	2.9	8.8	8.9	44.7	58.2	28.8	3.4	10.5	10.7	53.3	69.2
	Buvulunguti Central	24.4	9.5	0.0	8.5	42.3	55.0	29.0	11.3	0.0	10.1	50.3	65.4
	Kasuleta A	23.4	0.0	0.0	5.8	29.2	38.0	27.8	0.0	0.0	7.0	34.8	45.2
	Kasuleta B	13.4	0.0	0.0	3.3	16.7	21.7	15.9	0.0	0.0	4.0	19.9	25.9
	Lwamba Beeda	83.8	0.0	0.0	21.0	104.8	136.3	99.8	0.0	0.0	25.0	124.8	162.2
	Kibuye	90.4	0.0	0.0	22.6	113.0	146.9	107.6	0.0	0.0	26.9	134.5	174.9
	Nabusira A	22.7	0.0	0.0	5.7	28.4	36.9	27.1	0.0	0.0	6.8	33.8	44.0
	Nabusira B	18.9	0.0	0.0	4.7	23.7	30.7	22.5	0.0	0.0	5.6	28.2	36.6
	Nakibungulya A	29.8	1.2	0.0	7.7	38.7	50.4	35.5	1.4	0.0	9.2	46.1	60.0
	Nakibungulya B	28.6	1.2	0.0	7.5	37.3	48.5	34.1	1.4	0.0	8.9	44.4	57.7
	Buvulunguti East	14.4	0.0	0.0	3.6	18.0	23.5	17.2	0.0	0.0	4.3	21.5	27.9
	Buvulunguti West	29.8	0.0	0.0	7.5	37.3	48.5	35.5	0.0	0.0	8.9	44.4	57.7
	Parish Total	**425**	**18**	**18**	**115**	**575**	**748**	**506**	**21**	**21**	**137**	**685**	**891**
Nangala	Kanabi	34.5	4.3	0.0	9.7	48.5	63.0	41.1	5.1	0.0	11.5	57.7	75.0
	Kisu A	46.5	4.3	0.0	12.7	63.4	82.5	55.4	5.1	0.0	15.1	75.5	98.2
	Kitenga	38.2	13.9	0.0	13.0	65.2	84.7	45.5	16.6	0.0	15.5	77.6	100.9
	Parish Total	**119.2**	**22.4**	**0.0**	**35**	**177**	**230**	**141.9**	**26.7**	**0.0**	**42**	**211**	**274**
Kitenga RGC Water Supply Project Total		**544**	**40**	**18**	**150**	**752**	**978**	**648**	**48**	**21**	**179**	**896**	**1,165**

Source: Project Estimates

Annex 8.3

Water Supply Design Calculations

Figure 8.1: Water Quality Test Sample 1

NATIONAL WATER AND SEWERAGE CORPORATION

CENTRAL LABORATORY - BUGOLOBI

P.O BOX 7053 KAMPALA Email: waterquality@nwsc.co.ug

CERTIFICATE OF ANALYSIS

CLIENT: Alinea Uganda Limited **Serial No: ES/RF/2019/1858**

Address: Ntinda **Sampled by: Client's Staff**

Date Sample Received: 19/09/2019 **Date of Report: 08/10/2019**

Parameters	Units	DWD 24687 Borehole water	National Standards for Natural potable water
Sample Number	--	K5079/2019/C/B	
Alkalinity: Total	mg/L	340	500
Bact: Faecal coliforms	CFU/100mL	0	0
Bicarbonate	mg/L	414.8	500
Calcium: Ca^{2+}	mg/L	145.6	150
Colour (apparent)	PtCo	0	50
Electrical Conductivity (EC)	uS/cm	1934	2500
Fluoride	mg/L	0.21	1.5
Hardness: Total	mg/L	**876**	600
Iron:Total	mg/L	0.020	0.300
Magnesium:Mg^{2+}	mg/L	**122.88**	100
pH(Physical-Chemical)	-------	7.00	5.5-9.5
Salinity	ppt	0.0	NS
Sulphate	mg/L	240	400
Total Dissolved Solids (TDS)	mg/L	1237.76	1500
Total Phosphorous (TP)	mg/L	0.218	NS
Total Suspended Solids(TSS)	mg/L	0	0
Turbidity	NTU	0.38	25

Remarks

The water sample showed complying physiochemical and bacteriological characteristics with exception of Hardness and Magnesium as compared to the National Standards for Natural potable water.

ANALYSED BY: Robinah Muhairwe and Araa Kennedy

AUTHORISED BY: **Manager Central Laboratory Services:** ....

APPROVED BY: **Senior Manager - Water Quality Management Department:** ....

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Figure 8.2: Water Quality Test Sample 2

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CLIENT: Alinea Uganda Limited — **Serial No: ES/RF/2019/1858**

Address: Ntinda — **Sampled by: Client's Staff**

Date Sample Received: 19/09/2019 — **Date of Report: 08/10/2019**

Parameters	Units	WDD 4254 Underground water	National Standards for Natural potable water
Sample Number	--	K5077/2019/C/B	
Alkalinity: Total	mg/L	740	500
Bact: Faecal coliforms	CFU/100mL	0	0
Bicarbonate	mg/L	902.8	500
Calcium: Ca^{2+}	mg/L	155.2	150
Colour (apparent)	PtCo	0	50
Electrical Conductivity (EC)	uS/cm	1508	2500
Fluoride	mg/L	0.41	1.5
Hardness: Total	mg/L	810	600
Iron:Total	mg/L	0.021	0.300
Magnesium:Mg^{2+}	mg/L	101.28	100
pH(Physical-Chemical)	-------	7.06	5.5-9.5
Salinity	ppt	0.0	NS
Sulphate	mg/L	180	400
Total Dissolved Solids (TDS)	mg/L	965.12	1500
Total Phosphorous (TP)	mg/L	0.262	NS
Total Suspended Solids(TSS)	mg/L	0	0
Turbidity	NTU	0.41	25

Remarks

The water sample showed complying physiochemical and bacteriological characteristics with exception of Alkalinity, Bicarbonate, Calcium, Hardness and Magnesium as compared to the National Standards for Natural potable water.

ANALYSED BY: Robinah Muhairwe and Araa Kennedy

AUTHORISED BY: Manager Central Laboratory Services: ....

APPROVED BY: Senior Manager - Water Quality Management Department: ....

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Figure 8.3: Water Quality Test Sample 3

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CENTRAL LABORATORY - BUGOLOBI

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CLIENT: Alinea Uganda Limited **Serial No: ES/RF/2019/1858**

Address: Ntinda **Sampled by: Client's Staff**

Date Sample Received: 19/09/2019 **Date of Report: 08/10/2019**

Parameters	Units	DWD 66315 Underground water	National Standards for Natural potable water
Sample Number	--	K5074/2019/C/B	
Alkalinity: Total	mg/L	48	500
Bact: Faecal coliforms	CFU/100mL	1	0
Bicarbonate	mg/L	58.56	500
Calcium: Ca^{2+}	mg/L	443.2	150
Colour (apparent)	PtCo	0	50
Electrical Conductivity (EC)	uS/cm	4720	2500
Fluoride	mg/L	0.17	1.5
Hardness: Total	mg/L	3380	600
Iron:Total	mg/L	0.011	0.300
Magnesium:Mg^{2+}	mg/L	545.28	100
pH(Physical-Chemical)	-------	6.90	5.5-9.5
Salinity	ppt	2.6	NS
Sulphate	mg/L	257	400
Total Dissolved Solids (TDS)	mg/L	3020	1500
Total Phosphorous (TP)	mg/L	0.265	NS
Total Suspended Solids(TSS)	mg/L	0	0
Turbidity	NTU	0.55	25

Remarks

The water sample showed complying physiochemical characteristics with exception of Calcium, EC, Hardness, Magnesium and Total Dissolved Solids as compared to the National Standards for Natural potable water. However, the bacteriological characteristics did not comply with the National Standards for Natural potable water.

ANALYSED BY: Robinah Muhairwe and Araa Kennedy

AUTHORISED BY: Manager Central Laboratory Services: ....

APPROVED BY: Senior Manager - Water Quality Management Department: ....

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Figure 8.4: Water Quality Test Sample 4

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CENTRAL LABORATORY - BUGOLOBI

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CLIENT: Alinea Uganda Limited **Serial No: ES/RF/2019/1858**

Address: Ntinda **Sampled by: Client's Staff**

Date Sample Received: 19/09/2019 **Date of Report: 08/10/2019**

Parameters	Units	DWD 36078 Underground water	National Standards for Natural potable water
Sample Number	--	K5075/2019/C/B	
Alkalinity: Total	mg/L	344	500
Bact: Faecal coliforms	CFU/100mL	0	0
Bicarbonate	mg/L	419.68	500
Calcium: Ca^{2+}	mg/L	545.6	150
Colour (apparent)	PtCo	0	50
Electrical Conductivity (EC)	uS/cm	6360	2500
Fluoride	mg/L	0.26	1.5
Hardness: Total	mg/L	2230	600
Iron:Total	mg/L	0.018	0.300
Magnesium:Mg^{2+}	mg/L	207.84	100
pH(Physical-Chemical)	-------	6.86	5.5-9.5
Salinity	ppt	3.6	NS
Sulphate	mg/L	285	400
Total Dissolved Solids (TDS)	mg/L	4070	1500
Total Phosphorous (TP)	mg/L	0.197	NS
Total Suspended Solids(TSS)	mg/L	0	0
Turbidity	NTU	0.31	25

Remarks

The water sample showed complying physiochemical and bacteriological characteristics with exception of Calcium, EC, Hardness, Magnesium and TDS as compared to the National Standards for Natural potable water.

ANALYSED BY: Robinah Muhairwe and Araa Kennedy

AUTHORISED BY: **Manager Central Laboratory Services:** ....

APPROVED BY: **Senior Manager - Water Quality Management Department:** ....

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Table 8-7: Pumping Mains

Parameter	Raw Water Pumping Main	Backwash Line	Clear Water Pumping Main
Demand- 2040 (m^3/day)	**1,164.68**	**58.23**	**1,164.68**
Treatment Plant Use (5%) (m^3/day)	**58.23**	**0.00**	**0.00**
Total Amount of Water Abstracted (m^3/day)	**1,222.92**	**58.23**	**1,164.68**
Hours of Pumping (hr)	16	2	16
Efficiency (%)	60.0%	60.0%	60.0%
Required Delivery (m^3/hr)	76.43	29.12	72.79
Required Delivery (m^3/s)	0.0212	0.0081	0.0202
Pump Installation Level (m amsl)	1030.000	1043.000	1043.000
Inlet Level (m amsl)	1043.000	1053.000	1075.550
Static Lift (m)	13.0	10.0	32.6
Hazen Williams Coefficient, Cwh (C)	140	140	140
Pipe Details	**DN150 ST PN6**	**OD100 HDPE PN6**	**OD160 uPVC PN10**
Pipe Diameter ND (mm)	150.00	103.00	144.60
Pipe Diameter ND (m)	0.150	0.103	0.145
Velocity (m/s)	1.201	0.971	1.231
Flow in Pipe (m^3/s)	0.0212	0.0081	0.0202
Length of Pipe (m)	**1520**	**60**	**5040**
Friction Loss (m)	14.1	0.6	51.2
Fittings losses - 10% (m)	1.4	0.1	5.1
Total Friction Loss (m)	14.1	0.6	51.2
Total Head (m)	**28.6**	**10.6**	**88.9**
Head Used (m)	**29**	**11**	**89**
Power (kW)	**10.1**	**1.5**	**29.4**
Source: Project Estimates			

Table 8-8: Aerator Design Calculations

	Units	Value
Water Flow to Treat	m^3/day	862.69
	m^3/hr	53.92
	m^3/s	0.01
Number of Trays	Nr	3
Water Fall between Trays	mm	450
Difference in Height between Trays floor and soffit of upper floor slabs	mm	300
Height of Tray Copings	mm	150
Increase in Diameter with each Tray	mm	200
Internal Wall Clearance of Collection Chamber from Bottom Tray	mm	400
Thickness of Tray Slabs	mm	150
Internal Height Clearance from Collection Chamber Floor Slab to Bottom Tray	mm	1500
Height of Aerator from Floor Slab to Bellmouth	mm	3000
Internal Diameter of Tray 1- Top Tray	mm	700
Internal Diameter of Tray 2- Middle Tray	mm	900
Internal Diameter of Tray 3- Bottom Tray	mm	1100
Internal Width of Aerator Collection Chamber	mm	3000
Internal Depth of Aerator Collection Chamber	mm	1500
Internal Diameter of Centre Column	mm	450

Calculation of Tray Weir Loading			
Tray Number	**Weir Length**	**Weir Loading**	**Comments**
	(m)	(m^3/hr/m)	
Tray 1- Top Tray	2.200	34.742	OK!
Tray 2- Middle Tray	2.829	27.022	OK!
Tray 3- Bottom Tray	3.457	22.109	OK!
Design Criteria			
Weir Loading Rates- per metre length of weir	20 - 100	(m^3/hr/m)	

Table 8-9: Mixing Chamber Calculations

		Design
Flow into Rapid Mixing Chamber	m^3/hr	53.92
	m^3/s	0.0150
Detention Period	seconds	30
Volume of Water to be handled by Mixing Tank	m^3	0.449
Average Velocity of Flow	m/s	0.2
Total Distance of Flow by Water	m	6.0
Cross-sectional area of channels between baffles	m^2	0.075
Distance Between Baffles (Baffle spacing)	m	0.450
Minimum Depth of Channel required	m	0.166
Length of Channel / Internal Width of Mixing Chamber	m	2.0
Clear Distance between baffle and wall end	m	0.675
Effective Length of each Channel / each Baffle Length	m	1.325
Number of Channels required for mixing chamber	Nr	5
Summary of Rapid Mixing Tank		
Internal Width of Chamber	***m***	***2.00***
Internal Length of Chamber	***m***	***4.80***
Internal Depth of Chamber	***m***	***1.50***
Length of each Baffle Wall	***m***	***1.325***
Baffle Spacing / Channel Width	***m***	***0.45***
Baffle Wall Thickness	***m***	***0.1***
Clear Opening at Baffle End	***m***	***0.675***
No. of Channels in Mixing Chamber	***Nr***	***5***
No. of Baffle Walls in Mixing Chamber	***Nr***	***5***

