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 - Lugala RGC

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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
HEP	Hydro Electric Power
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.

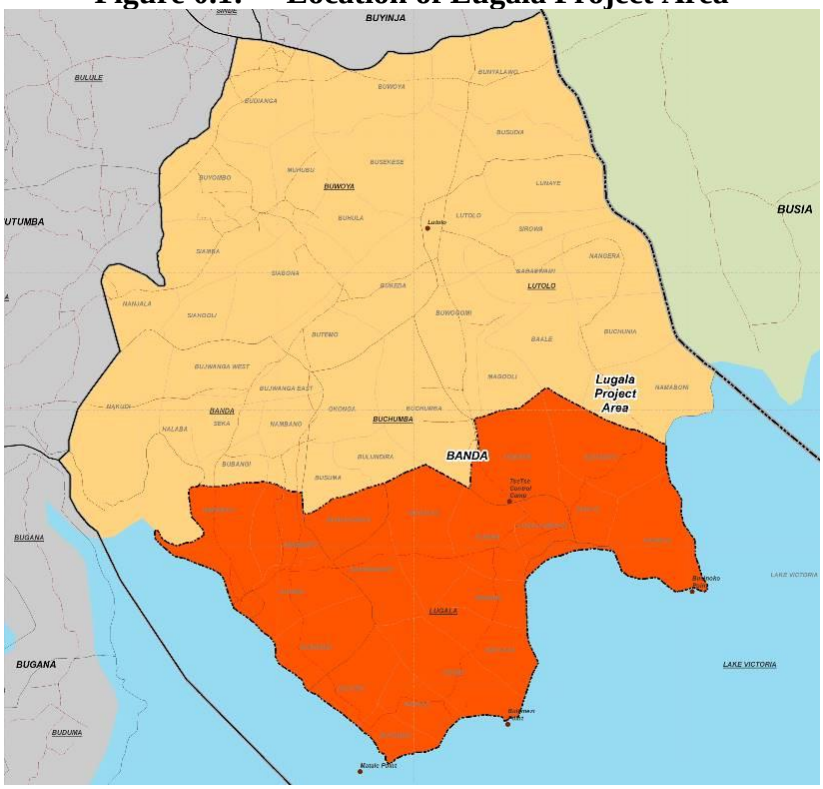
This is the design report for Lugala RGC Water Supply and Sanitation System. This report is in three volumes namely:

- 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

Lugala Centre RGC is also located in Banda sub-county, Namayingo District. The sub-county is bordered by Biyinja and Mutumba sub-counties to the North and West, Busia District to the East and Lake Victoria to the South. The district is also bordered by Bigiri District to the North and West, Busia to the East and Lake Victoria to the South. The RGC is located at the shores of Lake Victoria approximately 19 km by road from Namayingo District headquarters along the Namayingo-Lugala road. Figure 0.1 below shows the location of Lugala project area.

Figure 0.1: Location of Lugala Project Area



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 933.63m^3/day for the ultimate design horizon of 2040. The water source for the piped water system is surface water from Lake Victoria 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 (657.39m3/day). The water system will be designed as follows;

a) The source of water supply is Lake Victoria.
b) The intake system to be located in Lake Victoria 300m off the shoreline of Lugala Beach Village, Lugala parish, Banda Subcounty,
c) The raw water pumps have been sized on the basis of the water demand of 690m3/day (43.14m3/h at 16 hours pumping regime-intermediate year 2030 demand) inclusive of 5% MDD for treatment plant usage.
d) A raw water gravity main of DN150 ST delivers water (for the ultimate year demand -2040) from the intake to the flocculator at the Water Treatment Plant (WTP) whose capacity is 690m3/d which is the 2030 MDD.
e) The treated water transmission system consisting of a single pipe from the WTP delivers water to the reservoir located Buhima village, Lugala parish, Banda subcounty.
f) Solar energy is the proposed means of powering the raw water and clear water pumps and augmented by extension of HEP power for a distance of 1.5km
g) A reservoir tank of 296m^3 representing 30% of 2040 MDD as placed on a 15m tower has been adopted.
h) A distribution network shall be of length 13.16km as shown in the table below.

Table 0.1: Distribution Network

Pipe Details	Length (m)
OD225 uPVC PN10	287
OD160 uPVC PN10	5,511
OD110 uPVC PN10	3,084
OD90 HDPE PN10	931
OD75 HDPE PN10	768
OD63 HDPE PN10	1,007
OD50 HDPE PN10	1,573
Total	**13,160**
Source: Project Estimates	

i) A total of 258 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 1,888 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	
LUG G-1	General Items	522,700,000
LUG G-2	Method Related Charges	83,500,000
LUG G-3	Dayworks	6,944,200
	WATER SUPPLY, SANITATION AND EQUIPMENT	
LUG W-1	Intake structure works	323,181,669
LUG W-2	Raw Water Transmission Mains	107,036,182
LUG W-3	Treatment Plant Site Works	686,567,016
LUG W-4	Coagulator and Flocculator	163,585,017
LUG W-5	Sedimentation Tank	171,511,341
LUG W-6	Rapid Gravity Filters	363,714,106
LUG W-7	Clear Water Tank and Pump House	298,328,383
LUG W-8	Sludge Drying Beds	148,407,990
LUG W-9	Chemical House	258,521,995
LUG W-10	Laboratory and Workshop	117,808,095
LUG W-11	Clear Water Transmission Mains	192,105,318
LUG W-12	Storage Reservoir and Site Works	365,571,547
LUG W-13	Distribution Network	620,886,953
LUG W-14	Intensification Network	332,659,880
LUG W-15	Water Office Block	109,152,596
LUG ME-1	Mechanical Works	445,460,000
LUG EE-1	Electrical Works	837,460,000
LUG S-1	6 Stance Waterborne Toilet (2No.)	135,243,280
	Sub-Total 1	**6,290,345,568**
	Allow for 10% contingency	629,034,556.78
	Sub-Total 2	**6,919,380,125**
	Allow for 18% VAT	1,245,488,422
	GRAND TOTAL	**8,164,868,547**

0.5.2 Per Capita Investment Costs

The per capita investments and re-investment costs for the system 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 overleaf.

Table 0.3 Per Capita Investment & Re-investment Costs

Per Capita Investment Cost	Currency	
	(USh)	(US $)
Resident population - 2019	830,778	219
Resident population - 2020	802,145	211
Resident population - 2025	673,059	177
Resident population - 2030	564,783	149
Resident population - 2035	473,930	125
Resident population - 2040	397,677	105
Re-Investment Cost	**Currency**	
	(USh)	(US $)
Resident population - After 10 years (2030)	37,231	10
Resident population - After 20 years (2040)	26,215	7
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)	408	-3,306	-4,253	-4,623	-4,861
Dynamic Prime Cost - O & M (USh/m^3)	1,393	1,453	1,488	1,510	1,531
Dynamic Prime Cost - Total (USh/m^3)	2,398	3,755	4,796	5,574	6,409
Internal Rate of Return	**0.4%**				
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 1,453 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 (+0.4%). 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 3,755.

4. The Net Present Values (NPV) is USh -3,306 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, 408 million) is considered.

5. The ultimate year 2040 per capita investment costs are US$ 105. 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 Lugala 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.

1.7 Scope of Work

1.7.1 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

1.7.2 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.

1.7.3 Other Tasks Undertaken

The hydrogeological/geophysical tests to site and drill production wells within the project area was carried out and compiled by the implementing authority (DWD) also acting as the client. However, all the reports regarding this activity in the project areas have not yet been submitted to the consultant to form part of the contract as indicated in the terms of reference.

1.8 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 Lugala RGC Water Supply and Sanitation System

1.9 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 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 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

Lugala Centre RGC is also located in Banda sub-county, Namayingo District. The sub-county is bordered by Biyinja and Mutumba sub-counties to the North and West, Busia District to the East and Lake Victoria to the South. The district is also bordered by Bigiri District to the North and West, Busia to the East and Lake Victoria to the South. The RGC is located at the shores of Lake Victoria approximately 19 km by road from Namayingo District headquarters along the Namayingo-Lugala road. The coordinates of Lugala Centre are, 600504.33 m E, 022012.91 m N. The Aerial view of Lugala Centre RGC is given in Picture 2.1 below.

Picture 2.1: Lugala RGC Project Area

2.2 Administrative Structure

Lugala Center is located in Banda parish, one of 5 parishes in Banda sub-county as seen in Figure 2.1 overleaf. The centre is currently headed by the Senior Assistant Secretary or popularly known as the sub-county chairman. The town is where most of the commercial activities take place and consists mainly of shops, a market, a police station, saloon, fuel station and schools.

The RGC project area will comprise the core villages of Lugala Beach and Bunini both located in Lugala and Buchumba parishes respectively and parts of Buhima village also located in Lugala parish, Namake, Bukwoyo and Businono all located in Buchumba Parish.

Figure 2.1: Banda Sub-county UBOS Statistical Abstract 2014

According to the National Population and Housing Census 2014, the annual population growth rate for Namayingo district is 3.57 with an average household size of 5.4 for Banda sub-county. The number of Households (HH) and population in the project area is as given in Table 2.1 below.

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 Considered Popn 2018
BANDA	LUGALA	BUDALA A	300	5.4	1,620	1,864	90% of Population
		BUHIMA	222	5.4	1,199	1,379	100% of Population
		LUGALA BEACH	193	5.4	1,042	1,199	100% of Population
		SIDENDE	82	5.4	443	509	80% of Population
	BUCHUMBA	NAMAKE	218	5.4	1,177	1,355	80% of Population
		BUKWOYO	181	5.4	977	1,125	80% of Population
		BUNINI	144	5.4	778	895	80% of Population
		BUSINOHO	218	5.4	1,177	1,355	50% of Population
TOTAL PROJECT AREA			**1,558**	**5.4**	**8,413**	**9,681**	
	Source: UBOS 2014 Namayingo District, Project Estimates						

2.3 Accessibility

The area is accessible via the Namayingo-Lugala gravel road as seen in the Picture 2.2 overleaf.

Picture 2.2: Access road to Lugala Center

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 and Picture 2.4) below.

Picture 2.3: Core Project Area

Picture 2.4: Immediate Fringes

2.5 Power Source

Lugala centre is connected to the national electricity grid as seen as seen in Picture 2.5 below however the power is intermittent thus not stable.

Picture 2.5: Transformer within Lugala Center

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 2.6 to Picture 2.7 below show the commercial activities carried out within the project area.

Picture 2.6: Fish being dried at the landing site

Picture 2.7: Wednesday weekly market

Picture 2.8: Retail shop in Lugala centre

Picture 2.9: Boat construction in Lugala centre

2.8 Institutions

The main institutions within the project area are listed in Table 2.2 and shown in Picture 2.10 and Picture 2.11, shown overleaf;

Table 2.2: Main Institutions within the Project Area

Type of Institution	Institution Name	Ownership
Health Centre	Lugala Health Centre II	Gov.
Health Centre	Buchumba Health Centre II	Gov.
Market	Market (Weekly)	Trading centre
Religious	Catholic Churches	Church
Religious	Protestant Churches	Church
Religious	Mosque	Moslems
School	Lugala Primary School	Gov.
School	Budala Primary School	Gov
School	Buchumba Hill Primary School	Gov
School	Mayanja Primary School	Gov
Security	Police	Gov
Source: Field Visits		

Picture 2.10: Namayingo District Local Government Offices

Picture 2.11: Banda Sub-county Offices

Picture 2.12: Banda Sub-county Offices

Picture 2.13: Banda Sub-county Offices

2.9 Water Resources in the Project Area

2.9.1 Rainfall

Namayingo experiences extreme seasonal variations in monthly rainfall, falling throughout the year in the district. The most rain falls in April 19, with an average total accumulation of 259mm, while the least rain falls in July with an average total accumulation of 60mm, as shown in Figure 2.2.

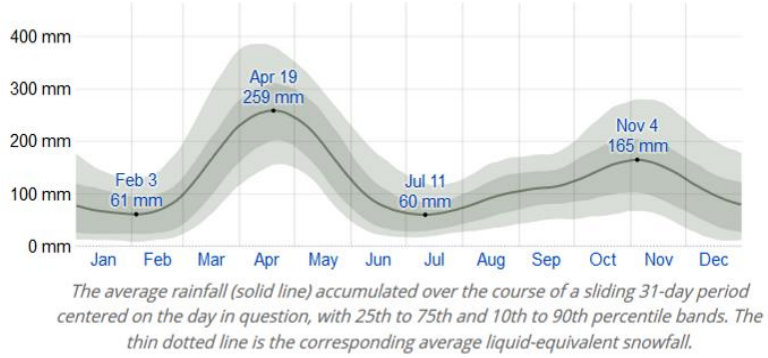


Figure 2.2: Average Monthly Rainfall for Namayingo District

2.9.2 Temperatures

According to weather spark.com, the annual mean average temperature in Namayingo is 29ºC with the lowest being 18ºC as shown in Figure 2.3.

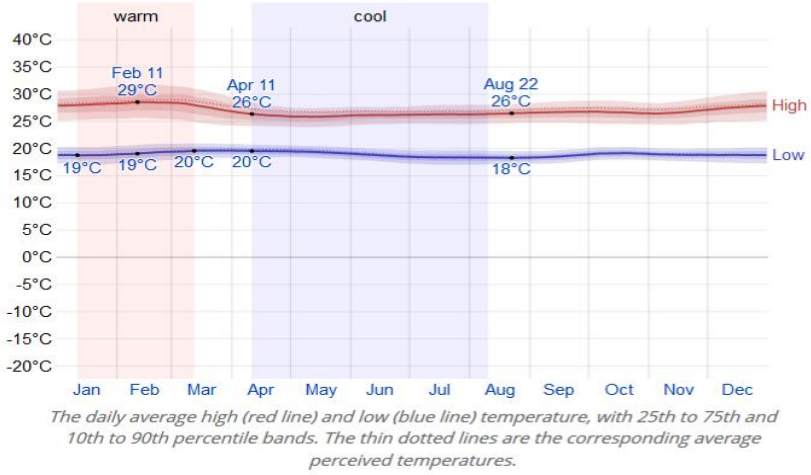


Figure 2.3: Average High and Low Temperatures for Namayingo District

2.9.3 Sun

The length of the day in Namayingo does not vary substantially over the course of the year, staying within 8 minutes of 12 hours throughout. In 2018, the shortest day is December 22, with 12 hours, 7 minutes of daylight; the longest day is June 21, with 12 hours, 8 minutes of daylight as seen in Figure 2.4.

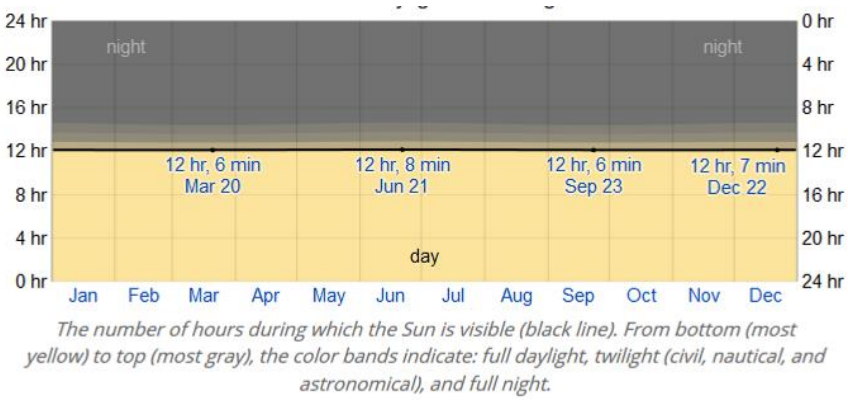


Figure 2.4: Hours of Daylight and Twilight

The earliest sunrise is on November 4, and the latest sunrise is on February 10. The earliest sunset is on November 2, and the latest sunset is on February 11 as seen in Figure 2.5.

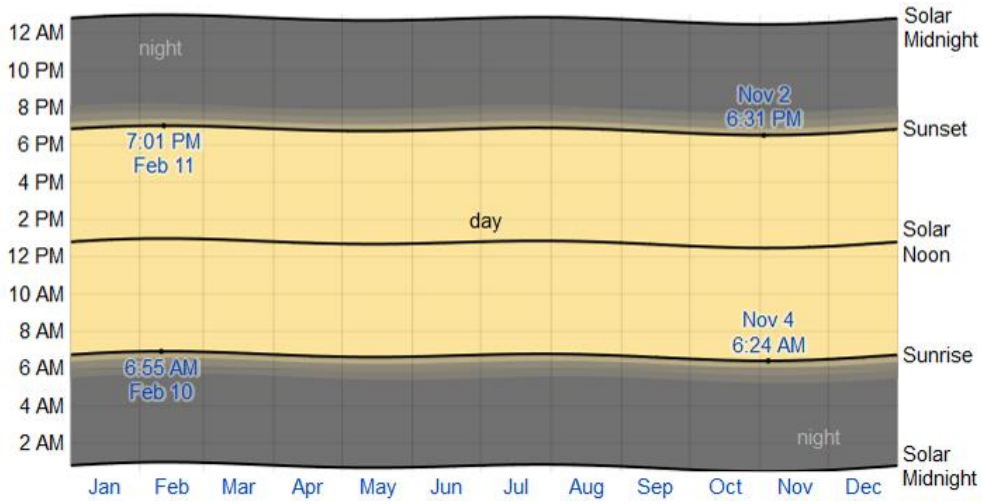


Figure 2.5: Sunrise and Sunset with Twilight

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 gray.