Table 8-10: Vertical Flow Baffled Flucculator Wall Calculations

		Design
Total Flow rate	l/s	14.98
Total Flow rate	m^3/s	0.0150
No of Flocculator Channels (Lanes)	Nr	2
Flow Rate per lane	l/s	7.5
Flow Rate per lane	m^3/s	0.0075
Depth of flow at US end of channel (flocculator outlet)	mm	1500
Width of channel	m	1.00
No of Concrete Baffle Walls (Weirs)	Nr	2
No of Steel Baffle Walls	Nr	3
Baffle Spacing	m	1.00
Upflow Velocity	m/s	0.00749
Upflow Velocity	m/h	27.0
Total Length of Mixing Section	m	6.50
Total Volume Retained	m^3	9.75

Hydraulic Retention Time (in secs)	secs	1301.97
Hydraulic Retention Time (in mins)	mins	21.70
Height of Orifice under Steel Baffle Plates	mm	200
Total Length of Channel	m	7.60
Summary of Vertical Flow Flocculator		
No. of Channels in Flocculator	***Nr***	***2***
No of Concrete Baffle Walls (Weirs)	***Nr***	***2***
No of Steel Baffle Walls	***Nr***	***3***
Internal Width of each Channel	***m***	***1.00***
Internal Length of each Channel	***m***	***6.90***
Internal Water Depth of each Channel	***m***	***1.50***
Baffle Spacing	***m***	***1.00***
Concrete Baffle Wall Thickness	***m***	***0.20***
Clear Opening under Steel Baffle Plates	***m***	***0.20***

Table 8-11: Sedimentation Tank Calculations

	Standards	**Design**	
Flow into Sedimentation Tanks		**53.92**	m^3/hr
		862.69	m^3/day
No of Sedimentation Tanks		**2**	No
Flow into each Sedimentation Tank		**26.96**	m^3/hr
Detention Time	*3-5 hrs*	*3.00*	*hrs*
Effective Volume of each Sedimentation Tank		**80.88**	m^3
Sludge depth		**0.50**	m
Total Volume of each Sedimentation Tank		**94.36**	m^3
Outlet Over Flow Weir	*< 450 $m^3/m/day$*	*215.67*	*$m^3/m/day$*
Sedimentation Tank Dimensions			
Clear depth		**3.00**	m
Total Tank Depth		***3.50***	*m*
Surface Area		**26.96**	m^2
Surface Loading Rate(SLR)- [16 hr operating day]	*15 - 25 m/day*	*16.00*	*m/day*
	0.94 - 1.56m/hr	*1.00*	*m/hr*
Length of each Sedimentation Tank		**14.00**	m
Width of each Sedimentation Tank		**1.93**	m
Length to Width Ratio	3:1	**7.27**	
Length to Depth Ratio	4:1	**4.67**	
Circular Dimensions (If required), Diameter		**5.9**	m
Cross Sectional Flow Area		**6.00**	m^2
Horizontal Flow Velocity	*4 - 36m/hr*	*4.49*	*m/hr*
	0.0011- 0.010m/s	*0.00125*	*m/s*
Summary of Sedimentation Tanks			
Internal Width of each Tank		**2.00**	**m**
Internal Length of each Tank		**14.00**	**m**
Water Internal Depth of each Tank- Shallow End		**3.00**	**m**
Water Internal Depth of each Tank- Deep End		**4.00**	**m**

Table 8-12: Rapid Gravity Filter Calculations

		Design
Flow into Rapid Sand Filters	m^3/hr	**53.92**
Number of Filters	Nr	2
Flow into each Rapid Sand Filters	m^3/hr	27.0
Filtration Rate	m/hr	5.0
Design Filter Surface Area	m^2	5.39
Filter Sand Bed Width	***m***	***2.00***
Filter Sand Bed Length	***m***	***2.70***
Height of Water above Filter Sand Bed	***m***	***2.00***
Summary of Rapid Sand Filters		
Filter Sand Bed Width	**m**	**2.00**
Width of Washwater Channel	**m**	**0.50**
Filter Internal Width	**m**	**2.70**
Filter Internal Length	**m**	**3.00**
Height of Water above Filter Sand Bed	**m**	**2.00**
Total Internal Length of Filter	**m**	**5.40**
Actual Filter Surface Area	m^2	6.00

Table 8-13: Clear Water Tank Calculations

Clear Water Tank		**Design**	
Flow into Clear Water Tank	m^3/hr	53.92	
Chlorine Contact Time	hrs	0.50	
Suction Time	hrs	1.00	
Total Time in Contact Tank	hrs	1.50	
Volume of Contact Tank	m^3	81.00	
Summary of Clear Water Tank		**Storage**	**Chlorine**
Volume of Contact Tank Considered	m^3	**54.0**	**27.0**
Depth to Top Water Level	**m**	**3.85**	**3.97**
Internal Depth of Contact Tank	**m**	**4.85**	**4.45**
Effective Internal Length of Contact Tank	**m**	**5.1**	**5.10**
Total Internal Length of Contact Tank	**m**	**5.10**	**5.50**
Effective Internal Width of Contact Tank	**m**	**2.80**	**1.30**
Total Internal Width of Contact Tank	**m**	**2.80**	**1.70**
No of Tank Compartments		**1**	**2**
Internal Width of each Compartment	**m**	**3.00**	**0.65**
Circular Dimensions (If required), Diameter	**m**	**3.8**	**2.8**

Table 8-14: Distribution Network Node Details

Node ID	Elevation (m.a.s.l)	Base Demand (lps)	Off Peak Flows (Peak Factor=0.5)			Normal Peak Flows (Peak Factor=1.0)			Peak Flows (Peak Factor=2.0)		
			Demand (lps)	Hydraulic Gradient (m.a.s.l)	Residual Pressure (m)	Demand (lps)	Hydraulic Gradient (m.a.s.l)	Residual Pressure (m)	Demand (lps)	Hydraulic Gradient (m.a.s.l)	Residual Pressure (m)
Junc N01	1074.943	0	0	1085.14	10.2	0	1085.13	10.19	0	1085.08	10.13
Junc N02	1056.145	0.35	0.17	1084.98	28.83	0.35	1084.54	28.39	0.7	1082.93	26.79
Junc N03	1053.424	0.35	0.17	1084.62	31.2	0.35	1083.24	29.82	0.7	1078.27	24.84
Junc N04	1075.08	0.61	0.31	1085.14	10.06	0.61	1085.11	10.03	1.22	1085.01	9.93
Junc N05	1059.902	1.01	0.5	1085.08	25.18	1.01	1084.91	25.01	2.02	1084.28	24.37
Junc N06	1051.606	0.61	0.31	1084.65	33.05	0.61	1083.36	31.75	1.22	1078.68	27.07
Junc N07	1049.269	0.81	0.41	1084.37	35.1	0.81	1082.33	33.06	1.62	1074.98	25.71
Junc N08	1060.436	0.38	0.19	1084.93	24.49	0.38	1084.34	23.9	0.76	1082.22	21.79
Junc N09	1053.83	0.38	0.19	1084.83	31	0.38	1084.01	30.18	0.76	1081.04	27.21
Junc N10	1057.326	0.14	0.07	1084.52	27.2	0.14	1082.89	25.56	0.28	1076.99	19.66
Junc N11	1047.038	0.61	0.31	1084.02	36.98	0.61	1081.07	34.04	1.22	1070.43	23.4
Junc N12	1056.285	0	0	1084.77	28.49	0	1083.79	27.5	0	1080.22	23.94
Junc N13	1057.07	0.87	0.44	1084.44	27.37	0.87	1082.57	25.5	1.74	1075.84	18.77
Junc N14	1040.21	0.82	0.41	1083.28	43.07	0.82	1078.38	38.17	1.64	1060.72	20.51
Junc N15	1047.45	0.61	0.31	1083.41	35.96	0.61	1078.87	31.42	1.22	1062.46	15.01
Junc N16	1070.08	0.47	0.23	1084.69	14.61	0.47	1083.51	13.43	0.94	1079.21	9.13
Junc N17	1040.08	0.47	0.23	1083.12	43.04	0.47	1077.81	37.73	0.94	1058.65	18.57
Junc N18	1044.11	0.47	0.23	1083.3	39.19	0.47	1078.49	34.38	0.94	1061.1	16.99
Junc N19	1046.8	0.61	0.31	1083.13	36.33	0.61	1077.85	31.05	1.22	1058.81	12.01
Junc N20	1051.79	0.47	0.23	1084.07	32.28	0.47	1081.25	29.46	0.94	1071.07	19.28
Junc N21	1054.23	1.54	0.77	1084.27	30.04	1.54	1081.99	27.76	3.08	1073.74	19.51
Junc N22	1061.91	0.61	0.31	1084.07	22.16	0.61	1081.24	19.33	1.22	1071.05	9.14
Junc N23	1062.26	1.31	0.65	1084.33	22.07	1.31	1082.18	19.92	2.62	1074.42	12.16
Resvr Kitenga_Rsvr	1085.15	#N/A	-6.75	1085.15	0	-13.5	1085.15	0	-27	1085.15	0

Source: Project Estimates

Table 8-15: Distribution Network Pipe Details

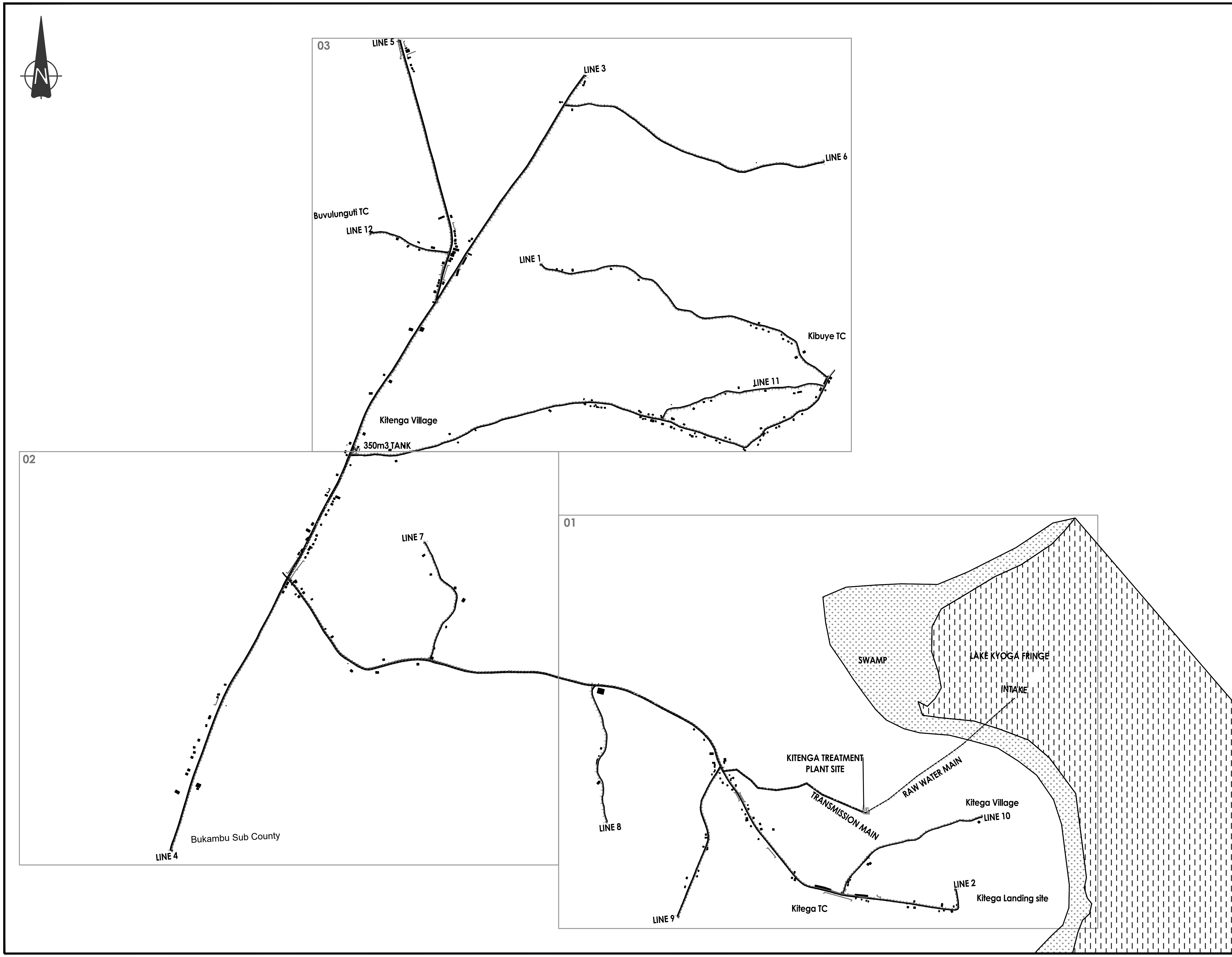
Pipe ID	Nodes	Length (m)	Pipe Details	Internal Diameter (mm)	Roughness	Velocity at Peak Flow (m/s)
Pipe 1	Kitenga_Rsvr to N01	22	OD225 uPVC PN10	203.4	140	0.83
Pipe 2	N01 to N02	1,025	OD160 uPVC PN10	144.6	140	0.52
Pipe 3	N02 to N03	1,434	OD110 uPVC PN10	99.4	140	0.53
Pipe 4	N03 to N13	210	OD63 HDPE PN10	55.4	140	0.72
Pipe 5	N01 to N04	42	OD225 uPVC PN10	203.4	140	0.57
Pipe 6	N04 to N06	1,966	OD110 uPVC PN10	99.4	140	0.52
Pipe 7	N06 to N07	1,151	OD75 HDPE PN10	66	140	0.4
Pipe 8	N07 to N15	2,088	OD63 HDPE PN10	55.4	140	0.51
Pipe 9	N04 to N05	851	OD225 uPVC PN10	203.4	140	0.4
Pipe 10	N05 to N21	1,804	OD90 HDPE PN10	79.2	140	0.63
Pipe 11	N05 to N08	1,126	OD160 uPVC PN10	144.6	140	0.49
Pipe 12	N08 to N09	1,014	OD160 uPVC PN10	144.6	140	0.38
Pipe 13	N09 to N10	996	OD110 uPVC PN10	99.4	140	0.59
Pipe 14	N10 to N11	1,109	OD90 HDPE PN10	79.2	140	0.63
Pipe 15	N11 to N18	822	OD50 HDPE PN10	44	140	0.62
Pipe 16	N02 to N12	308	OD90 HDPE PN10	79.2	140	0.78
Pipe 17	N12 to N23	1,339	OD90 HDPE PN10	79.2	140	0.53
Pipe 18	N06 to N07	1,038	OD75 HDPE PN10	66	140	0.43
Pipe 19	N03 to N14	1,693	OD63 HDPE PN10	55.4	140	0.68
Pipe 20	N08 to N16	813	OD63 HDPE PN10	55.4	140	0.39
Pipe 21	N09 to N20	877	OD50 HDPE PN10	44	140	0.62
Pipe 22	N10 to N19	987	OD50 HDPE PN10	44	140	0.8
Pipe 23	N11 to N17	1,037	OD50 HDPE PN10	44	140	0.62
Pipe 24	N12 to N22	498	OD50 HDPE PN10	44	140	0.8