2.9.4 Humidity

Namayingo experiences extreme seasonal variation in the perceived humidity. The muggier period of the year lasts for 9.4 months, from September to June, during which time the comfort level is muggy, oppressive, or miserable at least 32% of the time. The muggiest month of the year is May, with muggy conditions 82% of the time. The least muggy month of the year is July, with muggy conditions 16% of the time as seen in Figure 2.6.

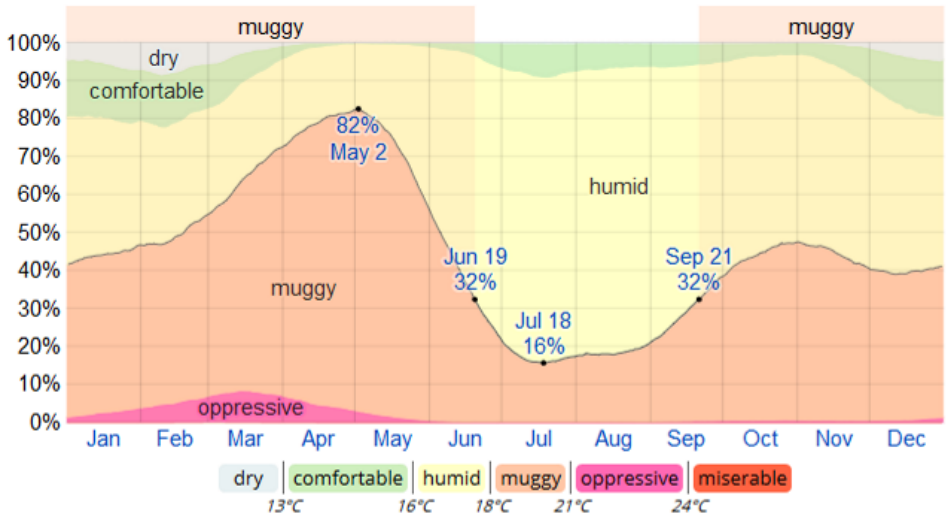


Figure 2.6: Humidity for Namayingo

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 2.3 months, from January 9 to March 18, with an

average daily incident shortwave energy per square meter above 6.6 kWh. The brightest day of the year is March 2, with an average of 7.0 kWh. The darker period of the year lasts for 1.6 months, from April 18 to June 6, with an average daily incident shortwave energy per square meter below 5.4 kWh. The darkest day of the year is May 3, with an average of 5.0 kWh. Figure 2.7 below best illustrates the solar energy trend in Namayingo district.

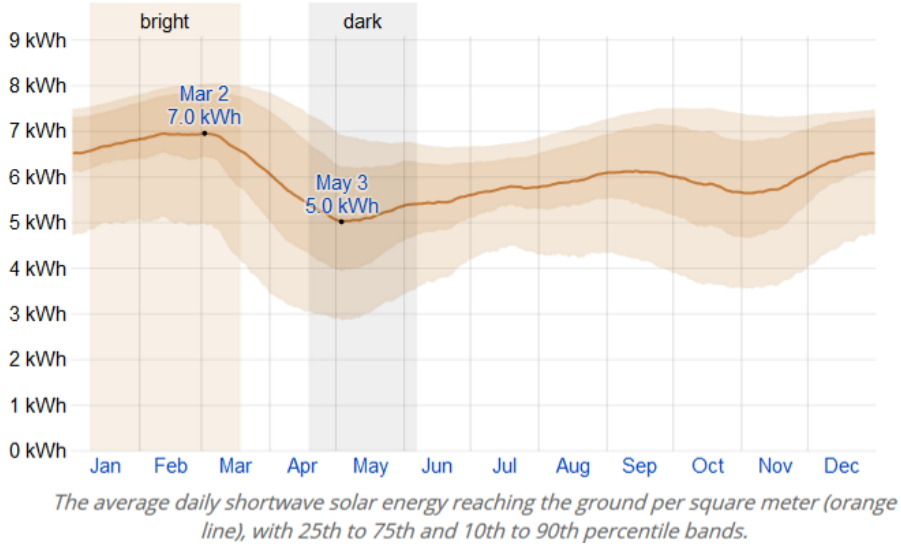


Figure 2.7: Average Incident Shortwave Solar Energy for Namayingo

2.9.6 Topography and Vegetation

The topography of Namayingo contains only modest variations in elevation, with a maximum elevation change of 148 meters and an average elevation above sea level of 1,180 meters. The area within district is covered by cropland (78%) and trees (12%), and the remaining swamps.

2.9.7 Geology

This rock system is a basement underlined by the Nyanzian system that is rather complex and includes a variety of granites, gneisses, quartzite and small areas of other kinds of strong folded metamorphic rocks.

2.9.8 Soils

Generally, all soil types in Namayingo District are mainly loamy and sand loams. These soils have fine textile with rather loose structure, which are easily eroded and leached. Most soils are acidic in nature. Soil types in the district include: (i) Yellow - red sandy, clay loams soils varying from dark grey to dark which are slightly acidic and mainly derived from granite, gneissic and sedimentary rocks. They occur on gently undulating - hilly topography; (ii) Brown - yellow clay loams with laterite horizon with a variety of dark brown to dark greyish brown, which are slightly acidic. These occur on flat ridge tops or as of undulating topography; (iii) Light - grey- white mottled loamy soils with laterite horizon ground, structure-less loamy sands. They are acidic - allocative and mainly found on the lower and bottom slopes.

2.9.9 Hydrogeology

The rock structure within the project area does not allow for the formation of fractures leading to low and/or poor ground water potential with very poor yields. And if a drilled borehole is successful, then

the water quality is compromised due to the high iron content in the water and mineral nature of the ground water within the project area which makes the water taste bad (salty). The District LCV Chairman informed the consultant of this (salty ground water) issue and proposed that water be abstracted from the lake instead of boreholes since they (boreholes) where being abandoned by the local residents as the water was not fit for consumption. Despite the ground water being saline in nature, it is the most consumed water for the inland towns in the district while for the landing sites, its surface water.

Ground water has been taped mainly in form of boreholes as shown in Picture 2.14 below. However these boreholes contain salty water and are thus abandoned.

Picture 2.14: Abandoned borehole in Lugala Centre

2.9.10 Surface Water

The major surface water bodies within or close to the project area are swamps and Lake Victoria. The project area is located along the shores of Lake Victoria and then stretches to the inland areas accordingly. Picture 2.15 below shows the shores of Lake Victoria within the project area.

Picture 2.15: Bicycles used in fetching surface water in Lugala Centre

3 SUMMARY OF FEASIBILITY STUDY REPORT

3.1 Socio-Economic Household Survey

Five villages from Lugala beach / parish in the project with a total household's population of 914 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 favor 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 centers, 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 centers 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

The total number of households (respondents) involved as units of analysis were 115 representing 12.6% of the total number of households in the entire project area. These were randomly distributed within 5 villages from the Lugala beach parish.

3.2 Socio-Demographic Characteristics

3.2.1 Population Age Structure

We set to find out the socio-demographic characteristics of the population in the project are through the selected sample respondents in order to project their implications on the implementation process and sustainability of the facilities of the project. Table 3.1 below provides demographic structure of the households in the sample.

Table 3.1: Percentage Distribution of Population by Age Composition

Age composition (Years)	0-5	6-17	18-35	36-45	46-65	65+	Total
Frequency	85	76	107	36	22	4	**330**
Percentage	25.7	23.0	32.4	10.9	6.6	1.2	**100**
Cumulative population Estimates for sampled household with a 5 year interval	**169**	**160**	**191**	**120**	**106**	**88**	**834**
Source: Socio-Economic Report – Lugala, February 2019							

3.2.2 Household Headship

The total number of respondents' as indicated by their sex in the study were 100 persons out of which 73.3 percent were males and 26.7 percent were female. The analysis indicates that 79.2 percent of those

who responded in the study were household heads. The survey results further reveal that, 22.4% of the sample households were headed by females while 77.6% are male headed.

Table 3.2: Percentage Distribution of Respondents by Sex

Sex of the household head		
	Freq	**Valid %**
Female	22	22.4
Male	76	77.6
Total	**98**	**100**
Source: Socio-Economic Report – Lugala, February 2019		

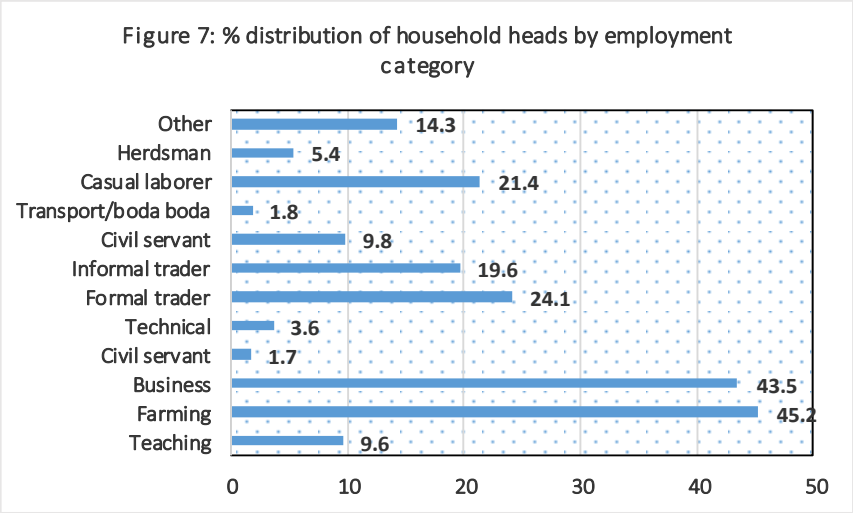
These percentages are highly revealing for the RTWSP activities. Female representation in the RTWSP related activities should not only be seen as a move towards gender balancing but specifically because women in the project area hold household headship positions in which key economic and administrative decisions rest. Women are also managers of homes

They provide and at the same time control the water used in homes in a country where headship of households has been dominantly by males.
It is only fair to recognize the ability of women to perform similar roles, and thereby incorporate them in the decision-making process of the project

3.2.3 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. Figure 3.1 below depicts the current employment situation in the project area. As seen in the results below, a significant size of the household heads in the sample are engaged in the informal sector activities.

Figure 3.1: Percentage Distribution of Household Head by Employment Category



Source: Socio-Economic Report – Lugala, February 2019

3.3 Existing Water Supply and Sanitation Situation

There is a mini water supply system constructed specifically for Lugala primary school within and another recently constructed by Ministry of Water and Environment just outside the project area to supply Nairobi and Lutolo trading centres with water. However, the residents within the project area depend on the lake majorly for their everyday water needs.

Lugala Centre currently has no central piped sewerage facilities. The population in the centre is mainly served by pit latrines. There are two public toilets that serve the entire population and are located at the entrance to the RGC on high ground where the soil is a little stable as the soils within the landing site are sandy and make excavation of pits in Lugala difficult.

As regards solid waste management, the designated solid waste dump site is located next to the weekly market along the shores of the lake. Rubbish is normally collected and burnt at this point.

3.4 Design Criteria

The design criteria and standards for the water supply system are 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).

3.5 Consumer Projections

The population for the project area was adopted from Uganda Bureau of Statistics based from the 2014 census. The adopted growth rate for Namayingo District is 3.57% p.a. and this has also been 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 3.3 below.

Table 3.3: Population Projections

S/County	Parish	Village	Total Population					
			2019	2020	2025	2030	2035	2040
Banda	Lugala	Budala A	1,931	2,000	2,383	2,840	3,384	4,033
		Buhima	1,429	1,480	1,764	2,102	2,505	2,985
		Lugala Beach	1,242	1,286	1,533	1,827	2,177	2,594
		Sidende	528	547	652	777	926	1,104
		Parish Total	**5,130**	**5,313**	**6,332**	**7,546**	**8,992**	**10,716**
	Buchumba	Namake	1,403	1,453	1,732	2,064	2,460	2,932
		Bukwoyo	1,165	1,207	1,438	1,714	2,043	2,435
		Bunini	927	960	1,144	1,363	1,624	1,935
		Businoho	1,403	1,453	1,732	2,064	2,460	2,932
		Parish Total	**4,898**	**5,073**	**6,046**	**7,205**	**8,587**	**10,234**
Lugala Water Supply Project Total			**10,028**	**10,386**	**12,378**	**14,751**	**17,579**	**20,950**

Source: 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 ranges of the maximum day total demands are given in Table 3.4 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 3.4: 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)	1,000	934	816
Source: Project Estimates			

In the design, the system will be sized on the basis of the Ability to Pay (ATP) the tariff of USh 50 per 20 litres. The design demand is therefore 933.63m^3/day.

3.7 Water Resources Assessment

3.7.1 Groundwater Assessment

No boreholes have yet been drilled for motorizing within the project area. The ultimate year (2040) maximum day demand is 933.63m^3/day. An analysis was carried of the borehole yield required for 16-hour pumping regime in Table 3.5 below.

Table 3.5: Available Borehole Capacity

Lugala RGC	Maximum Day Demand at Given Tariff (m^3/day)		
	USh 36/ 20L	USh 50/ 20L	USh 83/ 20L
Demand- m^3/hr	62.50	58.35	50.98
1 No Borehole	62.5	58.4	51.0
2 No Boreholes	31.3	29.2	25.5
3 No Boreholes	20.8	19.5	17.0
4 No Boreholes	15.6	14.6	12.7

From the table above, for the proposed tariff of USh 50/20L, the borehole yields required are as shown. It is proposed that the client carry out borehole drilling for at least three boreholes of 19.5m^3/hr yield over a 16 hr pumping regime. However, the geological structure of the ground water is such that the water is saline and will thus require specailised treatment processes whose operations and maintenance costs are high.

3.7.2 Surface Water Assessment

The reliable surface water source near Lugala RGC is Lake Victoria. Lake Victoria can meet the water demands of Lugala RGC.

3.7.3 Conclusion

The surface water source of Lake Victoria can provide the quantity of water needed for the piped water supply for Lugala 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 are indicated accordingly.

3.9 Preliminary Design – Water Supply

In the design, the system will be sized basing on the maximum day water demand of 933.63m^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 Victoria in Lugala Beach village (600192.28E, 21840.76N).
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 Victoria as the source of water and contains the following aspects:

a) Construction of an intake on Lake Victoria in Lugala Beach village
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 3.6 below

Table 3.6: Different Water Supply Scenario Components

Component	**Surface Water (MDD 933.63m^3/day)**	**Surface Water (MDD 933.63m^3/day)**
	Scenario I (Packaged WTP)	**Scenario II (Conventional WTP)**
Intake Capacity (m^3/day)	980.31	980.31
Intake Structure	1No.	1No.
Raw Water Pumping Main (m)		
OD225 uPVC PN10	300	300
Raw Water Pumps (Submersible)		
Head 16m, Flow 61.27m^3/hr	2No. (1No. Duty, 1No. Standby)	2No. (1No. Duty, 1No. Standby)
Water Treatment Plant Capacity (m^3/day)	1,120.00	933.63
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 9.1mx2.0mx2.0m deep with 5 Baffels
Sedimentation Tanks		2No. Rectangular 13mx4.3mx3.0m deep
Rapid Gravity Sand Filters		4No. Rectangular 5.4mx2.7mx2.0m deep
Clear Water / Contact Tank		2No. Rectangular 8.35mx3.75mx3.5m deep
Sludge Drying Beds		1No.
Sump, Chlorine Dosing Unit and Pump House	1No.	1No.
Clear Water Pumps		
Head 82m, Flow 58.35m^3/hr	2No. (1No. Duty, 1No. Standby)	2No. (1No. Duty, 1No. Standby)
Backwash Pumps		
Head 11m, Flow 2.92m^3/hr	2No. (1No. Duty, 1No. Standby)	2No. (1No. Duty, 1No. Standby)
Backwash Tank		
	1No. 40m^3 elevated on 10m tower	1No. 40m^3 elevated on 10m tower

Component	**Surface Water (MDD 933.63m^3/day)**	**Surface Water (MDD 933.63m^3/day)**
	Scenario I (Packaged WTP)	**Scenario II (Conventional WTP)**
Air Blowers		
		2No. (1No. Duty, 1No. Standby)
Clear Water Pumping Mains (m)		
OD160 uPVC PN10	3,500	3,500
Storage Tank	296m^3 Cold Pressed Steel Tank Elevated on 15m steel tower	
Distribution Network (m)	13,160	
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 3.7 overleaf.

Table 3.7 Summary of Combined Capital Cost Estimates

Item	**Description**	**Capital Investment Costs**	
		Ground Water Supply	**Surface Water Supply**
		Scenario I	**Scenario II**
1.0	Preliminary and General Items	600,116,668	464,516,175
2.0	Intakes / Pump House	673,254,676	673,254,676
3.0	Treatment Plant Works	3,364,924,928	1,795,000,000
4.0	Raw Water Transmission Mains	42,033,917	42,033,917
5.0	Clear Water Transmission Mains	200,358,236	200,358,236
6.0	Storage Reservoir	385,250,000	385,250,000
7.0	Distribution Network and Service Connections	665,824,926	665,824,926
8.0	Water Office	120,000,000	120,000,000
9.0	Mechanical and Electrical for Raw Water	155,000,000	175,000,000
10.0	Mechanical and Electrical for Clear Water	221,000,000	497,000,000
11.0	Solar Items	173,520,000	91,440,000
	Sub Total 1	**6,601,283,351**	**5,109,677,930**
	Allow 10% Contingency	660,128,335	510,967,793
	Sub Total 2	**7,261,411,686**	**5,620,645,723**
	Allow 18% VAT	1,307,054,103	1,011,716,230
	Grand Total	**8,568,465,789**	**6,632,361,953**
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 3.8 below.

Table 3.8 Per Capita Investment & Re-investment Costs

Per Capita Investment Cost	Currency			
	Scenario I (PWTP)		Scenario II (CWTP)	
	(USh)	(US $)	(USh)	(US $)
Resident population - Initial year (2020)	993,319	261	768,871	202
Resident population - Intermediate year (2030)	699,387	184	541,355	142
Resident population - Ultimate year (2040)	492,455	130	381,181	100
Per Capita Re-Investment Cost	**Currency**		**Currency**	
	(USh)	(US $)	(USh)	(US $)
	(USh)	(US $)	(USh)	(US $)
Resident population - Intermediate year (2030)	59,380	16	84,311	22
Resident population - Ultimate year (2040)	41,811	11	59,365	16
Source: Project estimates.				

3.11.3 Summary of Financial Indicators

The results of the analyses are summarised in the Table 3.9 below.

Table 3.9 Summary of Financial Indicators

Item	Discounted Totals				
	Discounted Rate (%/year)				
	0%	5%	8%	10%	12%
Scenario I (Packaged WTP)					
Net Present Value (in USh million)	1,389	-3,757	-5,044	-5,544	-5,867
Dynamic Prime Cost - O & M (USh/m^3)	970	1,029	1,064	1,086	1,107
Dynamic Prime Cost - Total (USh/m^3)	2,163	3,878	5,221	6,231	7,322
Internal Rate of Return	**0.9%**				
Scenario II (Conventional WTP)					
Net Present Value (in USh million)	1,848	-2,549	-3,657	-4,092	-4,376
Dynamic Prime Cost - O & M (USh/m^3)	1,050	1,109	1,143	1,164	1,185
Dynamic Prime Cost - Total (USh/m^3)	2,052	3,475	4,587	5,423	6,325
Internal Rate of Return	**1.5%**				
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 1,029 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 (+1.5%) with Scenario I having an IRR of +0.9%. 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 3,878 and USh 3,475 per cubic metre for Scenario I and II respectively.

4) The Net Present Values (NPV) are USh -3,757 million and USh -2,549 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 +1,389 million and USh +1,848 million for both Scenario I and II respectively.

5) The ultimate year 2040 per capita investment costs are US$ 130, and 100 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 Lugala 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.

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 3.10 below.

Table 3.10 Summary of Combined Capital Cost Estimates

No.	Proposed Intervention	Cost Estimates
1	Water Supply Investments	6,632,361,953
2	Sanitation Investments	271,100,000
	Total	**6,903,461,953**
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 Victoria 300m off the shoreline of Lugala Beach Village, Lugala parish, Banda Subcounty.

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-LUG-0.0.0** shows the layout of the proposed system.

i) The source of water supply is **Lake Victoria**.
ii) The intake system to be located in Lake Victoria 300m off the shoreline of Lugala Beach Village, Lugala parish, Banda Subcounty,

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 Buhima village, Lugala parish, Banda 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	2021
Design Year	Year	2041
Population at Design Horizon	P [inh.]	17,400
Maximum Day Demand	m^3/day	934
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 933m3/d. The system capacity is presented in Table 4.3 below.

Table 4.3: Water System Capacity

Description	Quantity (m^3/d)	2030	Comment
Maximum Day Demand	933.6	690.3	Maximum Day Demand
Capacity of Intake and Treatment Works	980.3	724.8	Maximum Day Demand plus 5% for Treatment Plant and Surrounding Community Use
Water Treatment Plant use	46.7	34.5	5% of Maximum Day Demand
Capacity of Raw Water Transmission Main	980.3	724.8	Maximum Day Demand plus 5% for Treatment Plant
Capacity of Treated Water Transmission Main	933.6	690.3	Maximum Day Demand for Lugala
Source: Project Estimates			

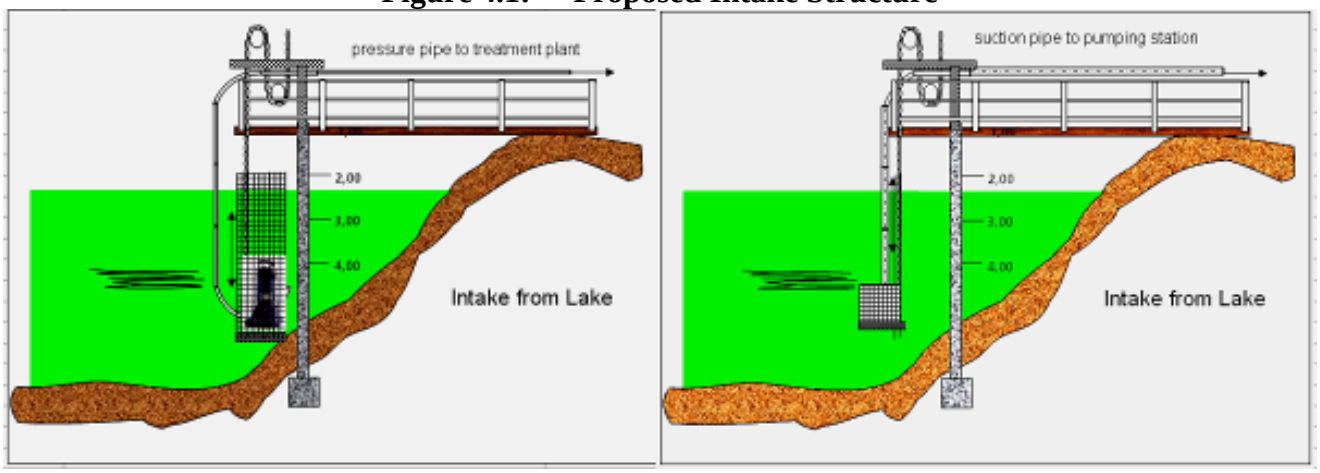
4.2 Detailed Design of Intake

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-LUG-1.1.0. The pictures overleaf shows the completed intake structure in question which was recently constructed in Pallisa Water Supply Project 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 mixing chamber. The total length will be 400m. The main will have the capacity to deliver 62m^3/hr.

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)	**Raw Water Pumping Main**
Treatment Plant Use (5%) (m^3/day)	**Raw Water Pumping Main**
Total Amount of Water Abstracted (m^3/day)	**933.63**
Hours of Pumping (hr)	**46.68**
Efficiency (%)	**980.31**
Required Delivery (m^3/hr)	16
Required Delivery (m^3/s)	60.0%
Pump Installation Level (m amsl)	61.27
Inlet Level (m amsl)	0.0170
Static Lift (m)	1129.000
Hazen Williams Coefficient, Cwh (C)	1142.994
Pipe Details	14.0
Pipe Diameter ND (mm)	140
Pipe Diameter ND (m)	**DN150 ST PN6**
Velocity (m/s)	150.00
Flow in Pipe (m^3/s)	0.150
Length of Pipe (m)	0.963
Friction Loss (m)	0.0170
Fittings losses - 10% (m)	**400**
Total Friction Loss (m)	2.5
Total Head (m)	0.2
Head Used (m)	2.5
Power (kW)	**16.7**
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. The proposed pumping head is based on 2030 demand because pumps have an economic life of 10 years and have to be replaced after. The energy calculations are for 8 pumping hours for each power source. Solar energy and HEP have been proposed to run the system for 8 hrs each in order to meet the demand in the ultimate year.

4.3 Detailed Design of the Treatment Plant

The treatment plant has been sized on the basis of the intermediate year demand (2030 MDD) which is 690m3/d (43.14m3/hr) inclusive of 5% plant use and will operate for16 hours per day. In 2030, new units (Coagulation and Flocculation, Sedimentation and Rapid Gravity Filters will need to be constructed to cater for the ultimate year demand (2040MDD).

4.3.1 Choice of Treatment Process

To evaluate the suitability of Lake Victoria 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 in the 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

No	Parameters	Unit	National standard	Lake Victoria
1	Faecal coliforms	CFU/100ml	0	23
2	Colour	PtCo	50	900
3	Total Suspended Solids	Mg/L	0	39
4	Turbidity	NTU	25	120

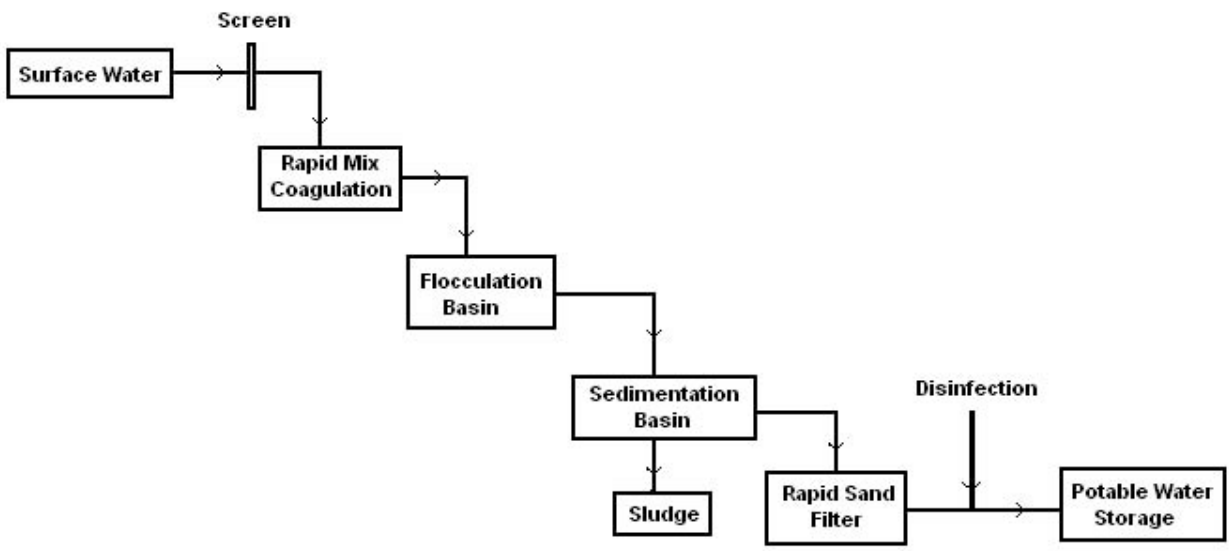
The water treatment processes required will therefore emphasises the removal of the total suspended solids (TSS) and colour through coagulation, flocculation, sedimentation and filtration as seen in the table below.

Table 4.6: Raw Water Treatment Process

Water quality parameter	Treatment- Process
Turbidity	Clarification & Rapid Sand filtration
Total Suspended Solids	Coagulation, flocculation, sedimentation
Faecal coliform	Chlorination - disinfection tanks
Colour	Coagulation, flocculation, sedimentation

The treatment flow process is shown in Figure 4.2 below.

Figure 4.2: Treatment Flow Process



4.3.2 Chemical Dosing

Chemical dosing will be done in a purpose built unit as given in Drawing SGI-MWE-LUG-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.

4.3.3 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 effect 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. 690.26m3/d (43.14m3/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.

4.3.4 Flocculation

4.3.4.1 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.

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

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

4.3.4.2 Sizing of the Flocculation Chamber

The Flocculator is a vertical flow baffled channel type. It contains a single chamber with five baffle walls; two weirs made of reinforced concrete and three plates made of stainless steel. Water inflow into the Flocculator 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 1.2m x 2.0m 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, 2500mm deep and 1240mm 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 1.2m 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 - 36.0m/h,
iii) Spacing of Baffles - 1.0m,

4.3.5 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 is given in Table 4.7 below.

Table 4.7: Sedimentation Tank Design Parameters

Description	Parameter	
Flow into Sedimentation Tanks	**43.14**	m^3/hr.
Detention Time	3	hrs.
Sludge depth	1	m
Clear depth	3.0	m
Total Volume of each Sedimentation Tank	86.28	m^3
Outlet Over Flow Weir	*203.02*	m^3/m/day
Surface Loading Rate (SLR)- [16 hr. operating day]	16	m/day
Internal Width of each Tank	1.70	m
Internal Length of each Tank	13.00	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 through 1No. sluice gate of size 300mm x 400mm 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.

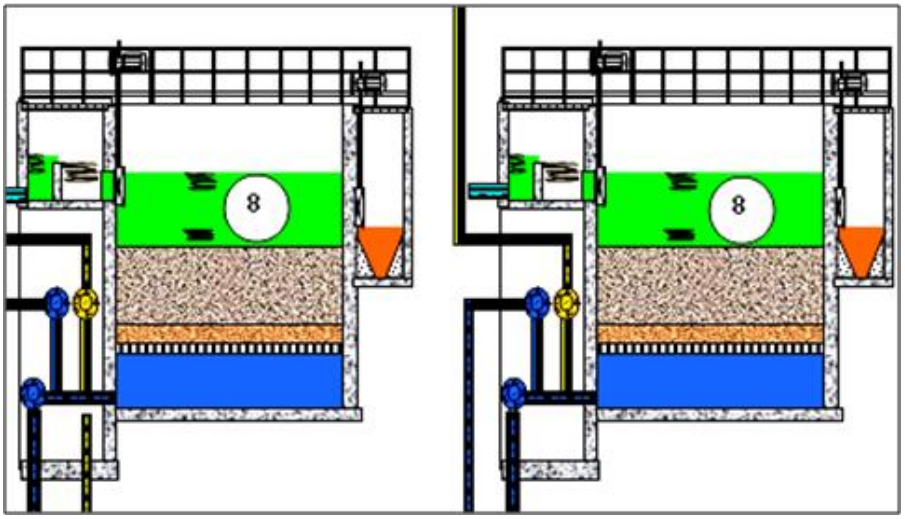
4.3.6 Rapid Gravity Filters

4.3.6.1 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

4.3.6.2 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 43.14 m3/hr. A bank of 2No. filters has been provided each with dimensions of 2.0 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: DN200 supplied from the backwash water tank

- Filter drain: DN100mm

4.3.7 Back Washing Process

4.3.7.1 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 200 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.

4.3.7.2 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 4.8 below.

Table 4.8: 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	101.09
Duration of Backwashing	mins	5.0
Volume of Water required for Backwashing One Filter	m^3	8.42
No.of Filter Bed Volumes of Backwash water consumed	Nr	1.8
Backwash Frequency	hr	24
Designed Water Treatment Plant Demand	**m^3/day**	**34.51**
Estimated Community Demand- 8 hours storage of WTP Demand	m^3/day	11.50
Water Treatment Plant Use only	m^3/day	23.01
Required size of Backwash tank (Community use, 2Nr Filters Backwash + 20% other WTP use)	m^3	31.72
Size of Backwash Tank Adopted	**m^3**	**100**
Ratio of Backwash Tank size to Water Treatment Plant & Community Demand	%	289.7%
	hrs	69.5
Maximum Velocity in Backwash Main	m/s	1.00
Cross Sectional area on Backwash Main	m^2	0.02808
Nominal Diameter of Backwash Main	mm	189.1
Backwash Delivery Main Details	**Pipe Details**	**DN200 DI**
	Nominal Diameter	**200**

	(mm)	
Actual Velocity in Backwash Main	m/s	0.89
Air Cycle		
Duration of blowing Air	mins	
Air Loading Rate	$m^3/m^2/hr$	4.0
Air Flow Rate	Nm^3/hr	60.0
Adopted Flow Rate for Air Blower	**Nm^3/hr**	259.2
	Nm^3/min	**260.0**

4.3.8 Clear Water Tank and Pump Station

4.3.8.1 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 13 km away from the treatment plant.

4.3.8.2 Water Tank

A clear water tank has been provided and will be 5.5 m long, 5.1 m wide and 4.8 m deep. The clear water tank will have two compartments as follows:

- Chlorine contact chamber – 43 m3
- and chlorinated water storage respectively – 65 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 DN150, overflow DN250, outlet will be DN150, and the drain will be DN 100 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

4.3.8.3 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 60m 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 - $41.09m^3/hr.$,

b) Head - 51m.

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 370Nm3/hr. (60m3/m2/hr. for 12.25m2 area),
b) Maximum Pressure in Delivery Line - 10m.

4.3.9 Water Treatment Plant Buildings

4.3.9.1 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.

4.3.9.2 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

4.3.9.3 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.

4.3.10 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 11kV/433 V oil filled 3-Phase Transformer with associated cabling to the nearby Overhead Three-Phase line, Site Lights, and Houses.
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

4.3.11 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 DN150,
ii) Rapid Gravity Filters to Clear Water Tank - DN150,
iii) Clear Water Tanks to Pumps (Suction Main) DN150.
iv) Backwash Pumping Main DN100.
v) Backwash Delivery Main DN200.
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 200.
c) Clear Water Pumping Main - DN 150
d) Backwash Pumping Main - DN 100

4.3.12 Treated Water Transmission Mains

The treated water transmission main will be DN150 ST PN10 delivering water from the treatment plant to the reservoir a distance of 3.5km. The main will have the capacity to deliver 58m^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 4.9. 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 4.9: Treated Water Transmission Design

Parameter	Clear Water Pumping Main
Demand- 2040 (m^3/day)	**933.63**
Treatment Plant Use (5%) (m^3/day)	**0.00**
Total Amount of Water Abstracted (m^3/day)	**933.63**
Hours of Pumping (hr)	16
Efficiency (%)	60.0%
Required Delivery (m^3/hr)	58.35
Required Delivery (m^3/s)	0.0162
Pump Installation Level (m amsl)	1137.199
Inlet Level (m amsl)	1177.066
Static Lift (m)	39.9
Hazen Williams Coefficient, Cwh (C)	140
Pipe Details	**OD160 uPVC PN10**

Parameter	Clear Water Pumping Main
Pipe Diameter ND (mm)	144.60
Pipe Diameter ND (m)	0.145
Velocity (m/s)	0.987
Flow in Pipe (m^3/s)	0.0162
Length of Pipe (m)	**2645**
Friction Loss (m)	17.8
Fittings losses - 10% (m)	1.8
Total Friction Loss (m)	17.8
Total Head (m)	**59.5**
Head Used (m)	**60**
Power (kW)	**15.9**
Source: Project Estimates	

4.3.13 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 HEP. The characteristics of the power requirement of the pump has been calculated using the formula seen in Table 4.10.