Annex 8.4

Design Drawings

Drawings List

SGI-MWE-KIT-0.0.0	General Layout
SGI-MWE-KIT-1.1.0	Intake Structure Top Plan
SGI-MWE-KIT-1.1.1	Intake Structure Sectional Plan Details
SGI-MWE-KIT-3.0.0	WTP Site layout
SGI-MWE-KIT-3.1.0	Aerator, Coagulation and Flocculation Plan
SGI-MWE-KIT-3.2.0	Sedimentation Tank Plan
SGI-MWE-KIT-3.3.0	Rapid Gravity Filter Plan
SGI-MWE-KIT-3.4.0	Clear Water Tank Plan
SGI-MWE-KIT-3.7.0	Chemical House
SGI-MWE-KIT-3.8.0	Workshop and Office Plan
SGI-MWE-KIT-5.0.0	Reservoir Tank Site Layout Plan
SGI-MWE-KIT-5.1.0	Reservoir Tank Plan
SGI-MWE-KIT-11.0.1	Public Toilet Plan
SGI-MWE-KIT-12.0.0	Water Office Block



LEGEND

- Raw Water Mains
- Transmission Mains
- Distribution Mains
- Tank/Source Sites
- Building/House
- Contours
- Road
- Lake

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Consultancy Services for Feasibility Study and Detailed Engineering Design and Environmental Impact Assessments of Piped Water Supply and Sanitation Systems in Selected 30no RGCs Across the Country-LOT 6

KITENGA WATER SUPPLY AND SANITATION SYSTEM IN KALIRO DISTRICT

CONSULTANTS

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DETAILED ENGINEERING DESIGN

DRAWING TITLE

GENERAL LAYOUT

SCALE	NTS	DRAWING No.	SGI-MWE-KIT-0.0.0
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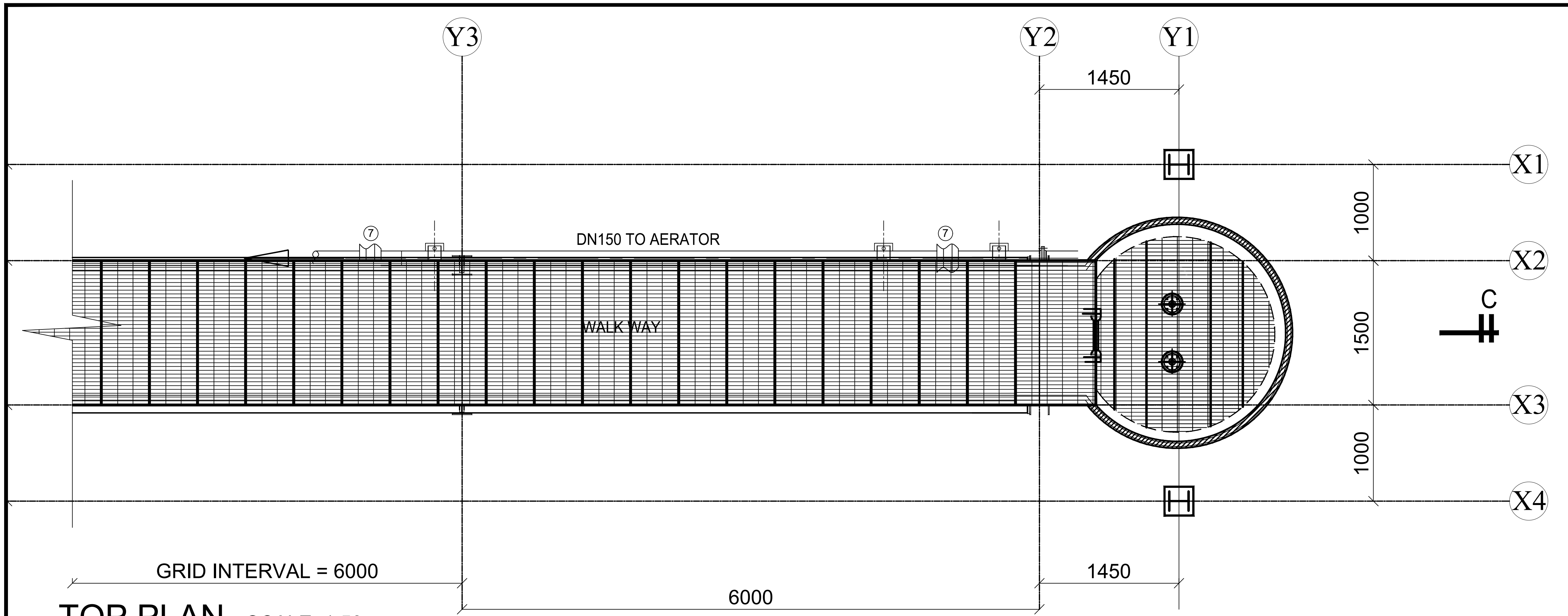
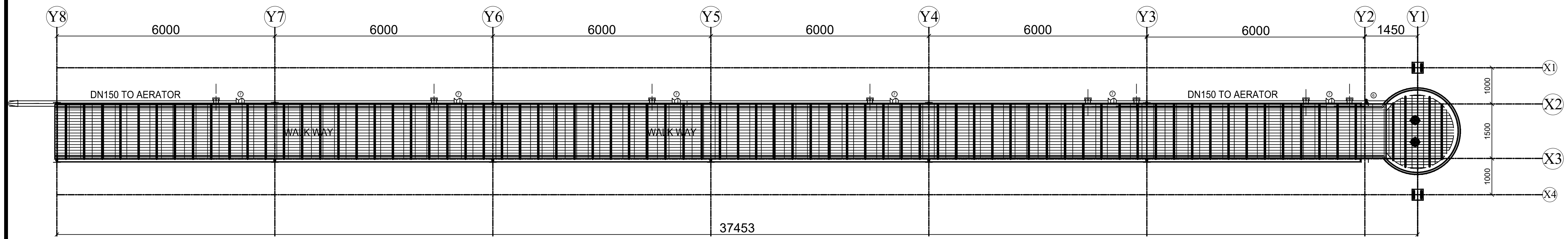
DATE	SEPT 2020	APPROVED	CP



TOP PLAN SCALE, 1:50



WALK WAY PLATFORM

SUCTION WELL

NOTES

1). All dimensions in millimetres unless ortherwise indicated
2). All levels in metres above sea level
3). Structural details are not included
4). All structural concrete is class 25/10mm aggregate
5). All mass concrete is class 15/10mm aggregate

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INTAKE STRUCTURE
TOP PLAN

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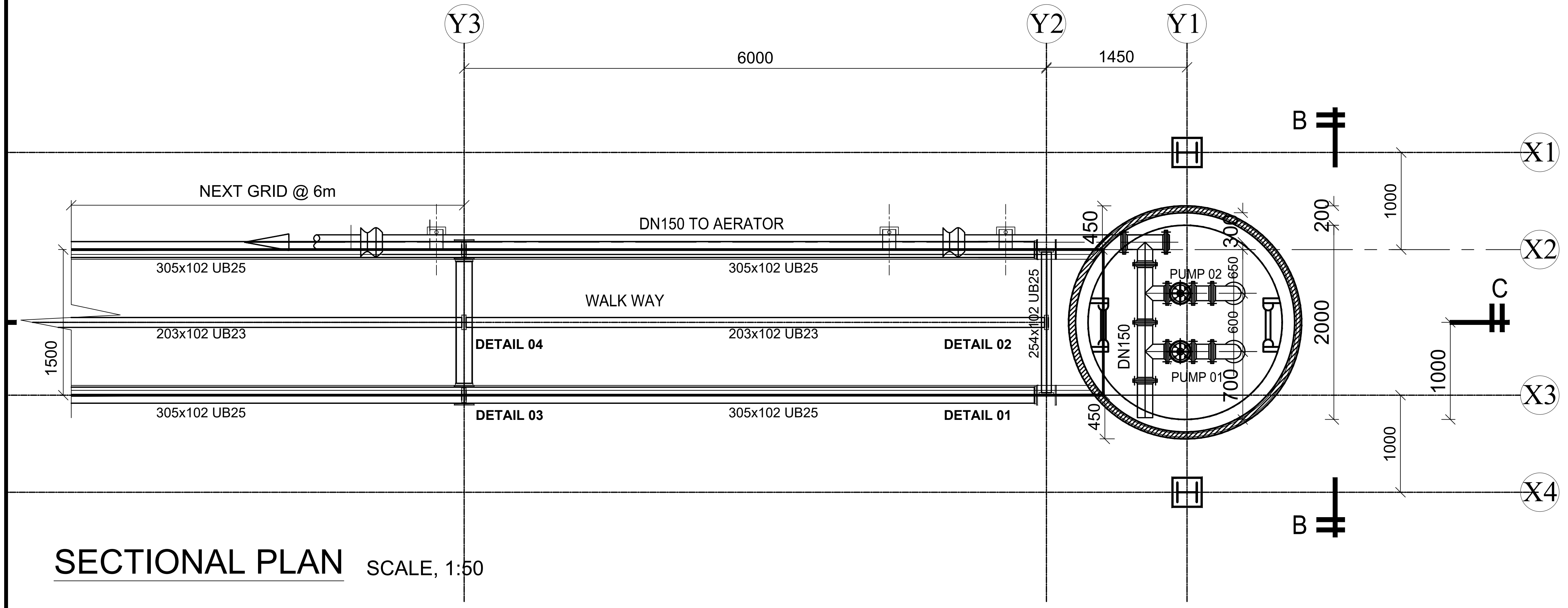
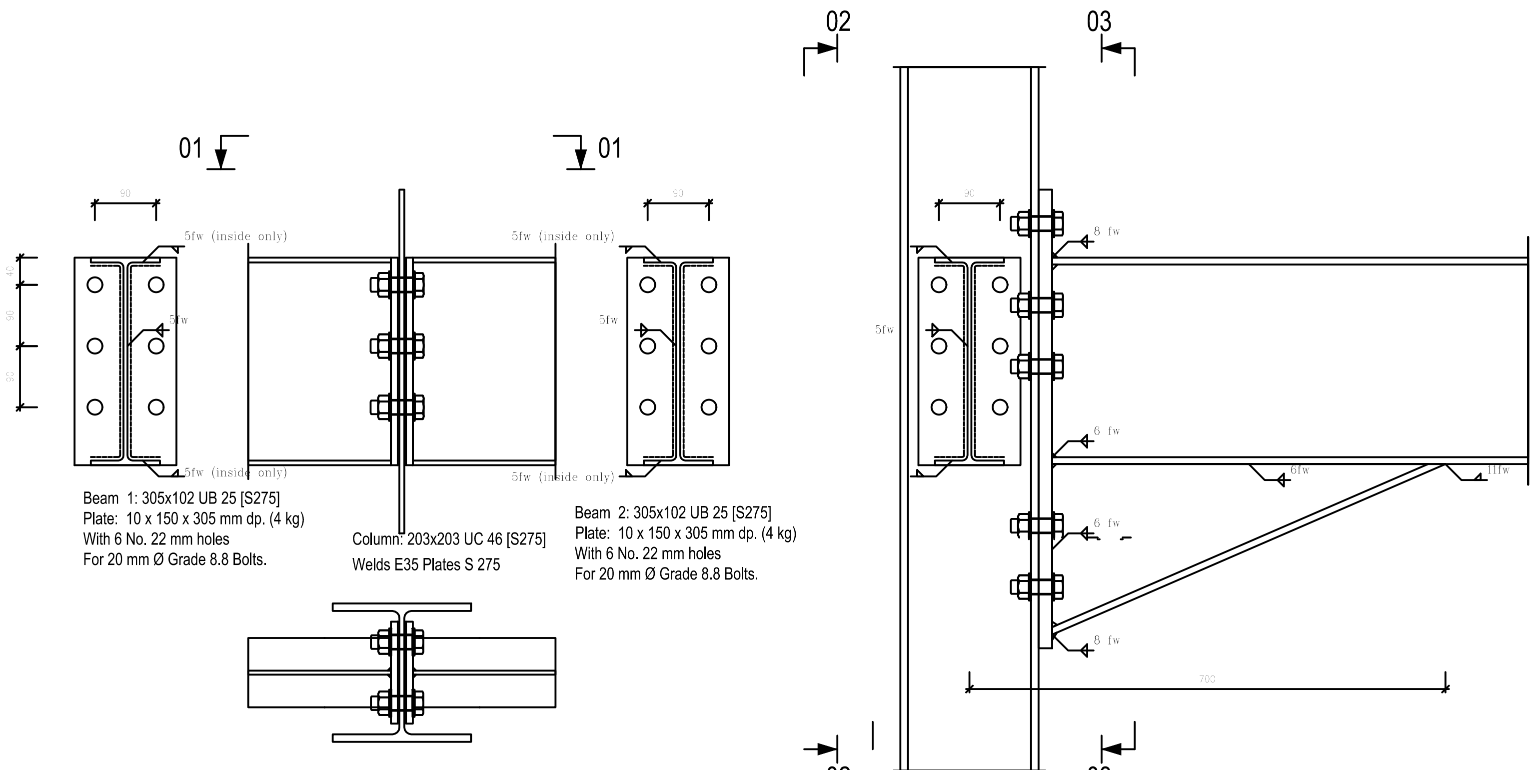