Table 4.10: 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 4.11 below.

Table 4.11: 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	12	43.1	2.4	1	2.7	3.0	1	3.75	3.75
Backwash Pump	15	16.4	1.1	1	1.3	2.0	1	2.50	2.50
Clear Water Pump	71	41.1	13.2	1	15.2	16.0	1	20.00	20.00
Source: Project Estimates									

Table 4.12: Solar Power

Location	SOLAR POWER DETAILS	
	Solar Panels No. (1x280pW)	Solar Panels area (m2)
Raw Water Pumps	12	7.27
Backwash Pump	8	4.85
Clear Water Pump	63	38.18
Other WTP Pumps and Structures	67	40.61
Source: Project Estimates		

The power requirement for the pumps and other water treatment plant structures includes the supply of and installation of 150No. 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 6 hrs after which the HEP power will kick in to power for supply the days demand for the next 6 hrs until 2030 after which both solar and HEP options will be used one after the other (series) for 8hrs each to power the pumps.

The HEP power option will include the extension of power for 1.5km, supply, supply and installation of 100kVA 3 phase transformer and all accessories.

4.3.14 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 maximum day demand and is therefore 280m^3. A 296m^3 main reservoir has been adopted since the 280m3 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 4.13 below.

Table 4.13: Reservoir Storage Capacity

Item	Lugala RGC Storage					
	2019	2020	2025	2030	2035	2040
MD Demand- m^3/day	447	463	552	657	783	934
Storage Capacity (m^3)	296	296	296	296	296	296
Hours of Storage	16	15	13	11	9	8
Storage Capacity (%)	66%	64%	54%	45%	38%	32%
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 15m 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 (296m^3) are as follows:-

- Length - 8.54m,
- Width - 7.32m,
- 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-LUG-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 4.14 below shows the estimated sizes and length of the distribution pipes while while Figure 4.5 shows the Epanet Model whose details are attached in Annex 8.3.

Figure 4.5: Lugala RGC Epanet Distribution Network Model

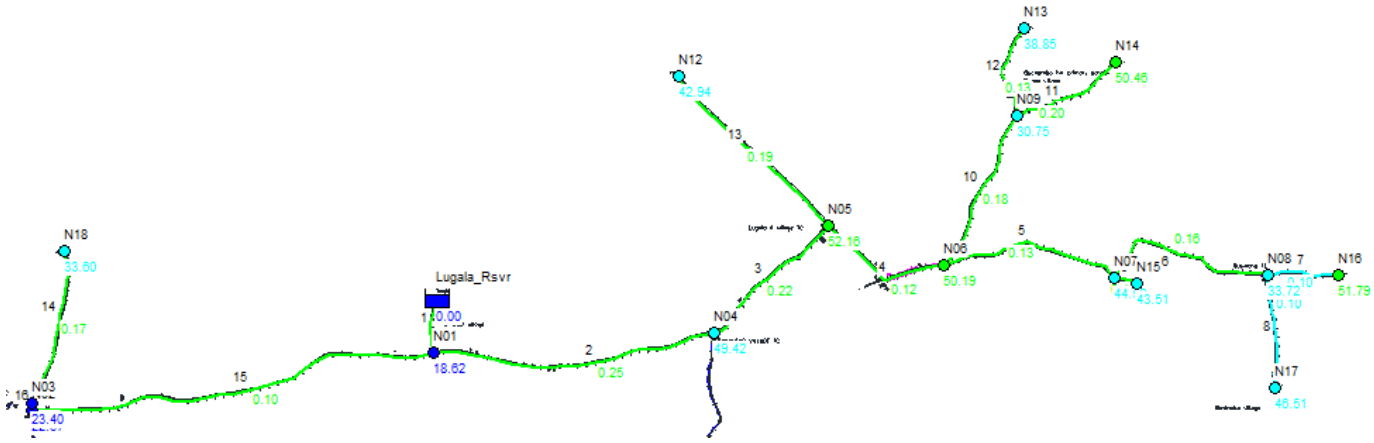


Table 4.14: Distribution Mains

Pipe Details	Length (m)
OD225 uPVC PN10	287
OD160 uPVC PN10	5,511
OD110 uPVC PN10	3,084
OD90 HDPE PN10	931
OD75 HDPE PN10	768
OD63 HDPE PN10	1,007
OD50 HDPE PN10	1,573
Total	**13,160**
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 4.15 below. The criteria used to determine the number of service connections for each served population category is as follows.

Table 4.15: 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 4.16: Required Service Connections

Lugala RGC	House Conn	Yard Tap	Stand Pipe	Total
2020	174	41	43	**258**
2025	207	49	51	**307**
2030	247	58	61	**366**
2035	294	69	73	**436**
2040	351	83	87	**521**
Total	**1,273**	**300**	**315**	**1,888**

A total of 1,888 No. service connections are to be made in Lugala RGC in the ultimate year 2040 as seen in Table 4.16 above while 258 as calculated were to be made in the initial year 2020. However due to the possible increase in demand for water connections when implementation commences, the number of allowed for connections in the BoQ has been increased to 400. 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 4.17 below

Table 4.17: 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
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**		

Item	Description	Unit	Quantity
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
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

Item	Description	Unit	Quantity
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
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

Item	Description	Unit	Quantity
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
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

Item	Description	Unit	Quantity
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, 99.1% 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 41.2%

ii) Private latrine 53.1%

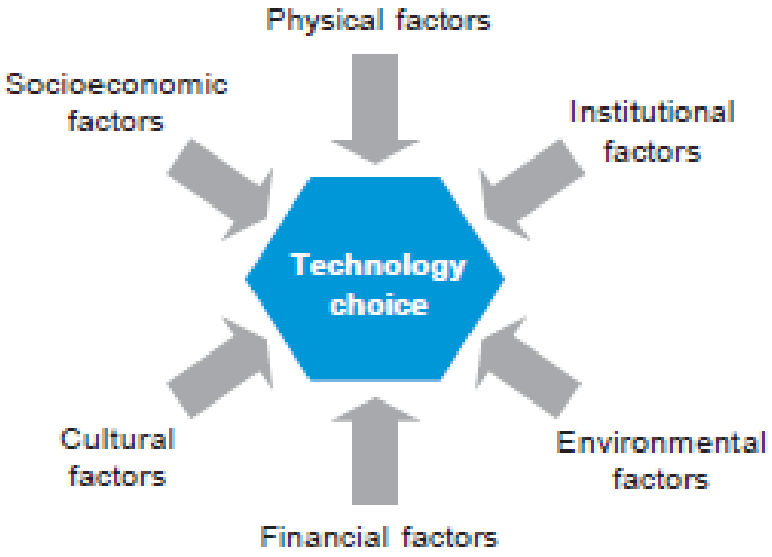
iii) Cast method 0.6%

iv) Dig a hole and bury 5.1%

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: Relation ship 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:

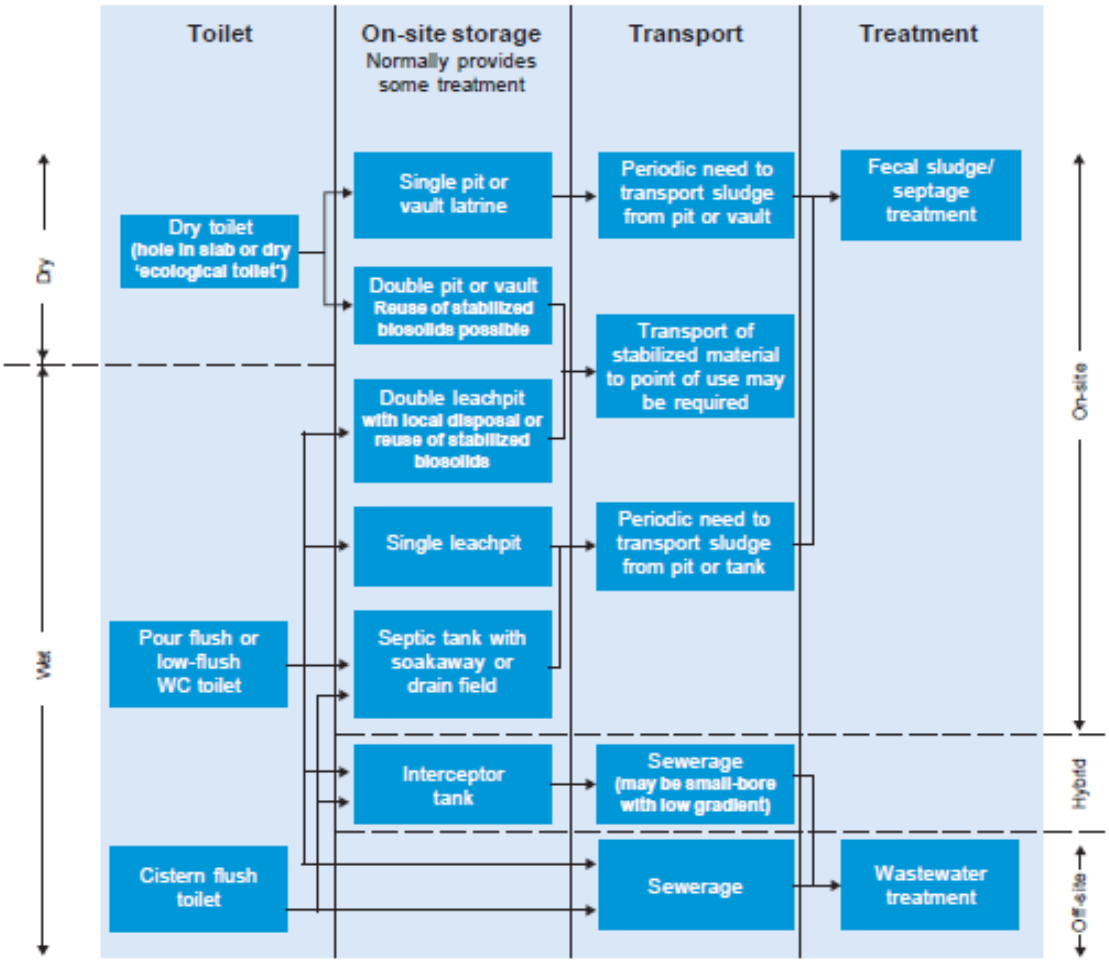
- On-site options will be most appropriate in areas of low-density housing (typically less than 40 housing units per hectare), relatively low water consumption, and ground conditions that allow the absorption of wastewater without harm to an aquifer

- 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			

Lugala RGC is located in Banda sub-county in Namayingo district and, as seen in Table 5.3 above, the closest fecal sludge treatment facilities are in Busia (Cluster 1) and Mayuge (Cluster 2). The consultant recommends that a study be carried out for a new fecal sludge treatment facility nearby since the Busia fecal sludge treatment facility has not yet been built while the Mayuge one is more than 40km the maximum distance required for the location of a FSTP according to the national fecal sludge assessment report to reduce on the haulage costs

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 Lugala 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 II) and 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	
LUG G-1	General Items	522,700,000
LUG G-2	Method Related Charges	83,500,000
LUG G-3	Dayworks	6,944,200
	WATER SUPPLY, SANITATION AND EQUIPMENT	
LUG W-1	Intake structure works	323,181,669
LUG W-2	Raw Water Transmission Mains	107,036,182
LUG W-3	Treatment Plant Site Works	686,567,016
LUG W-4	Coagulator and Flocculator	163,585,017
LUG W-5	Sedimentation Tank	171,511,341
LUG W-6	Rapid Gravity Filters	363,714,106
LUG W-7	Clear Water Tank and Pump House	298,328,383
LUG W-8	Sludge Drying Beds	148,407,990
LUG W-9	Chemical House	258,521,995
LUG W-10	Laboratory and Workshop	117,808,095
LUG W-11	Clear Water Transmission Mains	192,105,318
LUG W-12	Storage Reservoir and Site Works	365,571,547
LUG W-13	Distribution Network	620,886,953

Bill No	Description	Investment Costs UShs
LUG W-14	Intensification Network	332,659,880
LUG W-15	Water Office Block	109,152,596
LUG ME-1	Mechanical Works	445,460,000
LUG EE-1	Electrical Works	837,460,000
LUG S-1	6 Stance Waterborne Toilet (2No.)	135,243,280
	Sub-Total 1	**6,290,345,568**
	Allow for 10% contingency	629,034,556.78
	Sub-Total 2	**6,919,380,125**
	Allow for 18% VAT	1,245,488,422
	GRAND TOTAL	**8,164,868,547**

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
LUG ME-1	Mechanical Works	329,660,000
LUG EE-1	Electrical Works	85,000,000
	Sub-Total 1	**414,660,000**
	Allow for 10% contingency	41,466,000.00
	Sub-Total 2	**456,126,000**
	Allow for 18% VAT	82,102,680
	GRAND TOTAL	**538,228,680**

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 ('000 USh/month)	Staff Required (No.)	Total Staff Costs (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	40	40	40	2,000	80
Source: Project Estimates					

6.4.4 Energy Costs

The system will be jointly run by both solar power and HEP on a series basis (solar will be utilised for the day or when the irradiation is ok after which HEP will be switched on), the energy costs incurred while running the system shall be assumed to be Zero (0) for the solar component hence the energy costs have been computed on the basis of utilising hydroelectricity power from the national grid to run the pumps. The unit pumping power costs as seen in Table 6.6 overleaf are based on an Average Base

Tariff Rate of USh 646/kWh. It is derived from the UMEME Commercial Code- 10.2, 2020 Base Tariff Rates for 8hours Shoulder (8 hours pumping period).

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

Pump	**Energy** (kWh/m^3)	**Cost** (USh/m^3)
Raw Water Pump	0.05	31.10
Backwash Pump	0.06	38.88
Clear Water Tank	0.28	184.03
Totals	**0.39**	**254.01**

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)	168.9	201.3	239.9	285.9	340.8
Losses (in '000 m^3 / year)	33.8	40.3	48.0	57.2	68.2
Water Sold (in '000 m^3 / year)	135.2	161.1	192.0	228.8	272.6
Energy Costs (USh mio. / year)	42.9	51.1	60.9	72.6	86.6
Chemical Costs (USh mio. / year)	5.8	6.9	8.2	9.8	11.7
Maximum Day Demand (in m^3/day)	462.9	551.6	657.4	783.4	933.6
Supply hours per day	7.9	9.5	11.3	13.4	16.0
Cost of Water Produced (in USh/m^3)	0	1,311	1,146	1,008	893
Source: Project Estimates	168.9	201.3	239.9	285.9	340.8

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	3,828.98
Pipelines	1,526.78
Subtotal	**5,355.76**
Mechanical and Electrical Works	
Mechanical and Electrical Works	1,563.62
Subtotal	**1,563.62**
Total	**6,919.38**
Re-Investment Cost Estimates	
Mechanical and Electrical Works	456.13
Total Re-investment Costs	**456.13**
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	**Theoretical Life span** (years)	**Year of Construction**	**As-New Value year 2020** (million USh)	**As-New Value year 2030** (million USh)	**Remaining Value in year 2040** (million USh)
Civil Works					
Structures and Siteworks	3,829.0	-	50	2020	2,297.4
Pipelines	1,526.8	-	50	2020	916.1
Subtotal	**5,355.8**	-			**3,213.5**
Mechanical and Electrical Works					
Mechanical and Electrical Works[a, b]	1,563.6	-	10	2020	156.4
Mechanical and Electrical Works Re-Investment	-	456.1	10	2030	0.0
Subtotal	**1,563.6**	**456.1**			**156.4**
Total	**6,919.4**	**456.1**			**3,369.8**
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	5,355.8					5,355.8
Mechanical / Electrical Items	1,563.6					1,563.6
Total Project Costs	**6,919.4**					**6,919.4**
Reinvestment Costs						
Structures and Siteworks						0
Pipe work						0
Mechanical and Electrical Works			456.1			456
Total Reinvestment Costs	**-**	**-**	**456.1**	**-**	**-**	**456.1**
Operation Costs						

Energy Costs		51.1	60.9	72.6	86.6	**1,266.1**
Chemical Costs		6.9	8.2	9.8	11.7	**170.9**
Maintenance Costs		131.7	131.7	131.7	131.7	**2,634.8**
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		**263.9**	**275.1**	**288.3**	**304.1**	**5,554.9**
Residual Values					**-3,369.8**	**-3,369.8**
Grand Total	**6,919.4**	**263.9**	**731.2**	**288.3**	**-3,065.7**	**9,560.6**
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 11 years of full system operation with the base year 2019,

ii) Main discount rate applied is 5%, which is generally assumed as investment return for social infrastructure projects. In addition the 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/m³ consumed)			
	Discounted Rate (%/year)				Discounted Rate (%/year)			
	5%	8%	10%	12%	5%	8%	10%	12%
Total Water Consumed ('000 m³/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
Project Re-investments	456	434	422	415	407	114	194	254
Residual Values	-3,370	-1,876	-1,338	-1,074	-865	-845	-839	-806
Total	**4,006**	**5,148**	**5,491**	**5,631**	**5,720**	**1,005**	**2,302**	**3,308**
Operation Costs (USh million)								
Pumping Costs	1,266	710	527	440	372	318	318	318
Chemical Costs	171	96	71	59	50	43	43	43
Maintenance Costs	2,635	1,564	1,198	1,020	879	661	699	722
Personnel Costs	1,399	830	636	541	467	351	371	383
Office Running Costs	84	50	38	33	28	21	22	23
Total	**5,555**	**3,250**	**2,470**	**2,093**	**1,796**	**1,393**	**1,453**	**1,488**
Grand Total	**9,561**	**8,398**	**7,961**	**7,724**	**7,516**	**2,398**	**3,755**	**4,796**

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 overleaf.

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	-6,919.4									
Total Operation and Maintenance Costs		-264	-275	-288	-304					
Re-Investment			-456							
Residual Value					3,370					
Revenues (Water)		403	480	572	682					
Net Cash Flows	**-6,919.4**	**139**	**-251**	**284**	**3,747**	**408**	**-3,306**	**-4,253**	**-4,623**	**-4,861**
IRR										**0.4%**
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	830,778	219
Resident population - 2020	802,145	211
Resident population - 2025	673,059	177
Resident population - 2030	564,783	149
Resident population - 2035	473,930	125
Resident population - 2040	397,677	105
Re-Investment Cost	**Currency**	
	(USh)	(US $)
Resident population - After 10 years (2030)	37,231	10
Resident population - After 20 years (2040)	26,215	7
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)	408	-3,306	-4,253	-4,623	-4,861
Dynamic Prime Cost - O & M (USh/m^3)	1,393	1,453	1,488	1,510	1,531
Dynamic Prime Cost - Total (USh/m^3)	2,398	3,755	4,796	5,574	6,409
Internal Rate of Return	**0.4%**				
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 1,453 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 (+0.4%). 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 3,755.

4) The Net Present Values (NPV) is USh -3,306 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, 408 million) is considered.

5) The ultimate year 2040 per capita investment costs are US$ 105. 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 Recommendations

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

7 INSTITUTIONAL AND MANAGEMENT STRUCTURE

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 Lugala 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 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.

a) 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.

b) 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.

c) 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
Banda	Lugala	Budala A	1,620	3.6%	3.6%	3.6%	1,931	2,000	2,383	2,840	3,384	4,033
		Buhima	1,199	3.6%	3.6%	3.6%	1,429	1,480	1,764	2,102	2,505	2,985
		Lugala Beach	1,042	3.6%	3.6%	3.6%	1,242	1,286	1,533	1,827	2,177	2,594
		Sidende	443	3.6%	3.6%	3.6%	528	547	652	777	926	1,104
		Parish Total	**4,304**	**3.6%**	**3.6%**	**3.6%**	**5,130**	**5,313**	**6,332**	**7,546**	**8,992**	**10,716**
	Buchumba	Namake	1,177	3.6%	3.6%	3.6%	1,403	1,453	1,732	2,064	2,460	2,932
		Bukwoyo	977	3.6%	3.6%	3.6%	1,165	1,207	1,438	1,714	2,043	2,435
		Bunini	778	3.6%	3.6%	3.6%	927	960	1,144	1,363	1,624	1,935
		Businoho	1,177	3.6%	3.6%	3.6%	1,403	1,453	1,732	2,064	2,460	2,932
		Parish Total	**4,109**	**3.6%**	**3.6%**	**3.6%**	**4,898**	**5,073**	**6,046**	**7,205**	**8,587**	**10,234**
Lugala Water Supply Project Total			**8,413**	**3.6%**	**3.6%**	**3.6%**	**10,028**	**10,386**	**12,378**	**14,751**	**17,579**	**20,950**

Source: Project Estimates

Table 8.2: Served Population

S/County	Parish	Village	%	Served Population					
			Population Served	2019	2020	2025	2030	2035	2040
Banda	Lugala	Budala A	90%	1,738	1,800	2,145	2,556	3,046	3,630
		Buhima	100%	1,429	1,480	1,764	2,102	2,505	2,985
		Lugala Beach	100%	1,242	1,286	1,533	1,827	2,177	2,594
		Sidende	80%	422	438	522	622	741	883
		Parish Total	**94%**	**4,831**	**5,004**	**5,963**	**7,107**	**8,468**	**10,092**
	Buchumba	Namake	80%	1,122	1,162	1,386	1,651	1,968	2,346
		Bukwoyo	80%	932	966	1,150	1,371	1,634	1,948
		Bunini	80%	742	768	915	1,090	1,299	1,548
		Businoho	50%	702	727	866	1,032	1,230	1,466
		Parish Total	**71%**	**3,498**	**3,623**	**4,317**	**5,145**	**6,132**	**7,308**
Lugala Water Supply Project Total			**83%**	**8,329**	**8,626**	**10,281**	**12,251**	**14,600**	**17,400**

Source: Project Estimates

Table 8.3: Institutional Population

Demand Category	Unit	Population					
		2019	2020	2025	2030	2035	2040
Institutions							
Education							
Day Scholars	No.	7,525	7,793	9,288	11,068	13,190	15,718
Boarding Scholars	No.	0	0	0	0	0	0
Hospitals / Health Centres							
In-Patients	Beds	0	0	0	0	0	0
Out-Patients	No.	31	32	38	46	54	65
Non-Resident Staff	No.	7	8	9	11	13	15
Resident Staff	No.	0	0	0	0	0	0
Commercial / Industrial							
Restaurants/Eating Places	No.	31	32	38	46	54	65
Shops	No.	62	64	77	91	109	130
Dry Processing Mills	No.	4	4	5	6	7	9
Markets	No.	1	1	1	2	2	2
Offices	No.	10	11	13	15	18	22
Police Posts	No.	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)

S/County	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
Banda	Lugala	Budala A	46.9	12.2	9.5	17.2	85.8	111.5	48.6	12.6	9.8	17.8	88.9	115.5
		Buhima	38.6	9.2	9.5	14.3	71.6	93.1	40.0	9.5	9.8	14.8	74.2	96.4
		Lugala Beach	33.5	0.0	0.0	8.4	41.9	54.5	34.7	0.0	0.0	8.7	43.4	56.4
		Sidende	11.4	0.0	0.0	2.8	14.2	18.5	11.8	0.0	0.0	3.0	14.8	19.2
		Parish Total	**130**	**21**	**19**	**43**	**213**	**278**	**135**	**22**	**20**	**44**	**221**	**288**
	Buchumba	Namake	30.3	9.7	0.0	10.0	50.0	65.0	31.4	10.1	0.0	10.4	51.8	67.4
		Bukwoyo	25.1	0.0	0.0	6.3	31.4	40.9	26.1	0.0	0.0	6.5	32.6	42.4
		Bunini	20.0	0.0	0.0	5.0	25.0	32.5	20.7	0.0	0.0	5.2	25.9	33.7
		Businoho	18.9	0.0	0.0	4.7	23.7	30.8	19.6	0.0	0.0	4.9	24.5	31.9
		Parish Total	**94.4**	**9.7**	**0.0**	**26**	**130**	**169**	**97.8**	**10.1**	**0.0**	**27**	**135**	**175**
Lugala Water Supply Project Total			**225**	**31**	**19**	**69**	**344**	**447**	**233**	**32**	**20**	**71**	**356**	**463**

Source: Project Estimates

Table 8.5: Demand by Enumeration (2025 & 2030)

S/County	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
Banda	Lugala	Budala A	57.9	15.1	11.7	21.2	105.9	137.6	69.0	18.0	14.0	25.2	126.2	164.0
		Buhima	47.6	11.4	11.7	17.7	88.4	114.9	56.8	13.6	14.0	21.1	105.4	137.0
		Lugala Beach	41.4	0.0	0.0	10.3	51.7	67.3	49.3	0.0	0.0	12.3	61.7	80.2
		Sidende	14.1	0.0	0.0	3.5	17.6	22.9	16.8	0.0	0.0	4.2	21.0	27.3
		Parish Total	**161**	**26**	**23**	**53**	**264**	**343**	**192**	**32**	**28**	**63**	**314**	**408**
	Buchumba	Namake	37.4	12.0	0.0	12.4	61.8	80.3	44.6	14.3	0.0	14.7	73.6	95.7
		Bukwoyo	31.1	0.0	0.0	7.8	38.8	50.5	37.0	0.0	0.0	9.3	46.3	60.2
		Bunini	24.7	0.0	0.0	6.2	30.9	40.2	29.4	0.0	0.0	7.4	36.8	47.8
		Businoho	23.4	0.0	0.0	5.8	29.2	38.0	27.9	0.0	0.0	7.0	34.8	45.3
		Parish Total	**116.6**	**12.0**	**0.0**	**32**	**161**	**209**	**138.9**	**14.3**	**0.0**	**38**	**192**	**249**
Lugala Water Supply Project Total			**278**	**38**	**23**	**85**	**424**	**552**	**331**	**46**	**28**	**101**	**506**	**657**

Source: Project Estimates

Table 8.6: Demand by Enumeration (2030 & 2040)

S/County	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
Banda	Lugala	Budala A	82.2	21.4	16.7	30.1	150.4	195.5	98.0	25.5	19.9	35.8	179.2	232.9
		Buhima	67.6	16.1	16.7	25.1	125.6	163.2	80.6	19.2	19.9	29.9	149.6	194.5
		Lugala Beach	58.8	0.0	0.0	14.7	73.5	95.5	70.0	0.0	0.0	17.5	87.5	113.8
		Sidende	20.0	0.0	0.0	5.0	25.0	32.5	23.8	0.0	0.0	6.0	29.8	38.7
		Parish Total	**229**	**38**	**33**	**75**	**374**	**487**	**272**	**45**	**40**	**89**	**446**	**580**
	Buchumba	Namake	53.1	17.1	0.0	17.5	87.7	114.1	63.3	20.3	0.0	20.9	104.6	135.9
		Bukwoyo	44.1	0.0	0.0	11.0	55.2	71.7	52.6	0.0	0.0	13.1	65.7	85.5
		Bunini	35.1	0.0	0.0	8.8	43.8	57.0	41.8	0.0	0.0	10.4	52.2	67.9
		Businoho	33.2	0.0	0.0	8.3	41.5	54.0	39.6	0.0	0.0	9.9	49.5	64.3
		Parish Total	**165.5**	**17.1**	**0.0**	**46**	**228**	**297**	**197.3**	**20.3**	**0.0**	**54**	**272**	**354**
Lugala Water Supply Project Total			**394**	**55**	**33**	**121**	**603**	**783**	**470**	**65**	**40**	**144**	**718**	**934**

Source: Project Estimates

Annex 8.3

Water Supply Design Calculations

Figure 8.1: Water Quality 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	Lugala Goal Uganda Borehole	National Standards for Natural potable water
Sample Number	--	**K5081/2019/C/B**	
Alkalinity: Total	mg/L	36	500
Bact: Faecal coliforms	CFU/100mL	**46**	0
Bicarbonate	mg/L	43.92	500
Calcium: Ca^{2+}	mg/L	6.4	150
Colour (apparent)	PtCo	**900**	50
Electrical Conductivity (EC)	uS/cm	162.7	2500
Fluoride	mg/L	0.30	1.5
Hardness: Total	mg/L	44	600
Iron:Total	mg/L	0.166	0.300
Magnesium:Mg^{2+}	mg/L	6.72	100
pH(Physical-Chemical)	-------	6.88	5.5-9.5
Salinity	ppt	0.0	NS
Sulphate	mg/L	14	400
Total Dissolved Solids (TDS)	mg/L	104.128	1500
Total Phosphorous (TP)	mg/L	0.166	NS
Total Suspended Solids(TSS)	mg/L	**39**	0
Turbidity	NTU	**120**	25

Remarks

The water sample showed complying physiochemical characteristics with exception of Colour, TSS and Turbidity 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 8.2: Water Quality 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	DWD 66968 Underground water	National Standards for Natural potable water
Sample Number	--	**K5076/2019/C/B**	
Alkalinity: Total	mg/L	**700**	500
Bact: Faecal coliforms	CFU/100mL	**30**	0
Bicarbonate	mg/L	**854**	500
Calcium: Ca^{2+}	mg/L	**337.6**	150
Colour (apparent)	PtCo	5	50
Electrical Conductivity (EC)	uS/cm	**5880**	2500
Fluoride	mg/L	0.43	1.5
Hardness: Total	mg/L	**860**	600
Iron:Total	mg/L	0.009	0.300
Magnesium:Mg^{2+}	mg/L	3.84	100
pH(Physical-Chemical)	-------	6.93	5.5-9.5
Salinity	ppt	3.3	NS
Sulphate	mg/L	299	400
Total Dissolved Solids (TDS)	mg/L	**3763.2**	1500
Total Phosphorous (TP)	mg/L	0.132	NS
Total Suspended Solids(TSS)	mg/L	0	0
Turbidity	NTU	0.53	25

Remarks

The water sample showed complying physiochemical characteristics with exception of Alkalinity, Bicarbonate, Calcium, EC, Hardness 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 8.3: Water Quality Sample 3

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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 51464 Borehole water	National Standards for Natural potable water
Sample Number	--	**K5078/2019/C/B**	
Alkalinity: Total	mg/L	388	500
Bact: Faecal coliforms	CFU/100mL	**3**	0
Bicarbonate	mg/L	473.36	500
Calcium: Ca^{2+}	mg/L	**296**	150
Colour (apparent)	PtCo	0	50
Electrical Conductivity (EC)	uS/cm	1848	2500
Fluoride	mg/L	0.33	1.5
Hardness: Total	mg/L	**2560**	600
Iron:Total	mg/L	0.016	0.300
Magnesium:Mg^{2+}	mg/L	**436.8**	100
pH(Physical-Chemical)	-------	6.94	5.5-9.5
Salinity	ppt	0.0	NS
Sulphate	mg/L	221	400
Total Dissolved Solids (TDS)	mg/L	1182.72	1500
Total Phosphorous (TP)	mg/L	0.124	NS
Total Suspended Solids(TSS)	mg/L	0	0
Turbidity	NTU	0.67	25

Remarks

The water sample showed complying physiochemical characteristics with exception of Calcium, Hardness and Magnesium 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 Sample 4

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	WSS Tap water Potable water	National Standards for Natural potable water
Sample Number	--	**K5080/2019/C/B**	
Alkalinity: Total	mg/L	472	500
Bact: Faecal coliforms	CFU/100mL	**12**	0
Bicarbonate	mg/L	**575.84**	500
Calcium: Ca^{2+}	mg/L	110.4	150
Colour (apparent)	PtCo	0	50
Electrical Conductivity (EC)	uS/cm	1357	2500
Fluoride	mg/L	0.11	1.5
Hardness: Total	mg/L	**812**	600
Iron:Total	mg/L	0.028	0.300
Magnesium:Mg^{2+}	mg/L	**128.64**	100
pH(Physical-Chemical)	-------	7.69	5.5-9.5
Salinity	ppt	0.0	NS
Sulphate	mg/L	192	400
Total Dissolved Solids (TDS)	mg/L	868.48	1500
Total Phosphorous (TP)	mg/L	0.098	NS
Total Suspended Solids(TSS)	mg/L	0	0
Turbidity	NTU	0.42	25

Remarks

The water sample showed complying physiochemical characteristics with exception of Bicarbonate, Hardness and Magnesium 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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SIGN:
DATE: 8/10/2019
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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)	**933.63**	**46.68**	**933.63**
Treatment Plant Use (5%) (m^3/day)	**46.68**	**0.00**	**0.00**
Total Amount of Water Abstracted (m^3/day)	**980.31**	**46.68**	**933.63**
Hours of Pumping (hr)	16	2	16
Efficiency (%)	60.0%	60.0%	60.0%
Required Delivery (m^3/hr)	61.27	23.34	58.35
Required Delivery (m^3/s)	0.0170	0.0065	0.0162
Pump Installation Level (m amsl)	1129.000	1142.994	1137.199
Inlet Level (m amsl)	1142.994	1156.994	1195.726
Static Lift (m)	14.0	14.0	58.5
Hazen Williams Coefficient, Cwh (C)	140	140	140
Pipe Details	**DN150 ST PN6**	**OD110 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)	0.963	0.778	0.987
Flow in Pipe (m^3/s)	0.0170	0.0065	0.0162
Length of Pipe (m)	**400**	**60**	**2645**
Friction Loss (m)	2.5	0.4	17.8
Fittings losses - 10% (m)	0.2	0.0	1.8
Total Friction Loss (m)	2.5	0.4	17.8
Total Head (m)	**16.7**	**14.4**	**78.2**
Head Used (m)	**17**	**15**	**79**
Power (kW)	**4.7**	**1.6**	**20.9**
Source: Project Estimates			

Table 8.8: Rapid Mixing Tank Design

	Design Standards	Value Range
a	Velocity of Flow (m/s)	0.15 - 0.45
b	Minimum Distance Between Baffles (m)	0.45
c	Ratio of clear distance at end of channel to baffle spacing	1.5

		Design
Flow into Rapid Mixing Chamber	m³/hr	43.14
	m³/s	0.0120
Detention Period	seconds	30.0
Volume of Water to be handled by Mixing Tank	m³	0.360
Average Velocity of Flow	m/s	0.20
Total Distance of Flow by Water	m	6.0
Cross-sectional area of channels between baffles	m²	0.060
Distance Between Baffles (Baffle spacing)	m	0.450
Minimum Depth of Channel required	m	0.133
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 8.9: Vertical Flow Baffled Flocculator Design

Design Parameter	Unit	Design
Total Flow rate	l/s	11.98
Total Flow rate	m^3/s	0.0120
No of Flocculator Channels (Lanes)	Nr	1
Flow Rate per lane	l/s	12.0
Flow Rate per lane	m^3/s	0.0120
Depth of flow at US end of channel (flocculator outlet)	mm	2000
Width of channel	m	1.20
No of Concrete Baffle Walls (Weirs)	Nr	2
No of Steel Baffle Walls	Nr	3
Baffle Spacing	m	1.00
Upflow Velocity	m/s	0.00999
Upflow Velocity	m/h	36.0
Total Length of Mixing Section	m	6.50
Total Volume Retained	m^3	15.60
Hydraulic Retention Time (in secs)	secs	1301.77
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***	***1***
No of Concrete Baffle Walls (Weirs)	***Nr***	***2***
No of Steel Baffle Walls	***Nr***	***3***
Internal Width of each Channel	***m***	***1.20***
Internal Length of each Channel	***m***	***8.60***
Internal Water Depth of each Channel	***m***	***2.00***
Baffle Spacing	***m***	***1.00***
Concrete Baffle Wall Thickness	***m***	***0.20***
Clear Opening under Steel Baffle Plates	***m***	***0.20***