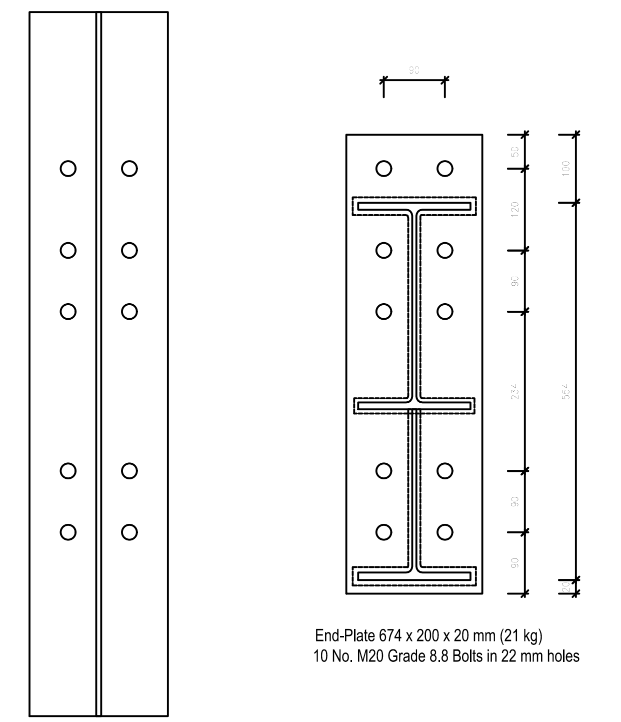
SECTIONAL PLAN

SCALE, 1:50



SECTION 01-021

BEAM TO COLUMN FLANGE & BEAM TO COLUMN WEB EXTENDED END PLATE CONNECTION DETAIL 01 & DETAIL 03



SECTION 02-02

SECTION 03-03

NOTES

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2). All levels in metres above sea level
3). Structural details are not included
4). All structural concrete is class 25/10mm aggregate
5). All mass concrete is class 15/10mm aggregate

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IN KALIRO DISTRICT

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DRAWING TITLE
INTAKE STRUCTURE
SECTIONAL PLAN, DETAIL 01 & 03

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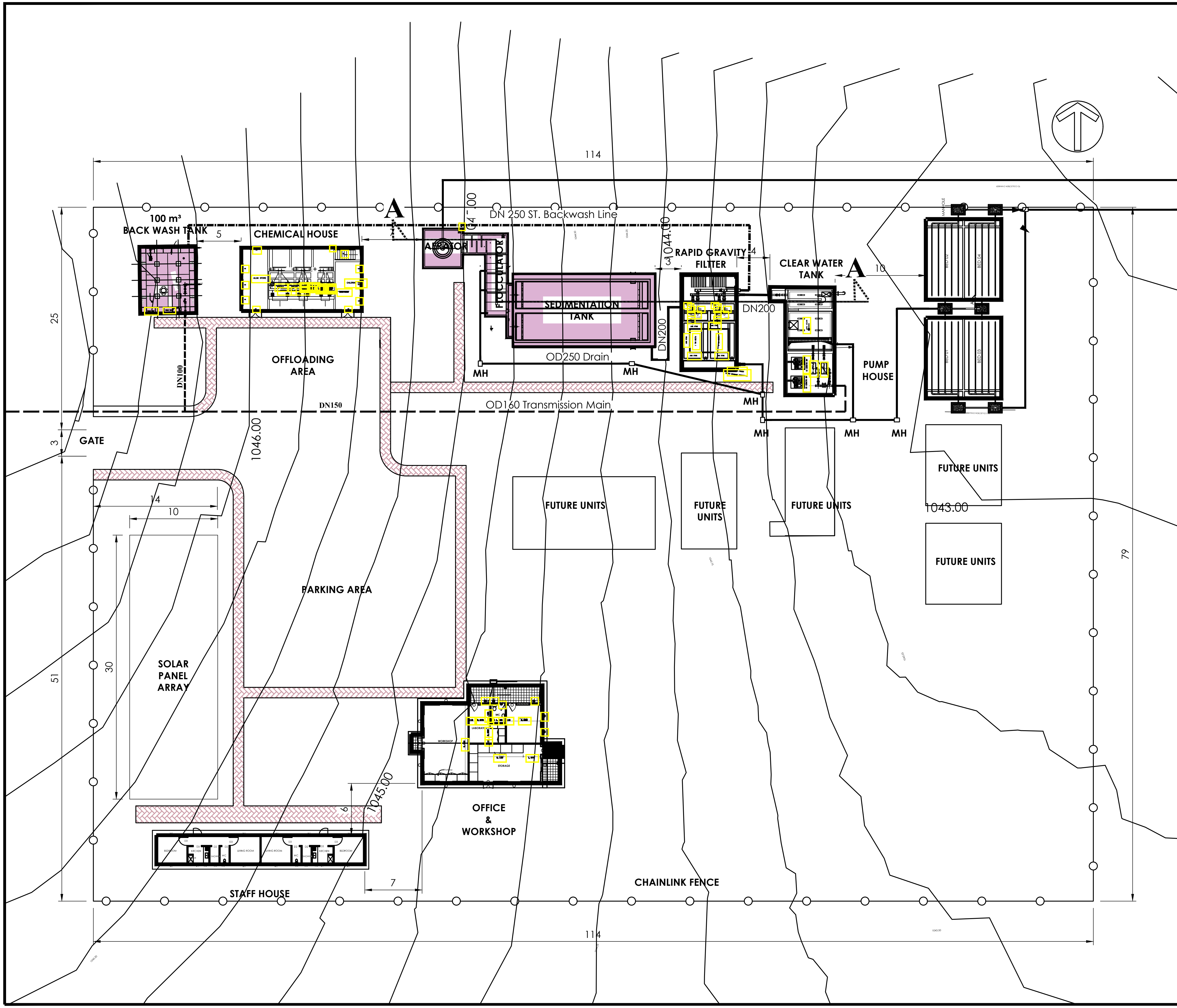

NOTES

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3). Structural details are not included
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DRAWING TITLE

WATER TREATMENT WORKS
GENERAL SITE LAYOUT

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SURVEYED	GW	DESIGNED	ORD
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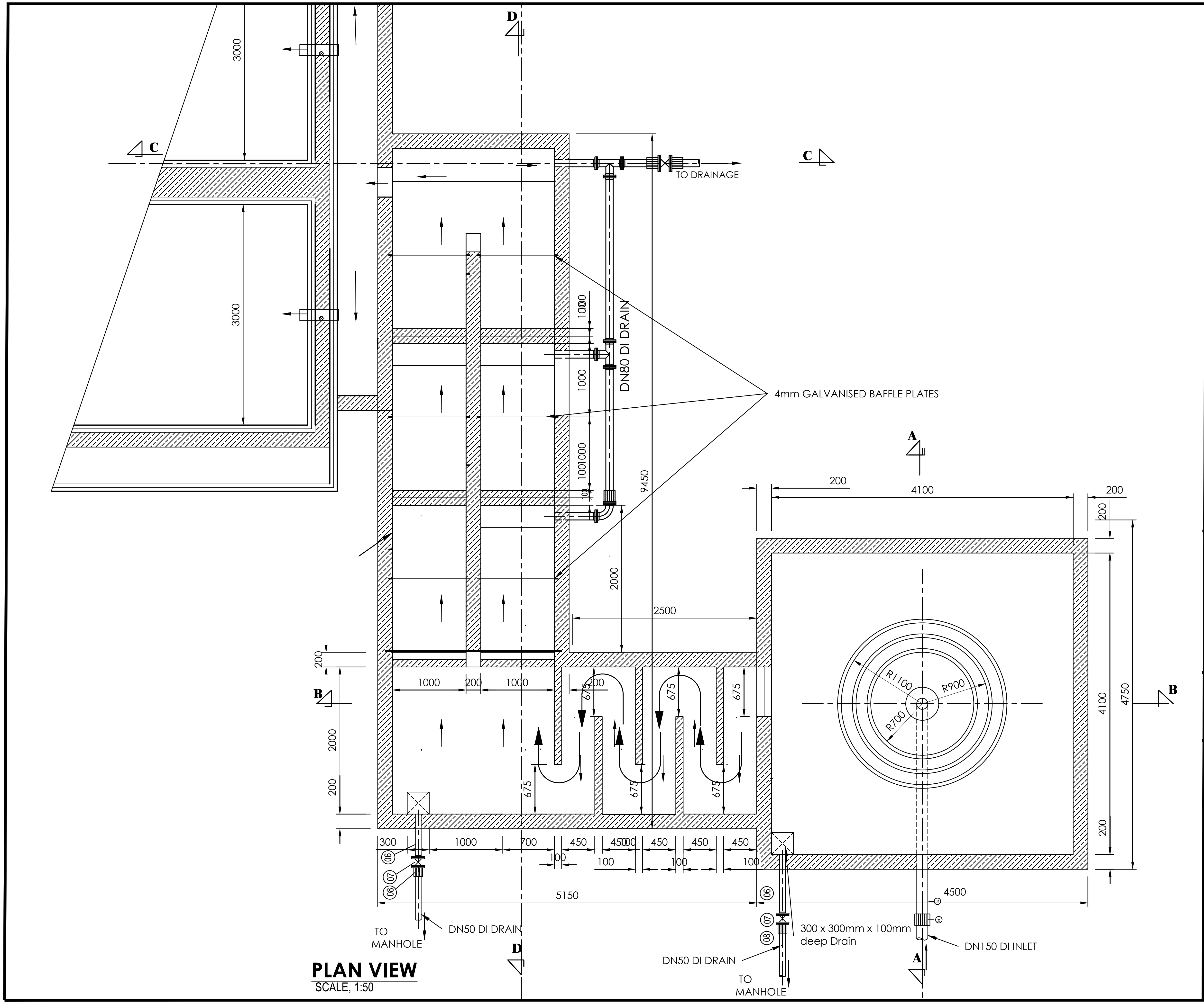
DATE	SEPT 2020	APPROVED	CP



NOTES

1). All dimensions in millimetres unless ortherwise indicated
2). All levels in metres above sea level
3). Structural details are not included
4). All structural concrete is class 25/10mm aggregate
5). All mass concrete is class 15/10mm aggregate

PIPE FITTING SCHEDULES

1. 1 No DN150 flanged adaptor.
2. 1No. bell mouth flanged adaptor.
3. 1No. DN150 double flanged pipe, length not exceeding 4.0m.
4. 1No. DN150 90^0 flanged bend.
5. 1No. DN150 double flanged pipe, length not exceeding 2.5m
6. 1No. DN50 double flanged pipe, length not exceeding 1.0m.
7. 1No. DN50 flanged gate valve.
8. 1No. DN50 flanged adaptor.

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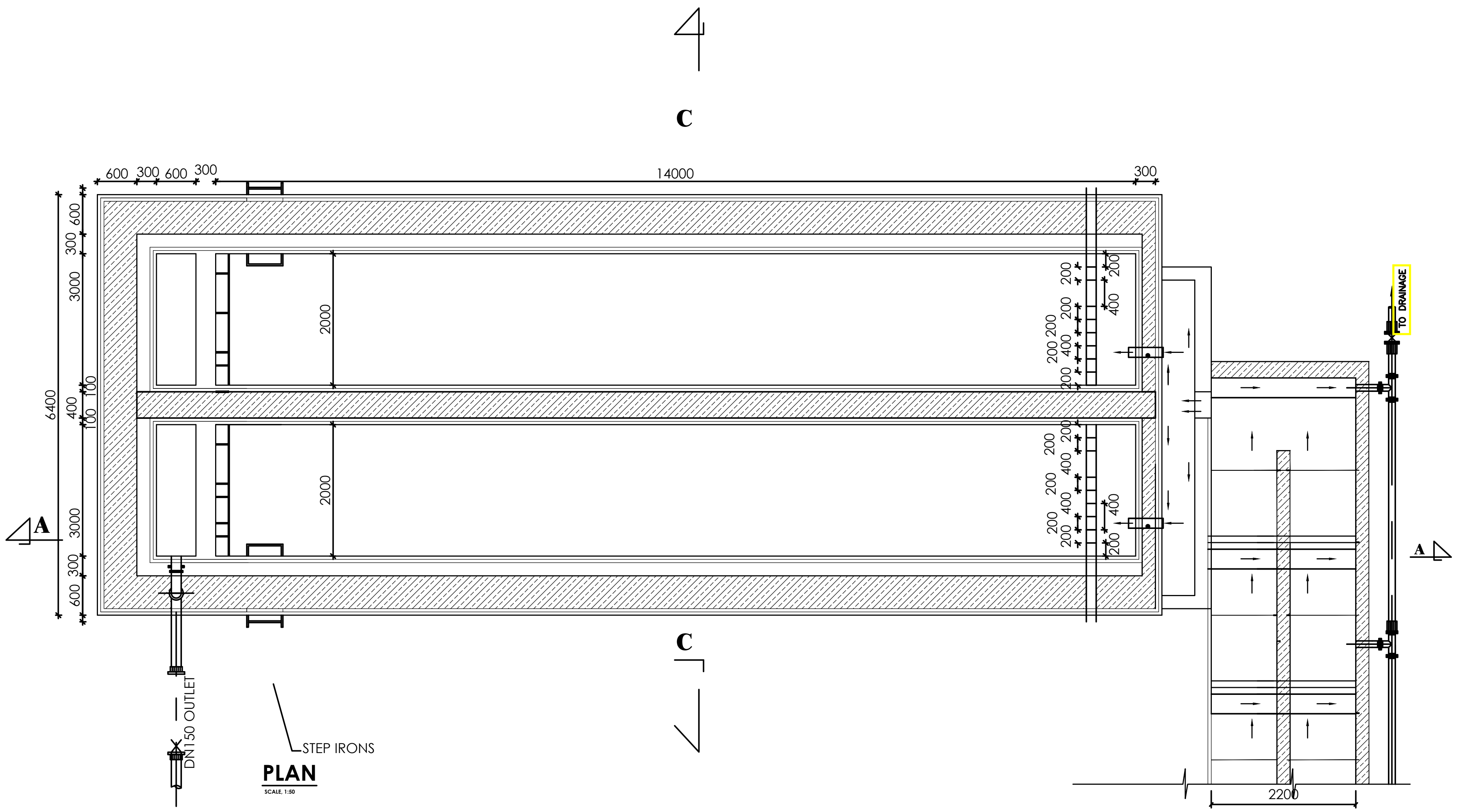
DETAILED ENGINEERING DESIGN