Table 8.10: Horizontal Flow Sedimentation Tank Design

	Standards	Design	
Flow into Sedimentation Tanks		**43.14**	m^3/hr
		690.26	m^3/day
No of Sedimentation Tanks		**2**	No
Flow into each Sedimentation Tank		**21.57**	m^3/hr
Detention Time	*3-5 hrs*	*3.00*	*hrs*
Effective Volume of each Sedimentation Tank		**64.71**	m^3
Sludge depth		**1.00**	m
Total Volume of each Sedimentation Tank		**86.28**	m^3
Outlet Over Flow Weir	*< 450 $m^3/m/day$*	*203.02*	*$m^3/m/day$*
Sedimentation Tank Dimensions			
Clear depth		**3.00**	m
Total Tank Depth		***4.00***	*m*
Surface Area		**21.57**	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		**13.00**	m
Width of each Sedimentation Tank		**1.66**	m
Length to Width Ratio	3:1	**7.83**	
Length to Depth Ratio	4:1	**4.33**	
Circular Dimensions (If required), Diameter		**5.2**	m
Cross Sectional Flow Area		**5.10**	m^2

Horizontal Flow Velocity	*4 - 36m/hr*	*4.23*	*m/hr*
	0.0011- 0.010m/s	*0.00117*	*m/s*

Table 8.11: Rapid Gravity Flow Filter Design

		Design
Flow into Rapid Sand Filters	m³/hr	**43.14**
Number of Filters	Nr	**2**
Flow into each Rapid Sand Filters	m³/hr	**21.6**
Filtration Rate	m/hr	**5.0**
Design Filter Surface Area	m²	**4.31**
Filter Sand Bed Width	***m***	***2.00***
Filter Sand Bed Length	***m***	***2.16***
Height of Water above Filter Sand Bed	***m***	***2.00***
Summary of Rapid Sand Filters		
Filter Sand Bed Width	**m**	
Width of Washwater Channel	**m**	**2.00**
Filter Internal Width	**m**	**0.50**
Filter Internal Length	**m**	**2.70**
Height of Water above Filter Sand Bed	**m**	**2.16**
Total Internal Length of Filter	**m**	**2.00**
Actual Filter Surface Area	m²	**5.40**

Table 8.12: Clear water Tank Design

Clear Water Tank		**Design**	
Flow into Clear Water Tank	m^3/hr	43.14	
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	64.71	
Summary of Clear Water Tank		**Storage**	**Mixing**
Volume of Contact Tank Considered	**m^3**	**43.1**	**21.6**
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**	**4.10**	**4.10**
Total Internal Length of Contact Tank	**m**	**4.10**	**4.30**
Effective Internal Width of Contact Tank	**m**	**2.70**	**1.30**
Total Internal Width of Contact Tank	**m**	**2.95**	**1.50**
No of Tank Compartments		**1**	**2**
Internal Width of each Compartment	**m**	**2.70**	**0.65**
Circular Dimensions (If required), Diameter	**m**	**3.4**	**2.5**

Table 8.13: 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	1171.753	0	0	1190.38	18.62	0	1190.24	18.48	0	1189.73	17.98
Junc N02	1167.475	0.66	0.33	1190.14	22.67	0.66	1189.4	21.92	1.32	1186.71	19.24
Junc N03	1166.727	0	0	1190.13	23.4	0	1189.35	22.62	0	1186.52	19.79
Junc N04	1140.137	0.9	0.45	1189.56	49.42	0.9	1187.29	47.15	1.8	1179.1	38.96
Junc N05	1137.035	0.45	0.23	1189.2	52.16	0.45	1185.97	48.94	0.9	1174.34	37.31
Junc N06	1138.903	0	0	1189.1	50.19	0	1185.61	46.71	0	1173.04	34.14
Junc N07	1144.318	0	0	1188.84	44.52	0	1184.68	40.36	0	1169.67	25.36
Junc N08	1154.441	0.15	0.08	1188.16	33.72	0.15	1182.23	27.79	0.3	1160.83	6.38
Junc N09	1157.805	0	0	1188.56	30.75	0	1183.66	25.86	0	1166.01	8.2
Junc N12	1145.69	2.92	1.46	1188.63	42.94	2.92	1183.93	38.24	5.84	1166.96	21.27
Junc N13	1149.37	0.39	0.19	1188.22	38.85	0.39	1182.44	33.07	0.78	1161.58	12.21
Junc N14	1137.53	1.38	0.69	1187.99	50.46	1.38	1181.62	44.09	2.76	1158.61	21.08
Junc N15	1145.22	1.32	0.66	1188.73	43.51	1.32	1184.3	39.08	2.64	1168.29	23.07
Junc N16	1136.22	0.3	0.15	1188.01	51.79	0.3	1181.69	45.47	0.6	1158.86	22.64
Junc N17	1141.41	0.3	0.15	1187.92	46.51	0.3	1181.37	39.96	0.6	1157.73	16.32
Junc N18	1156.16	2.7	1.35	1189.76	33.6	2.7	1188.03	31.87	5.4	1181.76	25.6
Resvr Lugala_Rsvr	1190.43	#N/A	-5.74	1190.43	0	-11.47	1190.43	0	-22.94	1190.43	0
Source: Project Estimates											

Table 8.14: Distribution Network Pipe Details

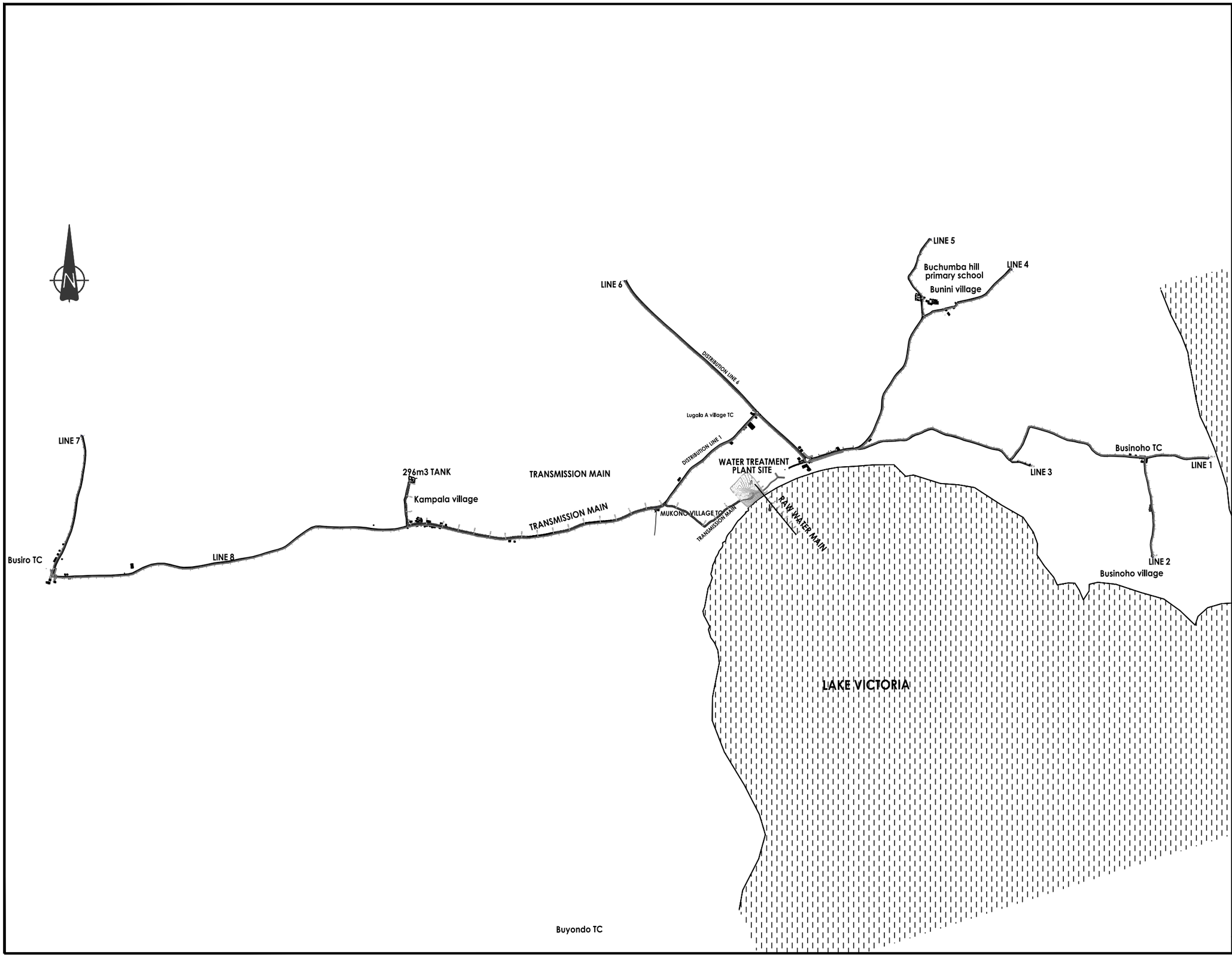
Pipe ID	Nodes	Length (m)	Pipe Details	Internal Diameter (mm)	Roughness	Velocity at Peak Flow (m/s)
Pipe 1	Lugala_Rsvr to N01	287	OD225 uPVC PN10	203.4	140	0.71
Pipe 2	N01 to N04	1,575	OD160 uPVC PN10	144.6	140	0.99
Pipe 3	N04 to N05	876	OD160 uPVC PN10	144.6	140	0.88
Pipe 4	N05 to N06	770	OD160 uPVC PN10	144.6	140	0.47
Pipe 5	N06 to N07	1,009	OD110 uPVC PN10	99.4	140	0.53
Pipe 6	N07 to N08	1,007	OD75 HDPE PN10	55.4	140	0.62
Pipe 7	N08 to N16	397	OD50 HDPE PN10	44	140	0.39
Pipe 8	N08 to N17	626	OD50 HDPE PN10	44	140	0.39
Pipe 9	N07 to N15	130	OD75 HDPE PN10	66	140	0.77
Pipe 10	N06 to N09	931	OD90 HDPE PN10	79.2	140	0.72
Pipe 11	N09 to N14	638	OD75 HDPE PN10	66	140	0.81
Pipe 12	N09 to N13	550	OD50 HDPE PN10	44	140	0.51
Pipe 13	N05 to N12	1,170	OD110 uPVC PN10	99.4	140	0.75
Pipe 14	N03 to N18	871	OD110 uPVC PN10	99.4	140	0.7
Pipe 15	N01 to N02	2,290	OD160 uPVC PN10	144.6	140	0.41
Pipe 16	N02 to N03	35	OD110 uPVC PN10	99.4	140	0.7
Source: Project Estimates		13,160				

Annex 8.4

Design Drawings

Drawings List

SGI-MWE-LUG-0.0.0	General Layout
SGI-MWE-LUG-1.1.0	Intake Structure Top Plan
SGI-MWE-LUG-1.1.1	Intake Structure Sectional Plan Details
SGI-MWE-LUG-3.0.0	WTP Site layout
SGI-MWE-LUG-3.1.0	Coagulation and Flocculation Plan
SGI-MWE-LUG-3.2.0	Sedimentation Tank Plan
SGI-MWE-LUG-3.3.0	Rapid Gravity Filter Plan
SGI-MWE-LUG-3.4.0	Clear Water Tank Plan
SGI-MWE-LUG-3.7.0	Chemical House
SGI-MWE-LUG-3.8.0	Workshop and Office Plan
SGI-MWE-LUG-5.0.0	Reservoir Tank Site Layout Plan
SGI-MWE-LUG-5.1.0	Reservoir Tank Plan
SGI-MWE-LUG-11.0.1	Public Toilet Plan
SGI-MWE-LUG-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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MINISTRY OF WATER AND ENVIRONMENT
DIRECTORATE OF WATER DEVELOPMENT

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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

LUGALA WATER SUPPLY AND SANITATION SYSTEM
IN NAMAYINGO DISTRICT

CONSULTANTS

SGI STUDIO GALLI INGEGNERIA
life, first

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REVISIONS :

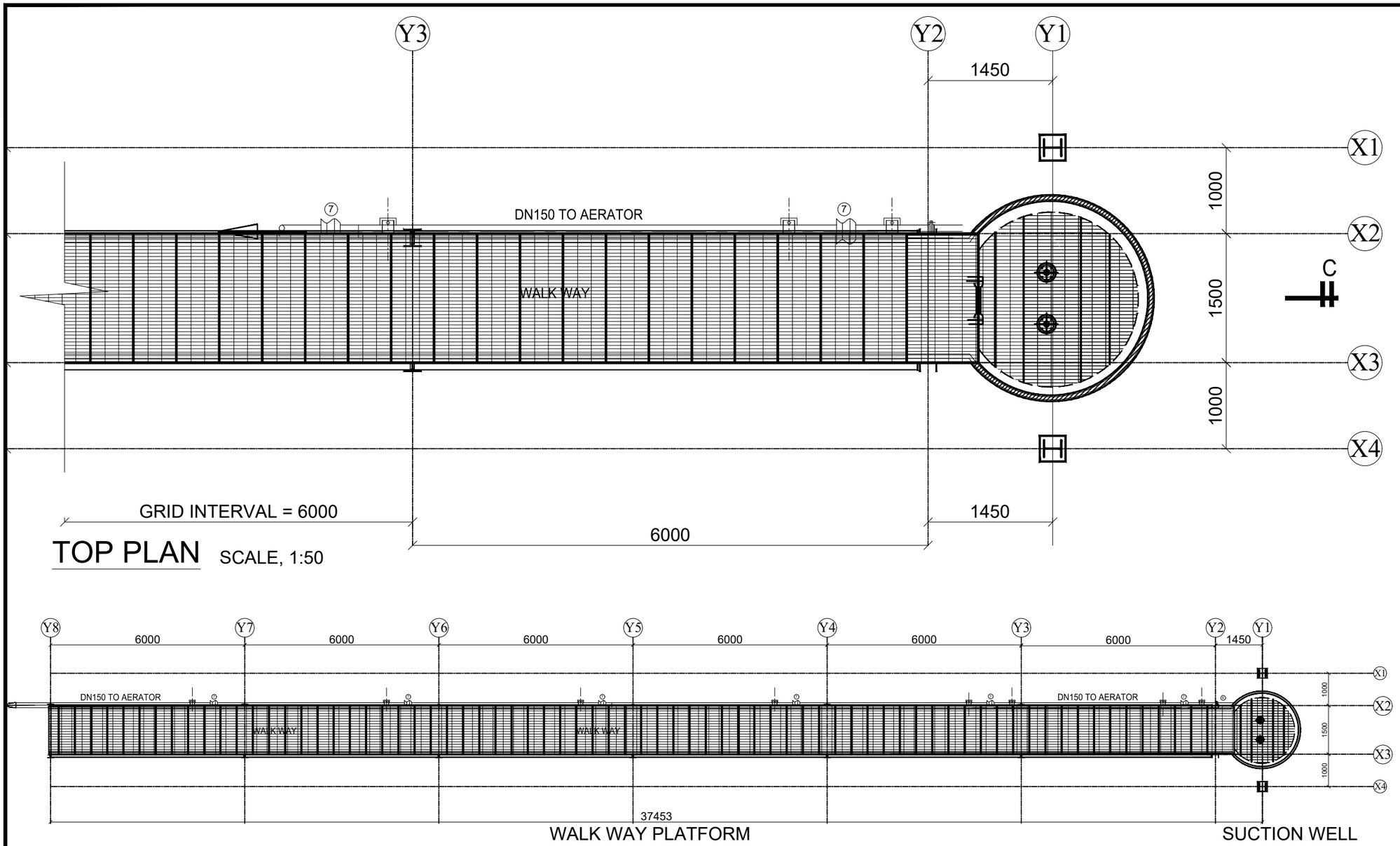
No	Date	Description

DETAILED ENGINEERING DESIGN

DRAWING TITLE

GENERAL LAYOUT

SCALE	NTS	DRAWING No.	SGI-MWE-LUG-0.0.0
SURVEYED	GW	DESIGNED	ORD
DRAWN	CDE	CHECKED	ORD
DATE	SEPT 2020	APPROVED	CP



TOP PLAN

SCALE, 1:50

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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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

LUGALA WATER SUPPLY AND SANITATION SYSTEM
IN NAMAYINGO DISTRICT

CONSULTANTS

SGI Studio Galli Ingeneria S.r.l.
Head office:
Via della Provvidenza, 15
35030 Sarmeola di Rubano (PD) Italy
Tel. +39 049 89 76 844
Fax +39 049 89 76 784

REVISIONS :

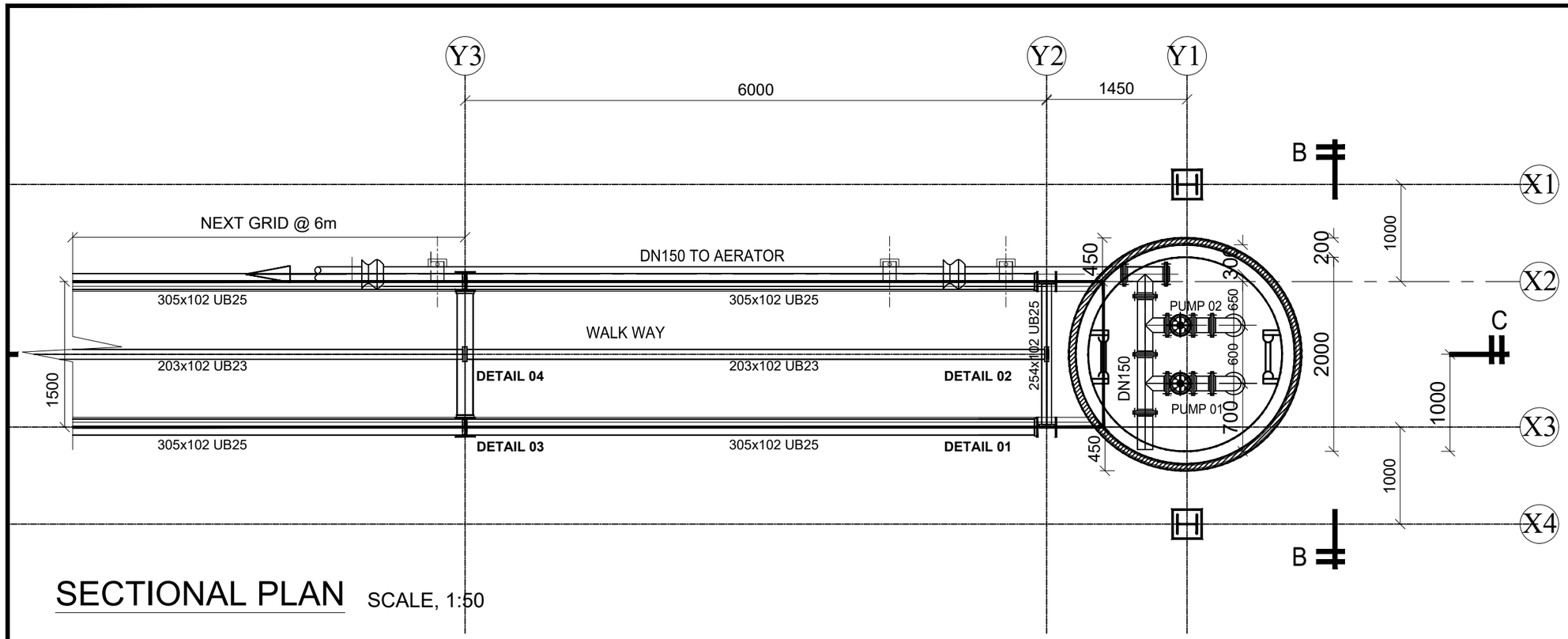
No	Date	Description

DETAILED ENGINEERING DESIGN

DRAWING TITLE

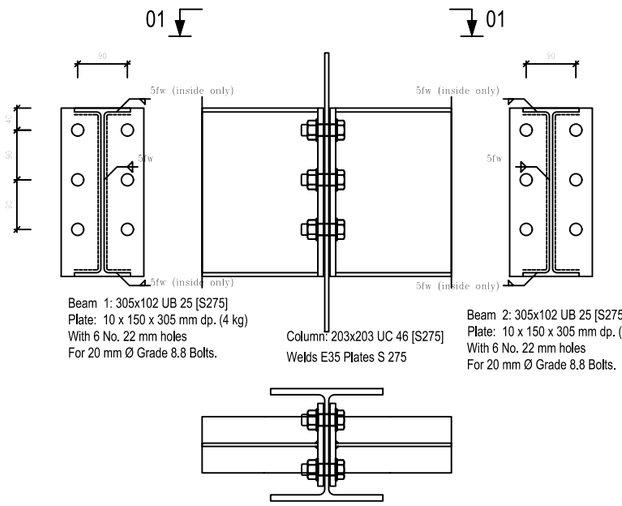
INTAKE STRUCTURE
TOP PLAN

SCALE	AS SHOWN	DRAWING No.	SGI-MWE-LUG-1.1.0
SURVEYED	GW	DESIGNED	ORD
DRAWN	CDE	CHECKED	ORD
DATE	SEPT 2020	APPROVED	CP



SECTIONAL PLAN

SCALE, 1:50

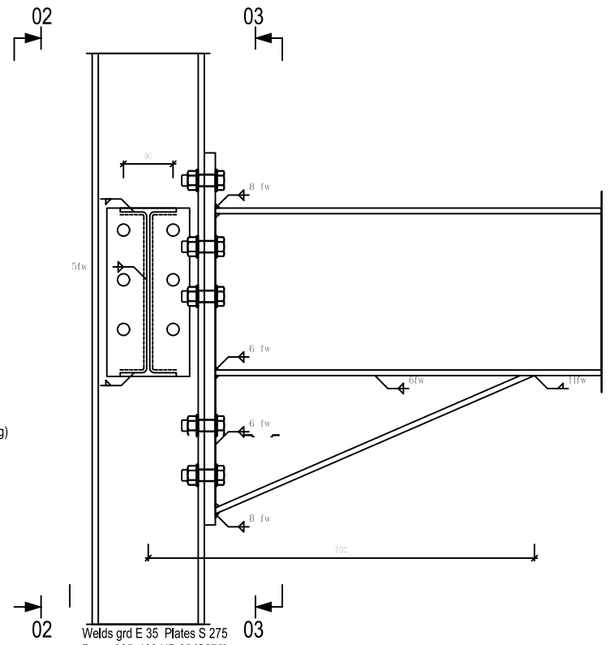


Beam 1: 305x102 UB 25 [S275]
Plate: 10 x 150 x 305 mm dp. (4 kg)
With 6 No. 22 mm holes
For 20 mm Ø Grade 8.8 Bolts.

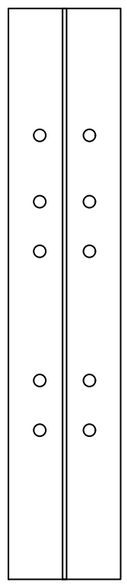
Column: 203x203 UC 46 [S275]
Welds E35 Plates S 275

Beam 2: 305x102 UB 25 [S275]
Plate: 10 x 150 x 305 mm dp. (4 kg)
With 6 No. 22 mm holes
For 20 mm Ø Grade 8.8 Bolts.

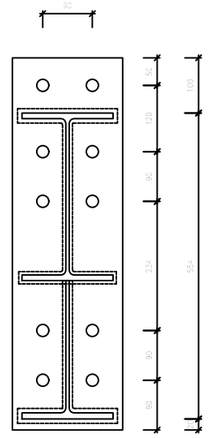
SECTION 01-021



Welds grd E 35 Plates S 275
Beam 305x102 UB 25 [S275]
Haunch 254x102 UB 25 [S275]
Column 203x203 UC 46 [S275]



SECTION 02-02



End-Plate 674 x 200 x 20 mm (21 kg)
10 No. M20 Grade 8.8 Bolts in 22 mm holes

SECTION 03-03

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

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

CLIENT

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

CO-FINANCED BY

GOVERNMENT OF UGANDA AND WORLD BANK

PROJECT:
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LUGALA WATER SUPPLY AND SANITATION SYSTEM
IN NAMAYINGO DISTRICT

CONSULTANTS

SGI STUDIO GALLI INGEGNERIA
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35030 Sarmeola di Rubano (PD) Italy
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Fax +39 049 89 76 784

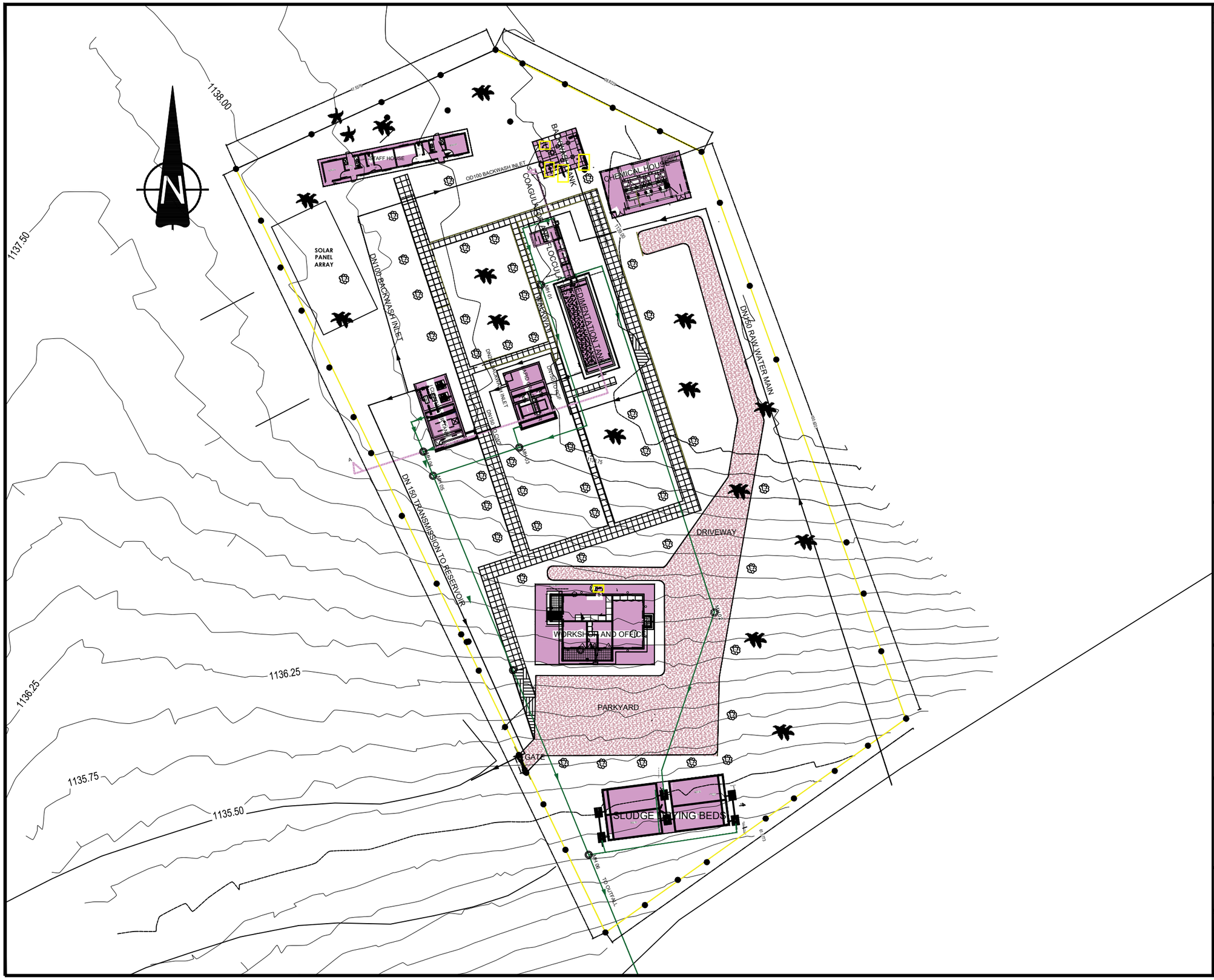
REVISIONS :

No	Date	Description

DETAILED ENGINEERING DESIGN

DRAWING TITLE
INTAKE STRUCTURE
SECTIONAL PLAN, DETAIL 01 & 03

SCALE	AS SHOWN	DRAWING No.	SGI-MWE-LUG-1.1.1
SURVEYED	GW	DESIGNED	ORD
DRAWN	CDE	CHECKED	ORD
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

CLIENT

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MINISTRY OF WATER AND ENVIRONMENT
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IN NAMAYINGO DISTRICT

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REVISIONS :

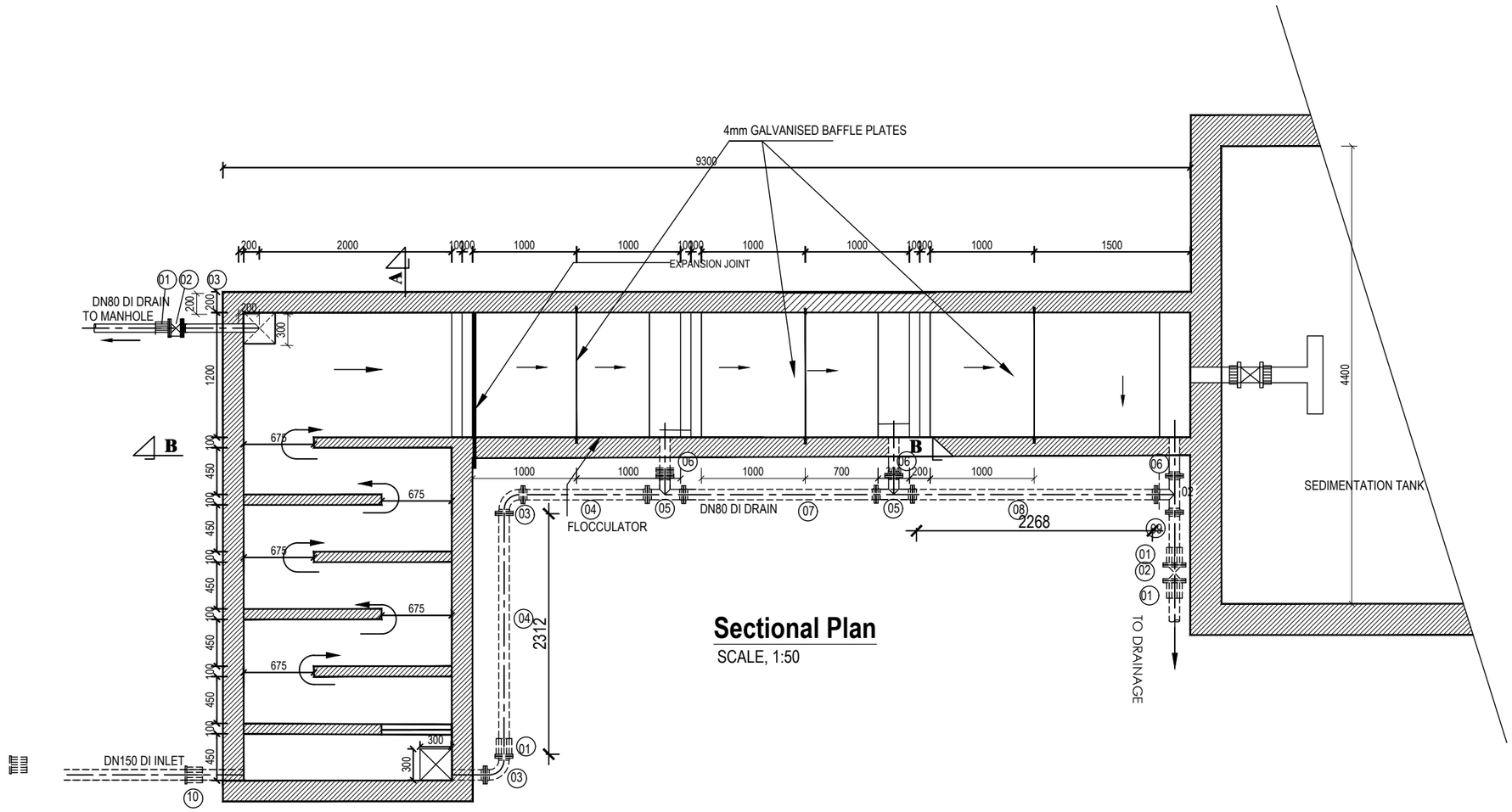
No	Date	Description

DETAILED ENGINEERING DESIGN

DRAWING TITLE

TREATMENT PLANT SITE LAYOUT

SCALE	AS SHOWN	DRAWING No.	SGI-MWE-LUG-3.0.0
SURVEYED	GW	DESIGNED	ORD
DRAWN	CDE	CHECKED	ORD
DATE	SEPT 2020	APPROVED	CP



Sectional Plan

SCALE, 1:50

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 SCHEDULE

1. 4No. DN80 flange adaptor
2. 4No. DN80 flange gate valves
3. 2No. DN80 90° flange bends
4. 1No. DN80 double flanged pipe, length n.e 2.5m
5. 2No. DN80 flange Tee
6. 3No. DN80 flanged spigot pipe, n.e 0.4m
7. 1No. DN80 double flanged pipe, n.e 2m
8. 1No. DN80 double flanged pipe, n.e 2.5m
9. 1 No. DN80 double flanged pipe, n.e 0.4m
10. 1No. DN150 flange adaptor

CLIENT

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REVISIONS :