DRAWING TITLE
AERATOR, COAGULATOR & FLOCCULATOR SECTIONAL PLAN AND SECTION C-C

SCALE	1:50	DRAWING No.	SGI-MWE-KIT-3.1.0
SURVEYED	GW	DESIGNED	ORD
DRAWN	CDE	CHECKED	ORD
DATE	SEPT 2020	APPROVED	CP

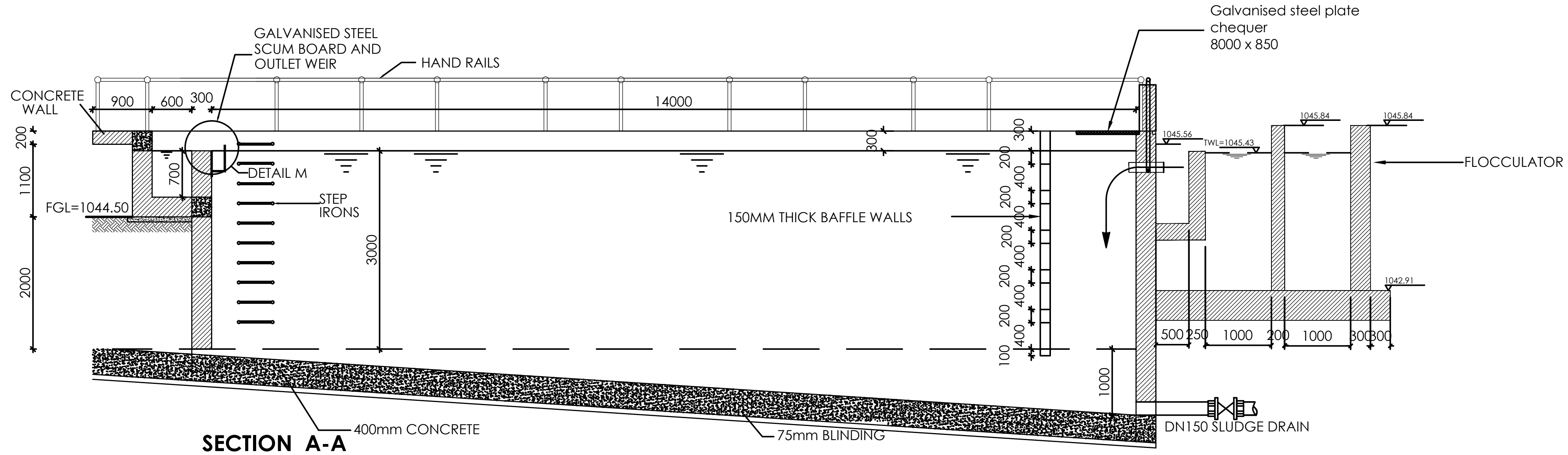
NOTES

1. All dimensions are in mm unless stated otherwise.
2. The depths are indicative, actual depth of pipe will be determined in the field.
3. All levels are in metres above sea level.
4. All Structural concrete to be CLASS 25/10.
5. All Mass Concrete to be CLASS 20/10.



PLAN

SCALE: 1:50



SECTION A-A

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DETAILED ENGINEERING DESIGN

DRAWING TITLE

SEDIMENTATION TANK

SECTIONAL PLAN AND SECTION A-A

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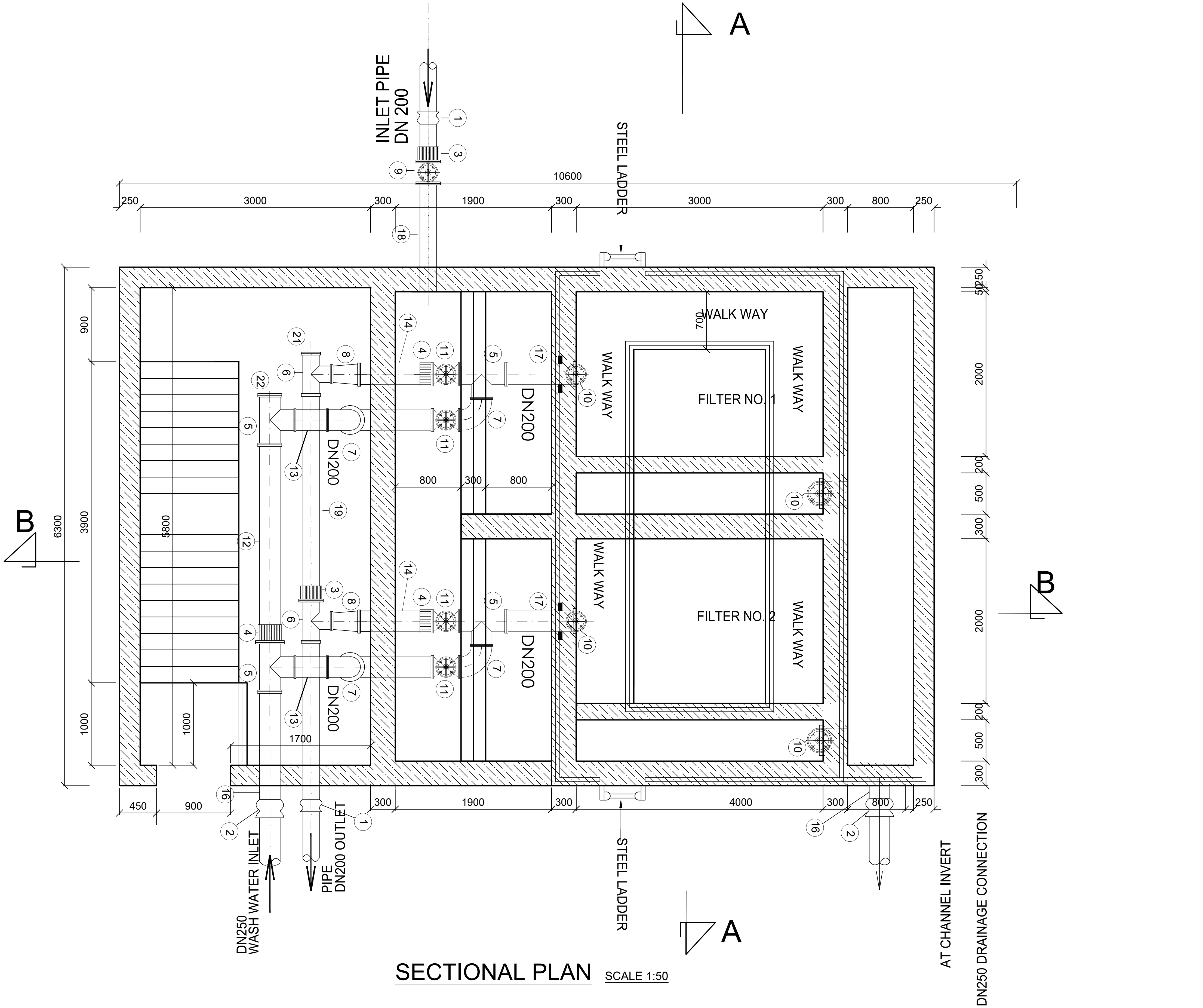
DRAWN	CDE	CHECKED	ORD
DATE	SEPT 2020	APPROVED	CP



SECTIONAL PLAN

SCALE 1:50

NOTES

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3). Structural details are not included
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5). All mass concrete is class 15/10mm aggregate

PIPE FITTING SCHEDULE

1. 2No. DN200 maxi coupling
2. 2No. DN250 maxi coupling
3. 2No. DN200 maxi flanged adaptor
4. 3No. DN250 maxi flanged adaptor
5. 4No. DN250/200 all flanged Tee
6. 4No. DN200/200 all flanged Tee
7. 6No. DN200 all flanged 90° bend
8. 2No. DN250/200 all flanged Taper
9. 1No. DN200 all flanged gate valve
10. 4No. 200x200 penstocks
11. 4No. DN200 flanged gate valve
12. 1No. DN250 flanged/spigot pipe length ne 3m
13. 2No. DN200 all flanged pipe length not exceeding 1.5m
14. 2No. DN200 flanged/spigot pipe length ne1.5m
15. 2No. DN200 all flanged pipe length ne 3m
16. 1No. DN250 flanged/spigot pipe with puddle flanged, ne 2m
17. 2No. DN200 all flanged pipe with puddle flanged, length ne
18. 1No. DN200 flanged/spigot pipe with puddle flanged, ne 2m
19. 2No. DN200 flanged/spigot pipe length ne 3m
20. 1No. DN200 flanged/spigot pipe with puddle flanged, ne 3m
21. 1No. DN 200 blank flange
22. 1No. DN250 blank flange

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Tel. +39 049 89 76 844
Fax +39 049 89 76 784

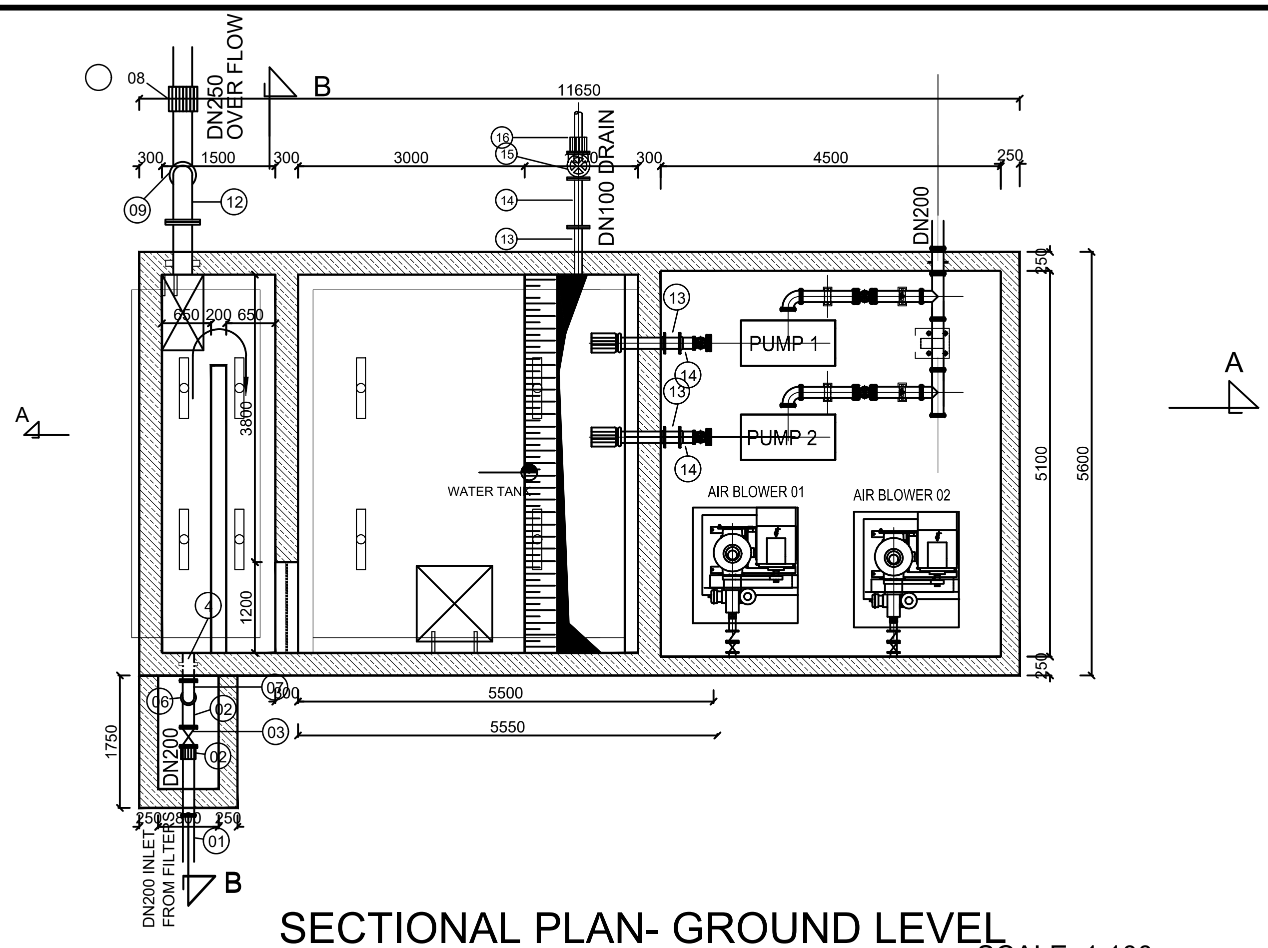
REVISIONS :

No	Date	Description

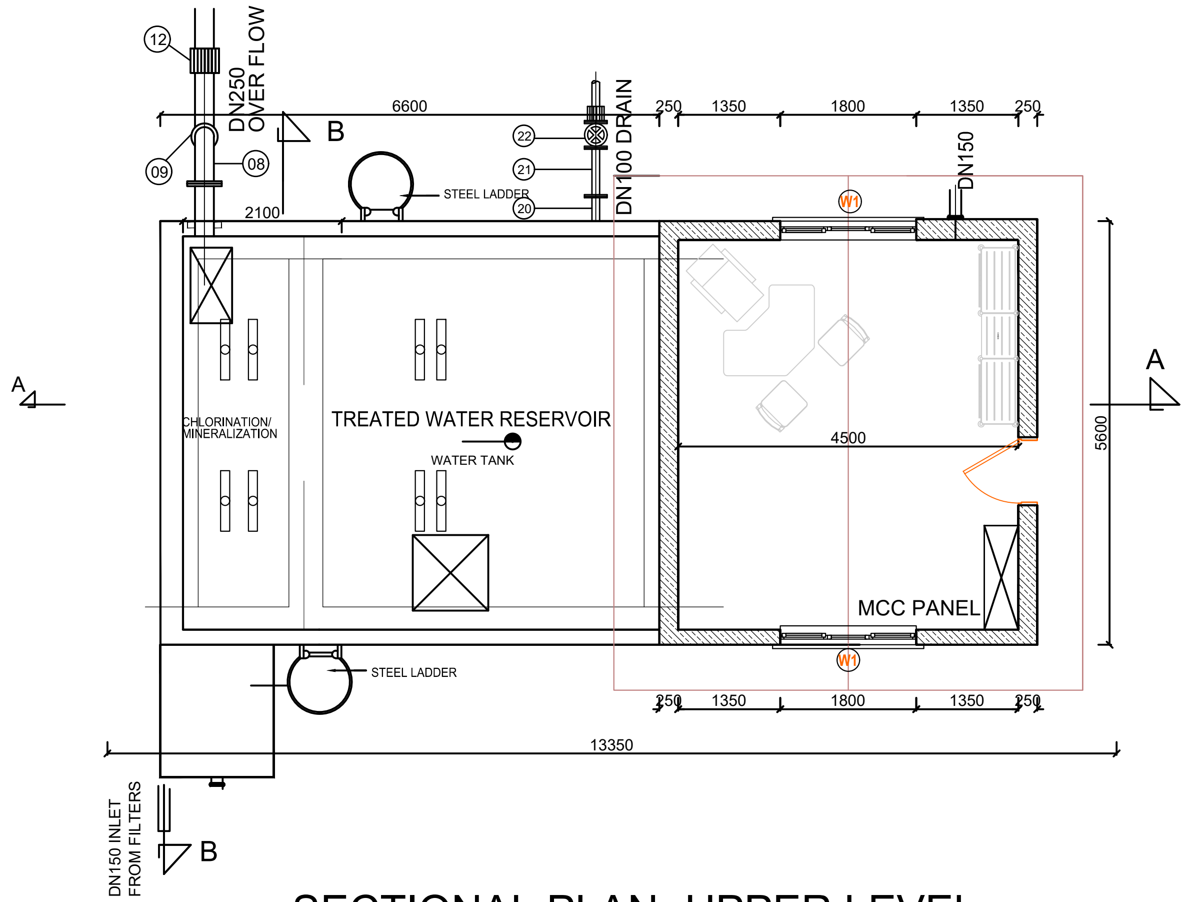
DETAILED ENGINEERING DESIGN

DRAWING TITLE
RAPID GRAVITY FILTER
SECTIONAL PLAN

SCALE	1:50	DRAWING No.	SGI-MWE-KIT-3.3.0
SURVEYED	GW	DESIGNED	ORD
DRAWN	CDE	CHECKED	ORD
DATE	SEPT 2020	APPROVED	CP



SECTIONAL PLAN- GROUND LEVEL SCALE, 1:100



SECTIONAL PLAN- UPPER LEVEL SCALE, 1:100

NOTES

1). All dimensions in millimetres unless otherwise indicated
2). All levels in metres above sea level
3). Structural details are not included
4). All structural concrete is class 25/10mm aggregate
5). All mass concrete is class 15/10mm aggregate

PIPE FITTING SCHEDULE

1. 1 No DN200 inlet from filter.
2. 2No. DN200 flanged adaptor.
3. 2No. DN200 90^0 flanged bend.
4. 1No. DN200 double flanged pipe, length not exceeding 2.5m.
5. 1No. DN200 double flanged pipe, length not exceeding 1.5m.
6. 1No. DN200 flanged gate valves.
7. 1No. DN200 double flanged pipe, length not exceeding 1.0m.
8. 1No. DN250 double flanged pipe, length not exceeding 1.5m.
9. 1No. DN250 90^0 flanged bend.
10. 1No. DN250 double flanged pipe, length not exceeding 2m.
11. 1No. DN250 90^0 flanged bend.
12. 1No. DN250 flanged adaptor.
13. 1 No. DN100 flanged pipe, length not exceeding 1.0m.
14. 1 No.DN100 double flanged pipe, length not exceeding 1.0m.
15. 1 No.DN100 flanged gate valves.
16. 1 No. DN100 flanged adaptor.
17.

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THE REPUBLIC OF UGANDA
MINISTRY OF WATER AND ENVIRONMENT
DIRECTORATE OF WATER DEVELOPMENT

CO-FINANCED BY

GOVERNMENT OF UGANDA AND WORLD BANK

PROJECT:

Consultancy Services for Feasibility Study and Detailed Engineering Design and Environmental Impact Assessments of Piped Water Supply and Sanitation Systems in Selected 30no RGCs Across the Country-LOT 6

KITENGA WATER SUPPLY AND SANITATION SYSTEM
IN KALIRO DISTRICT

CONSULTANTS

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REVISIONS :

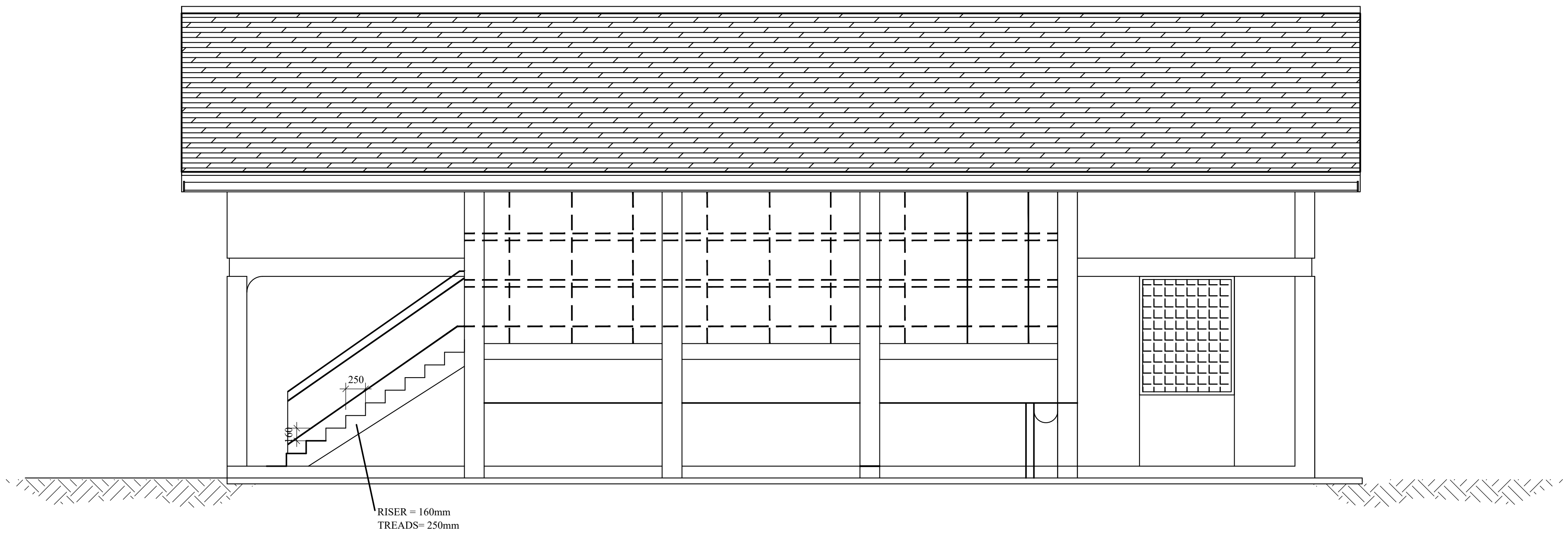
No	Date	Description

DETAILED ENGINEERING DESIGN

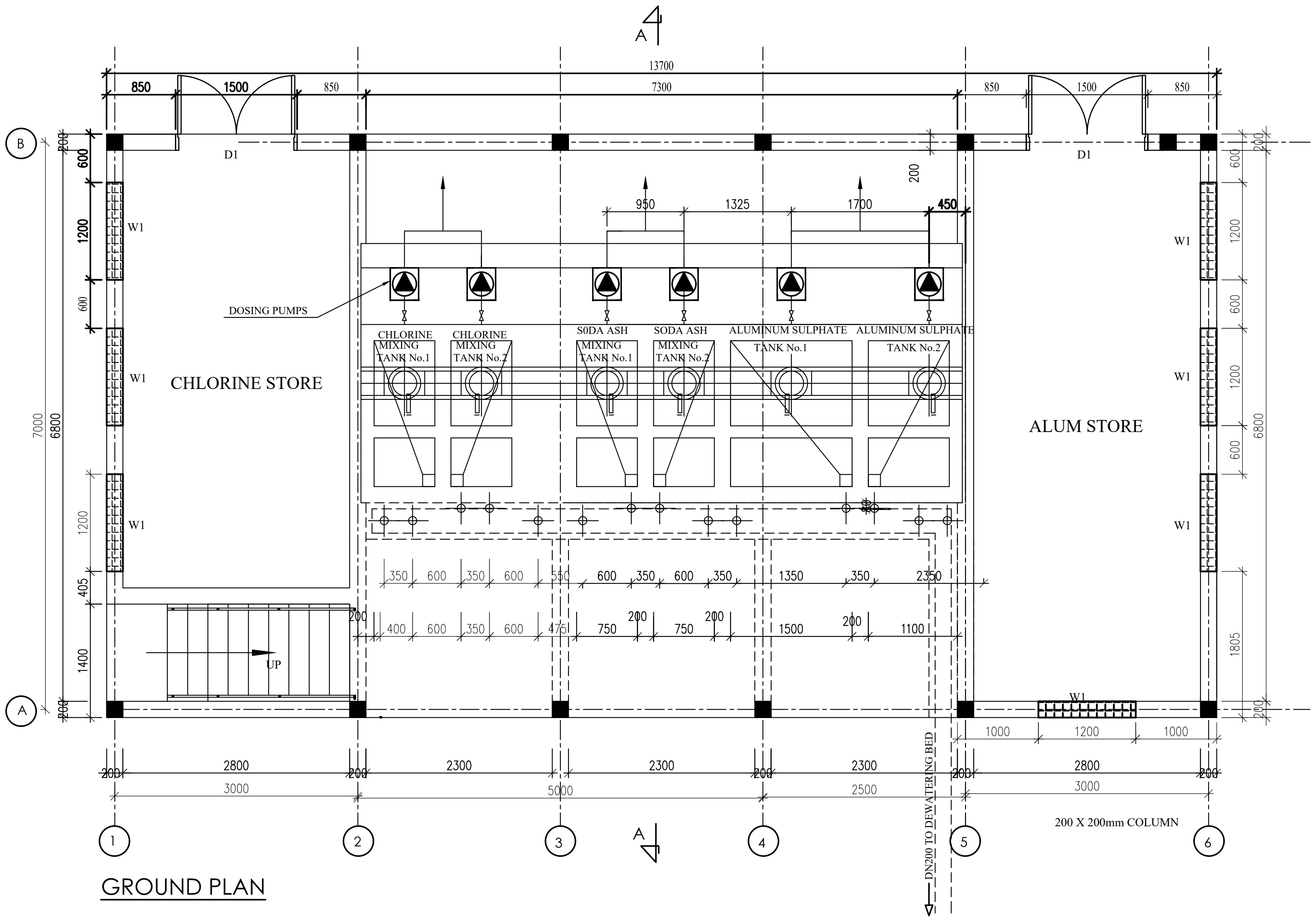
DRAWING TITLE

CLEAR WATER TANK + PUMP HOUSE
SECTION PLAN GROUND LEVEL& UPPER LEVEL

SCALE	1:100	DRAWING No.	SGI-MWE-KIT-3.4.0
SURVEYED	GW	DESIGNED	ORD
DRAWN	CDE	CHECKED	ORD
DATE	SEP 2020	APPROVED	CP



SIDE ELEVATION



GROUND PLAN

NOTES

1). All dimensions in millimetres unless ortherwise indicated
2). All levels in metres above sea level
3). Structural details are not included
4). All structural concrete is class 25/10mm aggregate
5). All mass concrete is class 15/10mm aggregate
6). For Site Layout, see Dwg. MWE/LOT1/BUS/W/1.0.0

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REVISIONS :

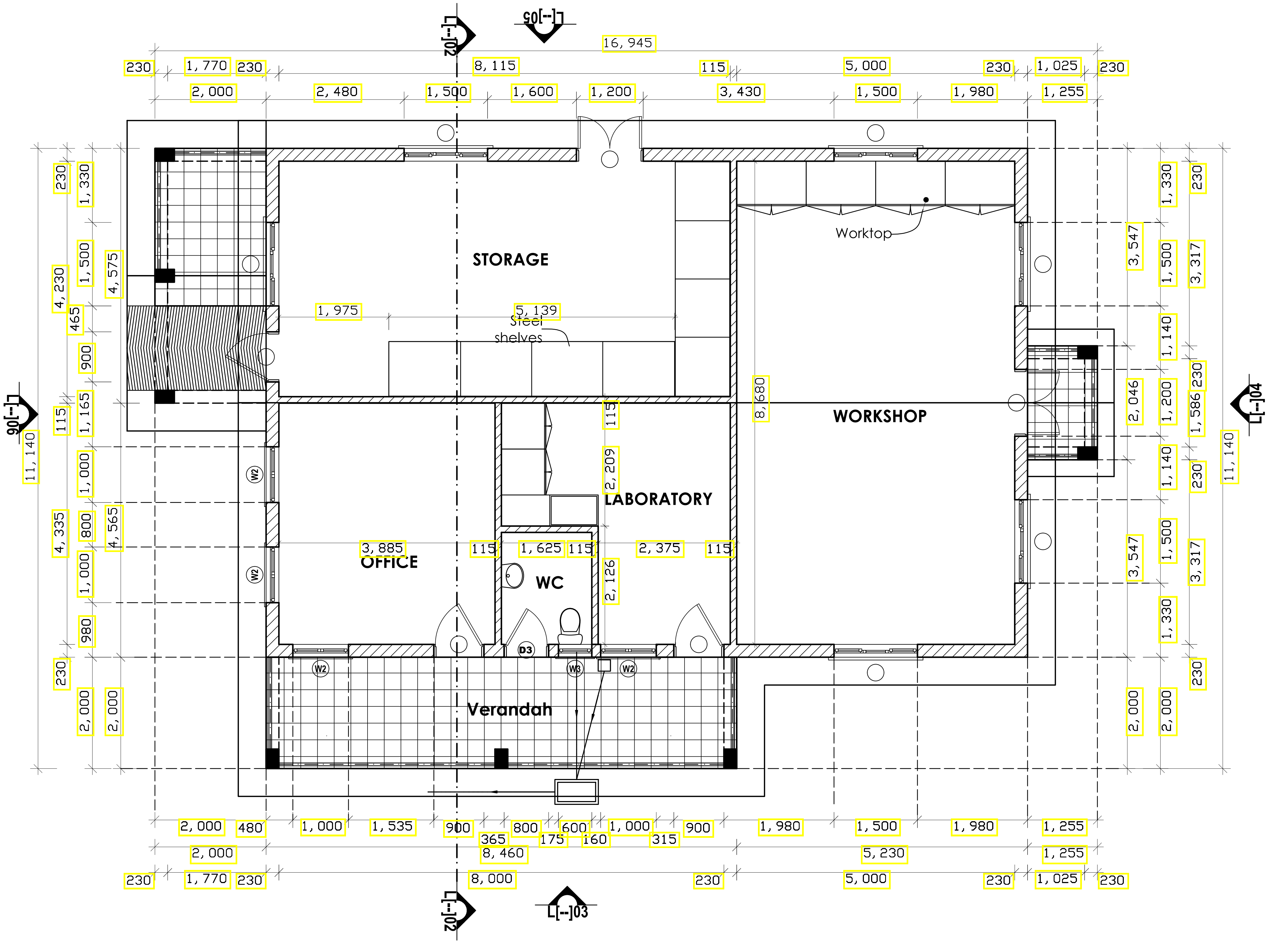
No	Date	Description

DETAILED ENGINEERING DESIGN

DRAWING TITLE

CHEMICAL HOUSE
SECTIONAL PLAN & ELEVATION

SCALE	AS SHOWN	DRAWING No.	SGI-MWE-KIT-3.7.0
SURVEYED	GW	DESIGNED	ORD
DRAWN	CDE	CHECKED	ORD
DATE	SEPT 2020	APPROVED	CP



GROUND FLOOR PLAN [L--]01 scale 1:100

NOTES

1). All dimensions in millimetres unless ortherwise indicated

2). All levels in metres above sea level

3). Structural details are not included

4). All structural concrete is class 25/10mm aggregate

5). All mass concrete is class 15/10mm aggregate

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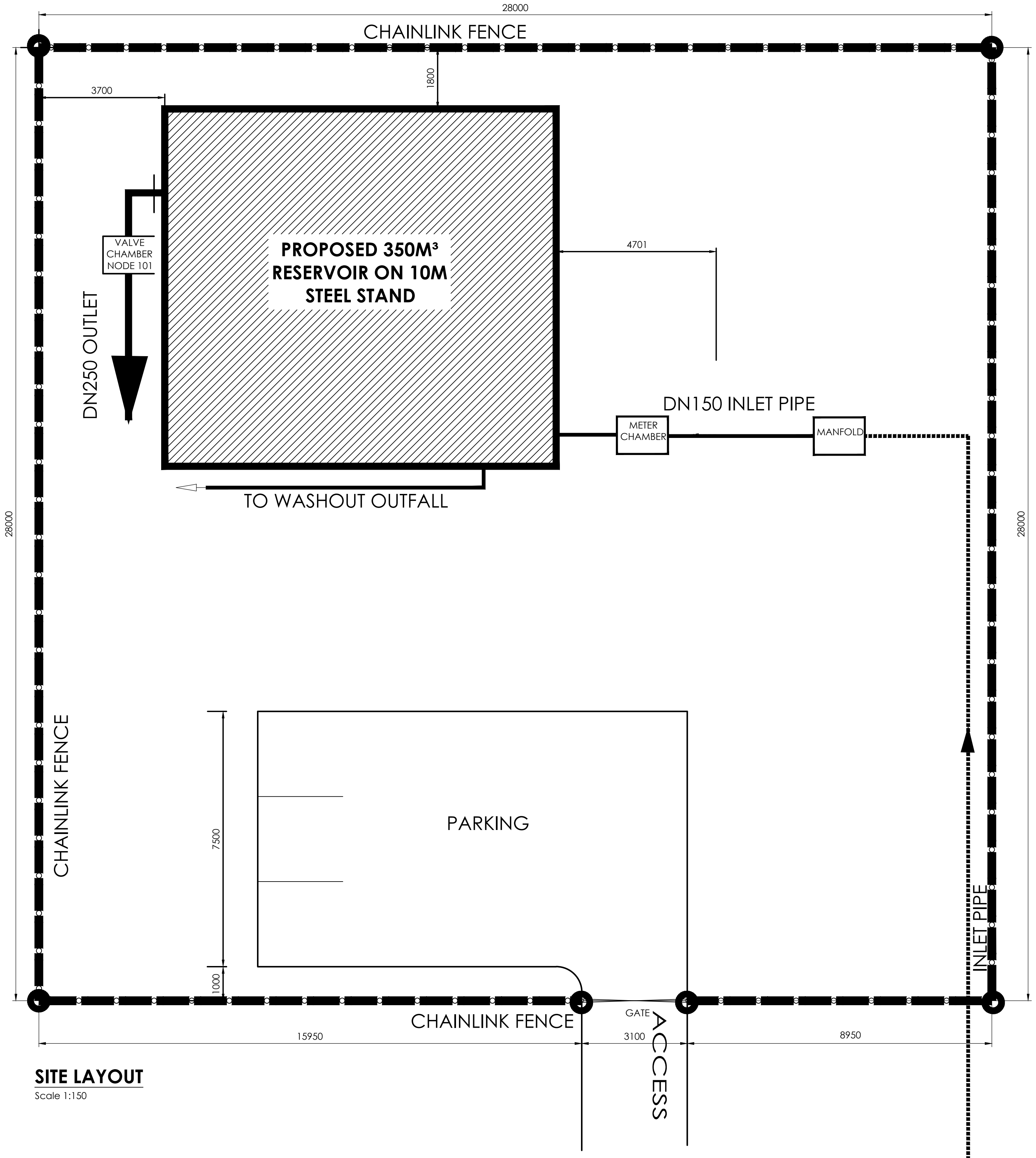
REVISIONS :

No	Date	Description

DETAILED ENGINEERING DESIGN

DRAWING TITLE
WORKSHOP & OFFICE
GROUND PLAN

SCALE	AS SHOWN	DRAWING No.	SGI-MWE-KIT-3.8.0
SURVEYED	GW	DESIGNED	ORD
DRAWN	CDE	CHECKED	ORD
DATE	SEPT 2020	APPROVED	CP



SITE LAYOUT

Scale 1:150

NOTES

1. All dimensions are in mm unless stated otherwise.
2. All levels are in metres above sea level.
3. For Site location see Dwg. SGI-MWE-KIT-0.0.0
4. Structural details are not included.
5. All structural concrete is Class 25/10.
6. All mass concrete is Class 15/10.

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MINISTRY OF WATER AND ENVIRONMENT
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KITENGA WATER SUPPLY AND SANITATION SYSTEM IN KALIRO DISTRICT

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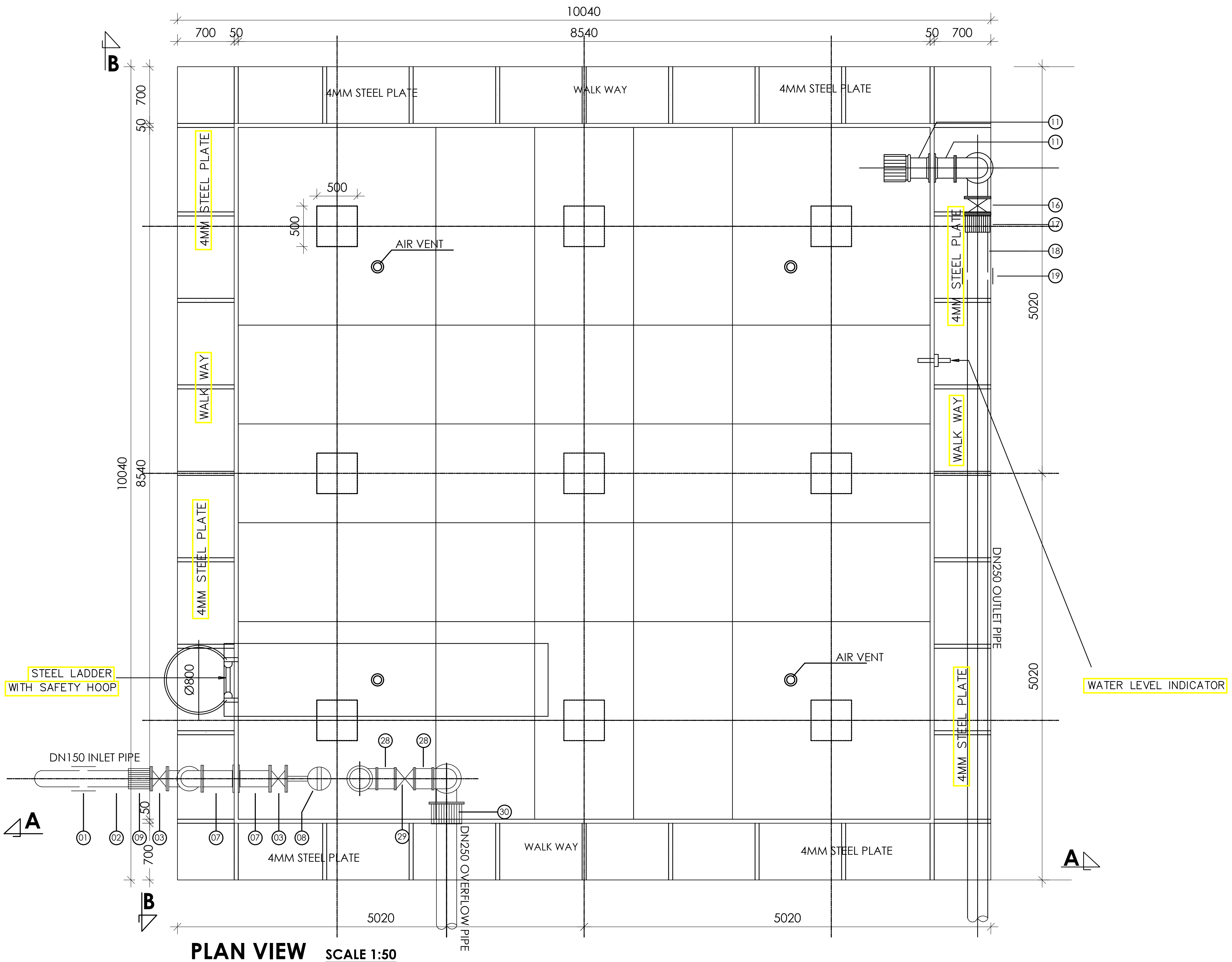
REVISIONS :

No	Date	Description

DETAILED ENGINEERING DESIGN

DRAWING TITLE
350M³ RESERVOIR TANK
SITE LAYOUT PLAN

SCALE	1:150	DRAWING No.	SGI-MWE-KIT-5.0.0
SURVEYED	GW	DESIGNED	ORD
DRAWN	CDE	CHECKED	ORD
DATE	SEPT 2020	APPROVED	CP



PLAN VIEW SCALE 1:50

NOTES

1. All dimensions are in mm unless stated otherwise.
2. All levels are in metres above sea level.
3. For Site location see Dwg. SGI-MWE-KIT-0.0.0
4. Structural details are not included.
5. All structural concrete is Class 25/10.
6. All mass concrete is Class 15/10.

PIPE FITTING SCHEDULE

1. 1No.DN150 Coupling.
2. 1No.DN150 Pipe not exceeding 2.0m.
3. 1No.DN150 All Flanged Gate Valve.
4. 1No.DN150 All Flanged Duck foot 90° bend.
5. 3No.DN150 Double Flanged Pipe not exceeding 6.0m.
6. 1No.DN150 All Flanged 90° bend.
7. 2No.DN150 Double Flanged Pipe not exceeding 0.6m.
8. 1No.DN150 Flanged Ball Float Valve.
9. 1No.DN150 Flanged Adaptor,Maxi type or similar.
10. 1No.DN150 Flanged Outlet Pipe Strainer.
11. 2No.DN250 Double Flanged Pipe not exceeding 0.6m.
12. 1No.DN250 All Flanged 90° bend.
13. 2No.DN250 Double Flanged Pipe not exceeding 6.0m.
14. 1No.DN250 Double Flanged Pipe not exceeding 2.0m.
15. 1No.DN250 All Flanged Duck foot 90° bend.
16. 1No.DN250 Flanged Gate Valve.
17. 1No.DN250 Flanged Adaptor,Maxi type or similar.
18. 1No.DN250 Double Flanged Pipe not exceeding 2.0m.
19. 1No.DN250 Coupling.
20. 1No.DN250 Flanged Bell Mouth.
21. 1No.DN250 Double Flanged Pipe not exceeding 2.8m.
22. 1No.DN250 Double Flanged Pipe not exceeding 2.0m.
23. 1No.DN250/100 All Flanged Tee.
24. 2No.DN250 Double Flanged Pipe not exceeding 6.0m.
25. 1No.DN250 All Flanged Duck foot 90° bend.
26. 1No.DN250 All Flanged Pipe with puddle flange n.e 2.0m
27. 1No.DN250 All Flanged 90° bend.
28. 1No.DN250 Double Flanged Pipe not exceeding 0.4m.
29. 1No.DN250 Flanged Gate Valve.
30. 1No.DN250 Flanged Adaptor,Maxi type or similar.

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Design and Environmental Impact Assessments of Piped Water Sup
and Sanitation Systems in Selected 30no RGCs Across the Country-L

KITENGA WATER SUPPLY AND SANITATION SYSTEM
IN KALIRO DISTRICT

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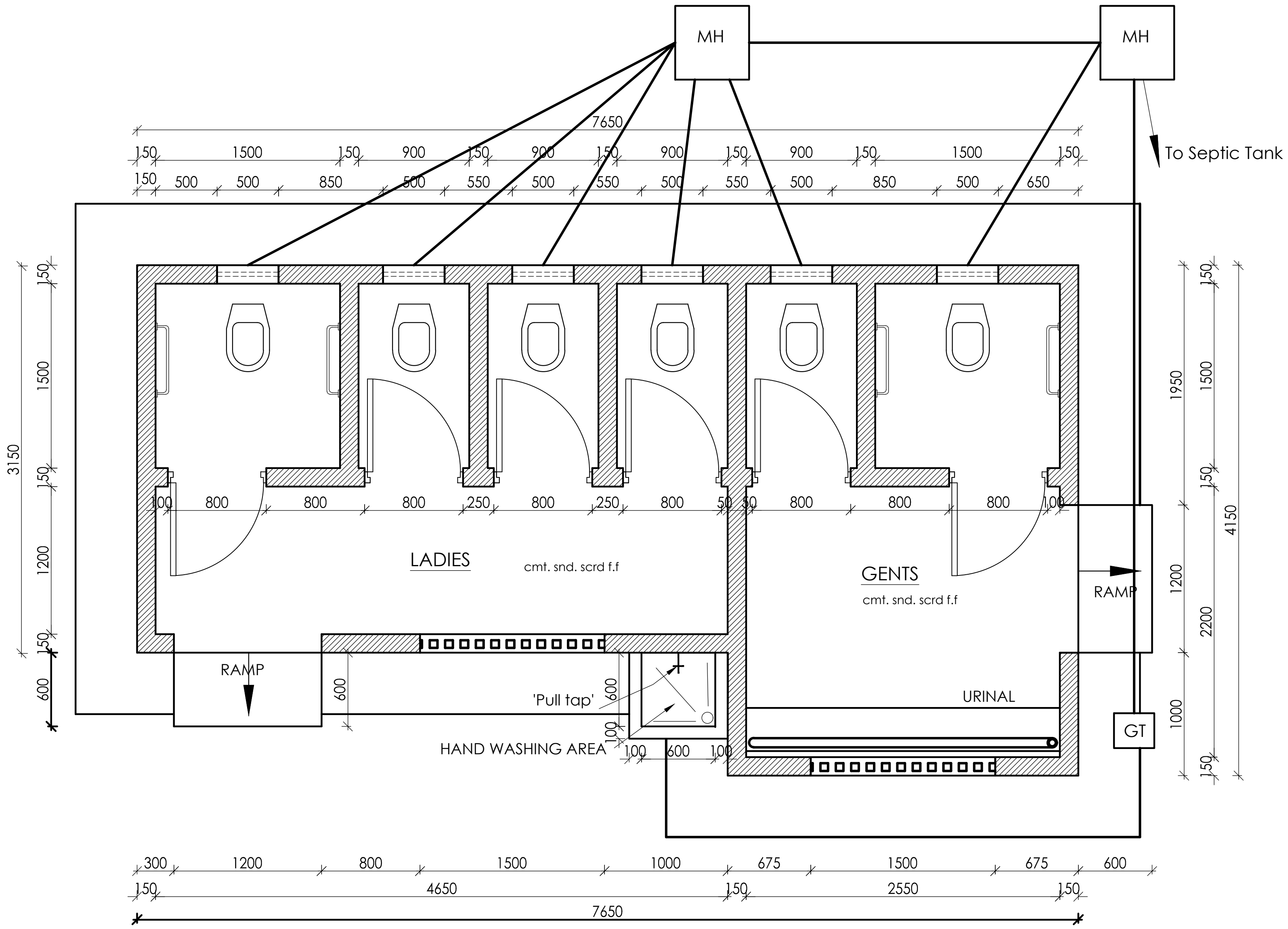
REVISIONS :

No	Date	Description

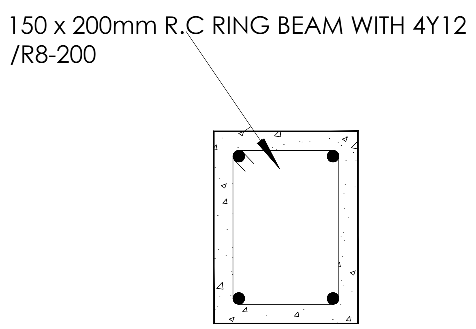
DETAILED ENGINEERING DESIGN

DRAWING TITLE
350M³ RESERVOIR TANK PLAN

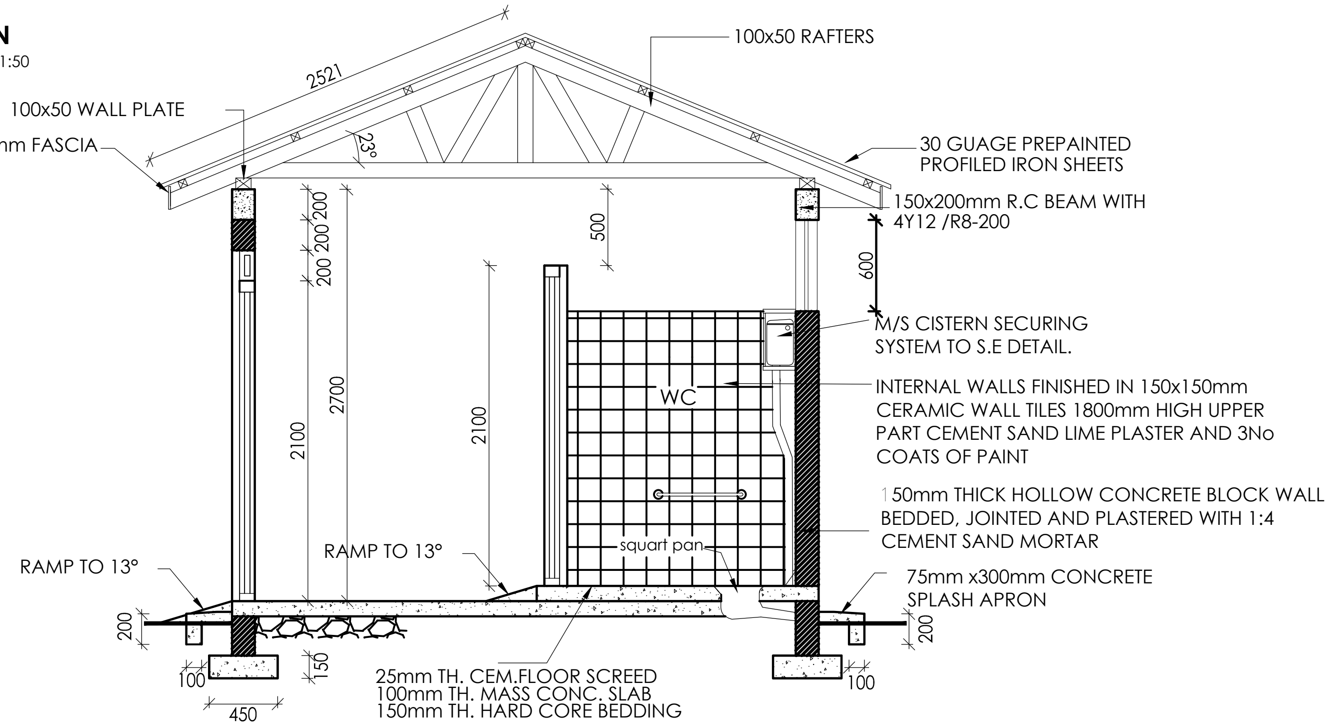
SCALE	1:50	DRAWING No.	SGI-MWE-KIT-5.1
SURVEYED	GW	DESIGNED	ORD
DRAWN	CDE	CHECKED	ORD
DATE	SEPT 2020	APPROVED	CP



PLAN
scale, 1:50



RING BEAM DETAIL
scale, 1:10



SECTION Y-Y
scale, 1:50

NOTES

1. All dimensions are in mm unless stated otherwise.
2. All levels are in metres above sea level.
3. Structural details are not included.
4. All structural concrete is Class 25/10.
5. All mass concrete is Class 15/10.

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KITENGA WATER SUPPLY AND SANITATION SYSTEM IN KALIRO DISTRICT

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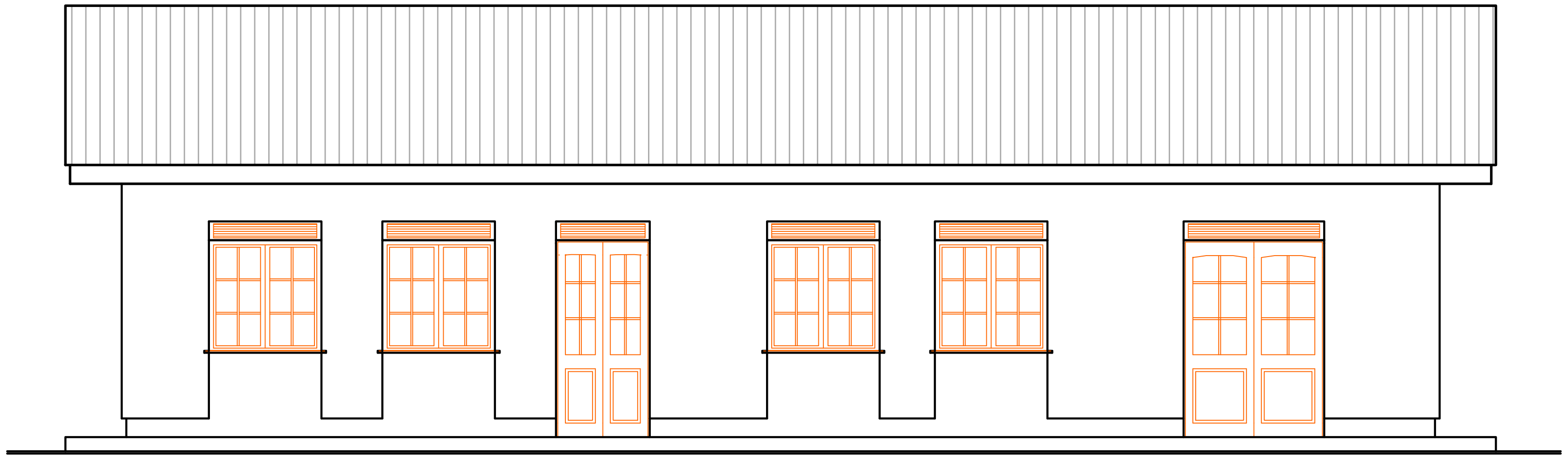
REVISIONS :

No	Date	Description

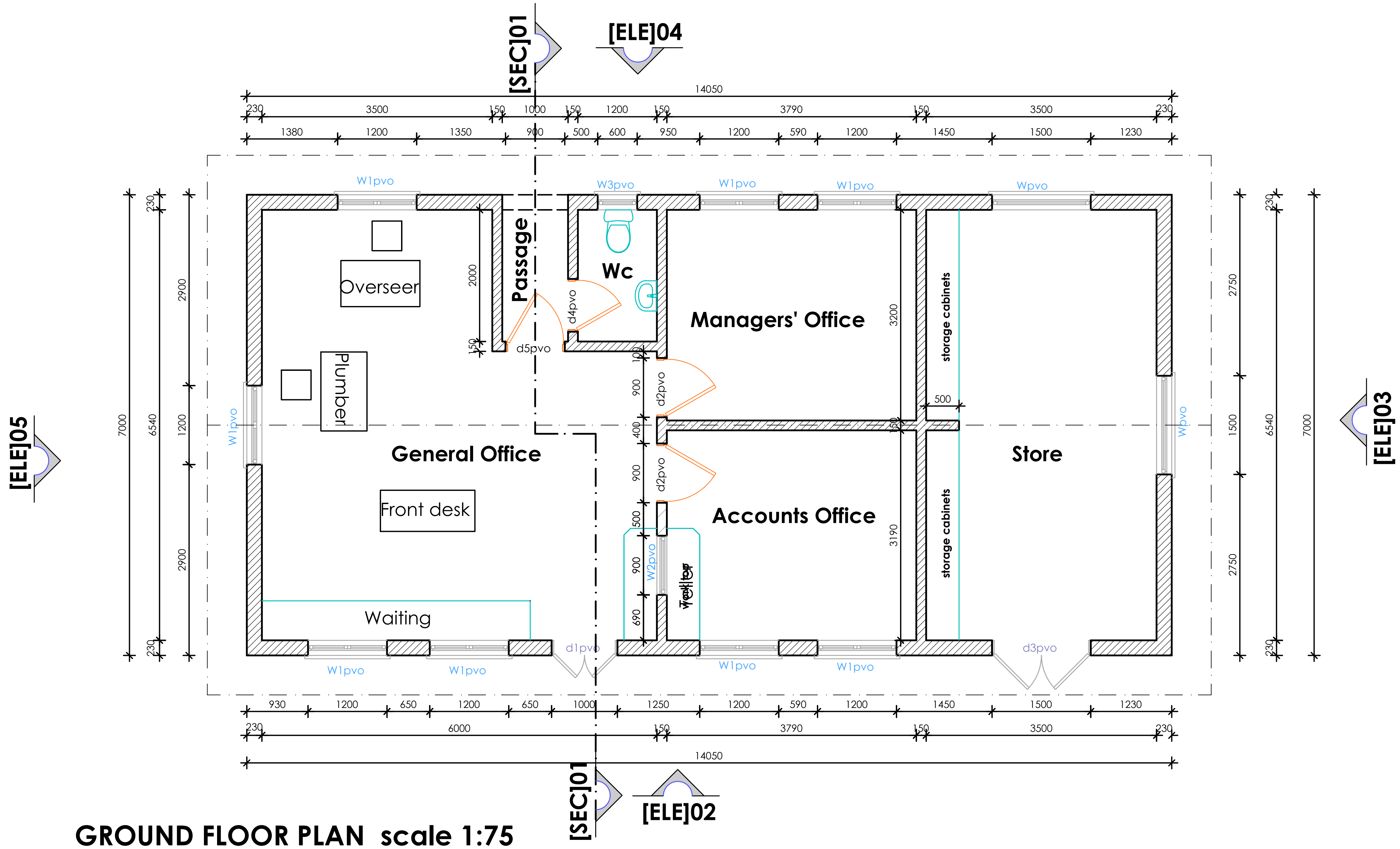
DETAILED ENGINEERING DESIGN

DRAWING TITLE
PUBLIC TOILET
PLAN, SECTION AND RING BEAM DETAIL

SCALE	AS SHOWN	DRAWING No.	SGI-MWE-KIT-11.0.1
SURVEYED	GW	DESIGNED	ORD
DRAWN	CDE	CHECKED	ORD
DATE	SEPT 2020	APPROVED	CP



ELEVATION 02 scale 1:75



GROUND FLOOR PLAN scale 1:75

NOTES

1. All dimensions are in mm unless stated otherwise.
2. All levels are in metres above sea level.
3. For Site location see Dwg. SGI-MWE-KIT-0.0.0
4. Structural details are not included.
5. All structural concrete is Class 25/10.
6. All mass concrete is Class 15/10.

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THE REPUBLIC OF UGANDA
MINISTRY OF WATER AND ENVIRONMENT
DIRECTORATE OF WATER DEVELOPMENT

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REVISIONS :

No	Date	Description

DETAILED ENGINEERING DESIGN

DRAWING TITLE
WATER OFFICE
FLOOR PLAN AND ELEVATION

SCALE	AS SHOWN	DRAWING No.	SGI-MWE-KIT-12.0.0
SURVEYED	GW	DESIGNED	ORD
DRAWN	CDE	CHECKED	ORD
DATE	SEPT 2020	APPROVED	CP