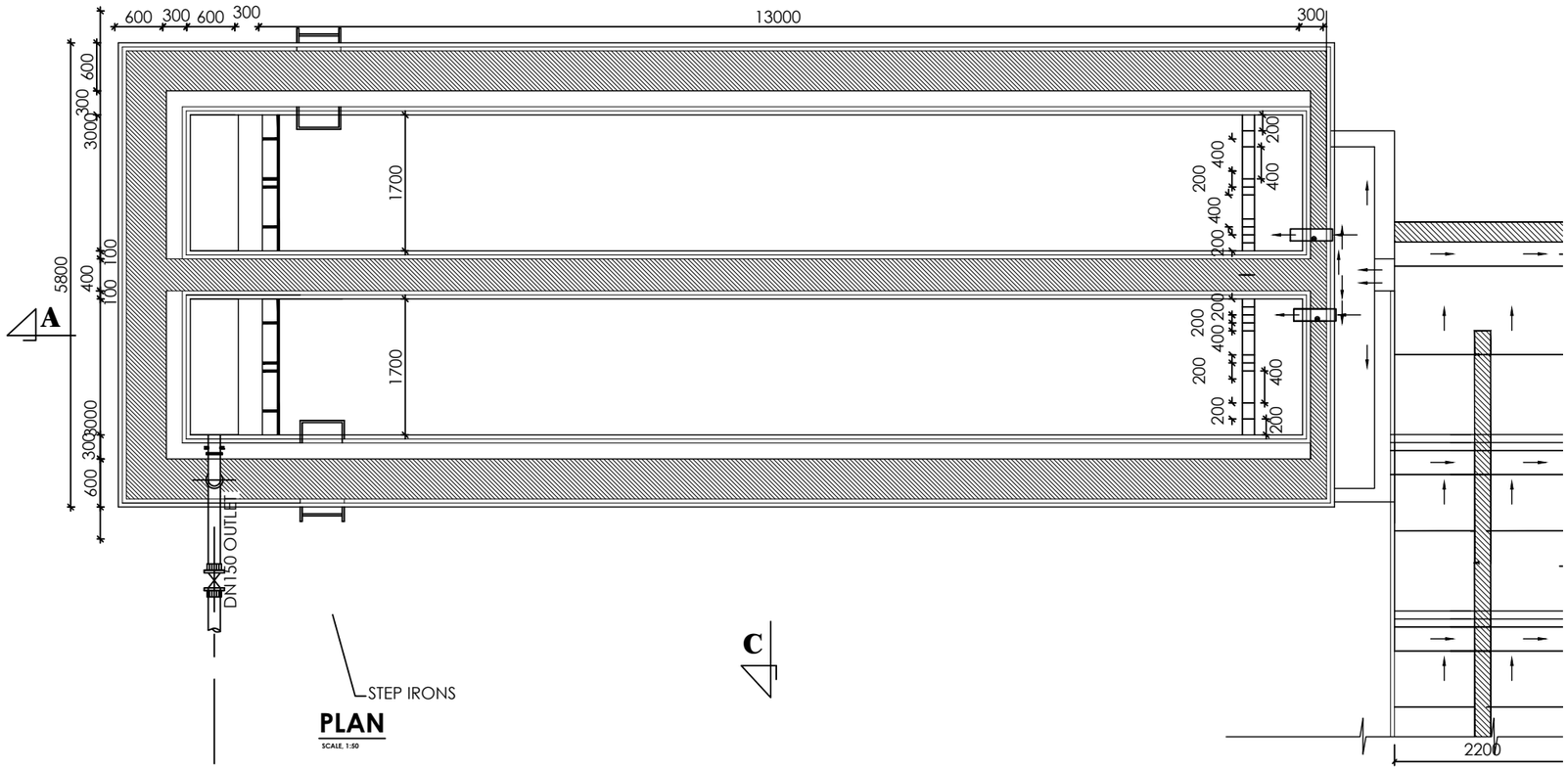
No	Date	Description

DETAILED ENGINEERING DESIGN

DRAWING TITLE

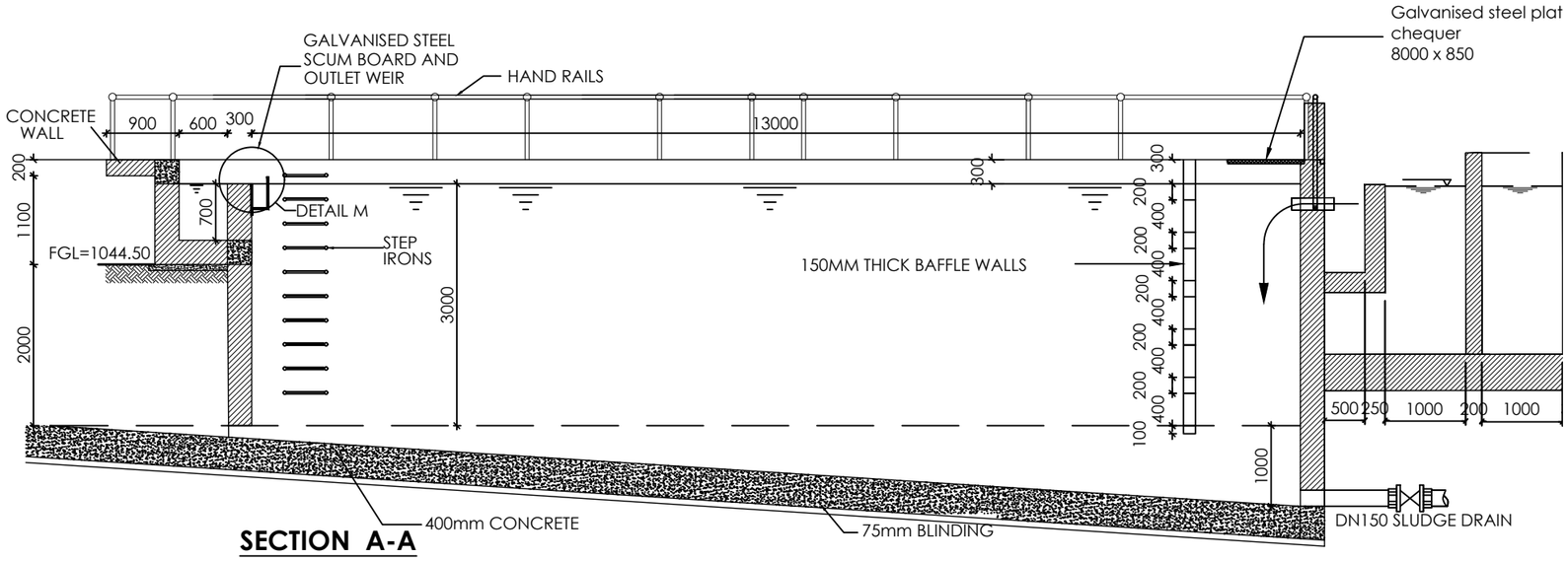
COAGULATOR & FLOCCULATOR
SECTIONAL PLAN

SCALE	AS SHOWN	DRAWING No.	SGI-MWE-LUG-3.1.0
SURVEYED	GW	DESIGNED	ORD
DRAWN	CDE	CHECKED	ORD
DATE	SEPT 2020	APPROVED	CP



PLAN

SCALE 1:50



SECTION A-A

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.

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REVISIONS :

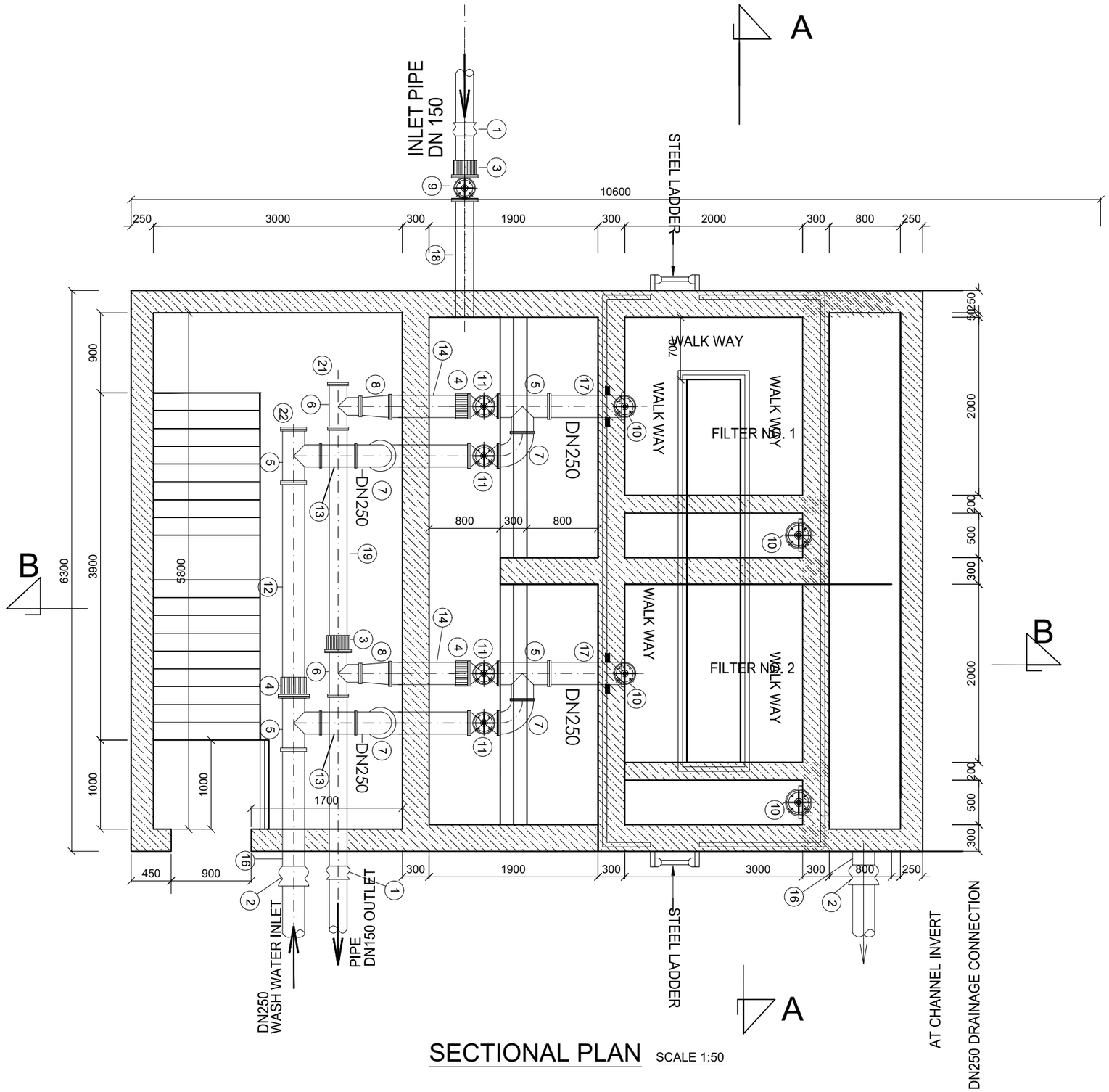
No	Date	Description

DETAILED ENGINEERING DESIGN

DRAWING TITLE

SEDIMENTATION TANK
SECTIONAL PLAN AND SECTION A-A

SCALE	1:75	DRAWING No.	SGI-MWE-LUG-3.2.0
SURVEYED	GW	DESIGNED	ORD
DRAWN	CDE	CHECKED	ORD
DATE	SEPT 2020	APPROVED	CP



SECTIONAL PLAN

SCALE 1:50

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 SCHEDULE

1. 2No. DN150 maxi coupling
2. 2No. DN250 maxi coupling
3. 2No. DN150 maxi flanged adaptor
4. 3No. DN250 maxi flanged adaptor
5. 4No. DN250/250 all flanged Tee
6. 2No. DN150/150 all flanged Tee
7. 6No. DN250 all flanged 90° bend
8. 2No. DN250/150 all flanged Taper
9. 1No. DN150 all flanged gate valve
10. 4No. 500x500 penstocks
11. 4No. DN250 flanged gate valve
12. 1No. DN250 flanged/spigot pipe length ne 3m
13. 2No. DN250 all flanged pipe length not exceeding 1.5m
14. 2No. DN250 flanged/spigot pipe length ne1.5m
15. 2No. DN250 all flanged pipe length ne 3m
16. 1No. DN250 flanged/spigot pipe with puddle flanged, ne 2m
17. 2No. DN250 all flanged pipe with puddle flanged, length ne
18. 1No. DN150 flanged/spigot pipe with puddle flanged, ne 2m
19. 2No. DN150 flanged/spigot pipe length ne 3m
20. 1No. DN150 flanged/spigot pipe with puddle flanged, ne 3m
21. 1No. DN 150 blank flange
22. 1No. DN250 blank flange

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LUGALA WATER SUPPLY AND SANITATION SYSTEM
IN NAMAYINGO DISTRICT

CONSULTANTS

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Fax +39 049 89 76 784

REVISIONS :

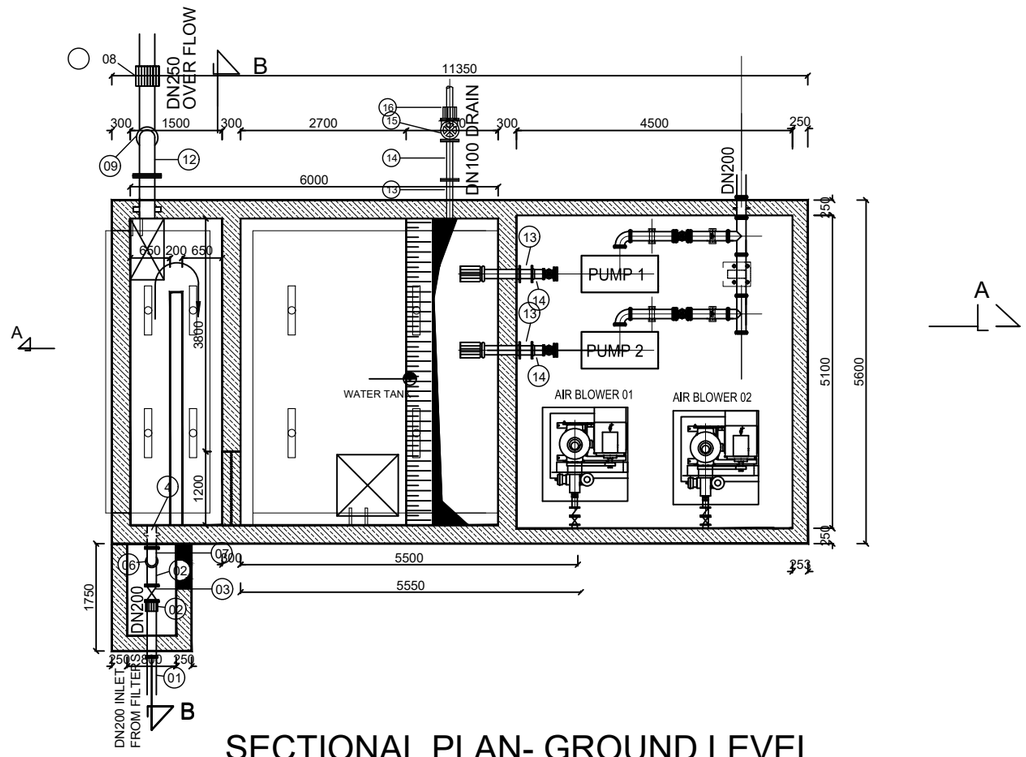
No	Date	Description

DETAILED ENGINEERING DESIGN

DRAWING TITLE

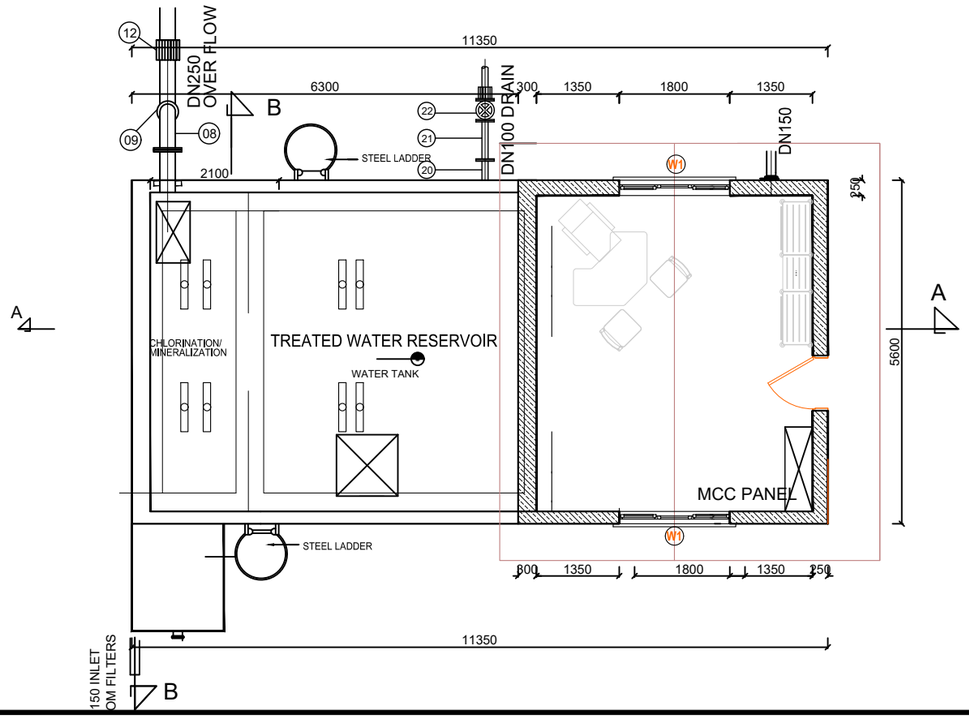
RAPID GRAVITY FILTER
SECTIONAL PLAN

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



SECTIONAL PLAN- GROUND 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. 2No. DN150 all flanged pipe with puddle flange, n.e 1.5m.
2. 2No. DN150 detachable coupling.
3. 2No. DN150 flanged gate valve.
4. 1No. DN150 flange/spigot with puddle flange, n.e 1.0m
5. 4No. DN150 90° flange bends.
6. 3No. DN150 flanged gate valve.
7. 1No. DN150 double flanged pipe, length not exceeding 4m.
8. 1No. DN150 detachable coupling.
9. 2No. DN250 flanged spigot pipe with puddle flange, n.e 1.0m
10. 2No. DN150 flanged strainer.
11. 1No. DN250 all flanged pipes, length not exceeding 1.5m.
12. 2No. DN250 90° flange bends.
13. 1No. DN250 double flanged pipe with puddle flange, n.e 4m
14. 1No. DN250 blank flange.
15. 2No. DN100 flanged spigot pipe, n.e 2.5m
16. 1No. DN100 flanged gate valve.
17. 1No. DN100 flange adaptor.

CLIENT

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IN NAMAYINGO DISTRICT

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REVISIONS :

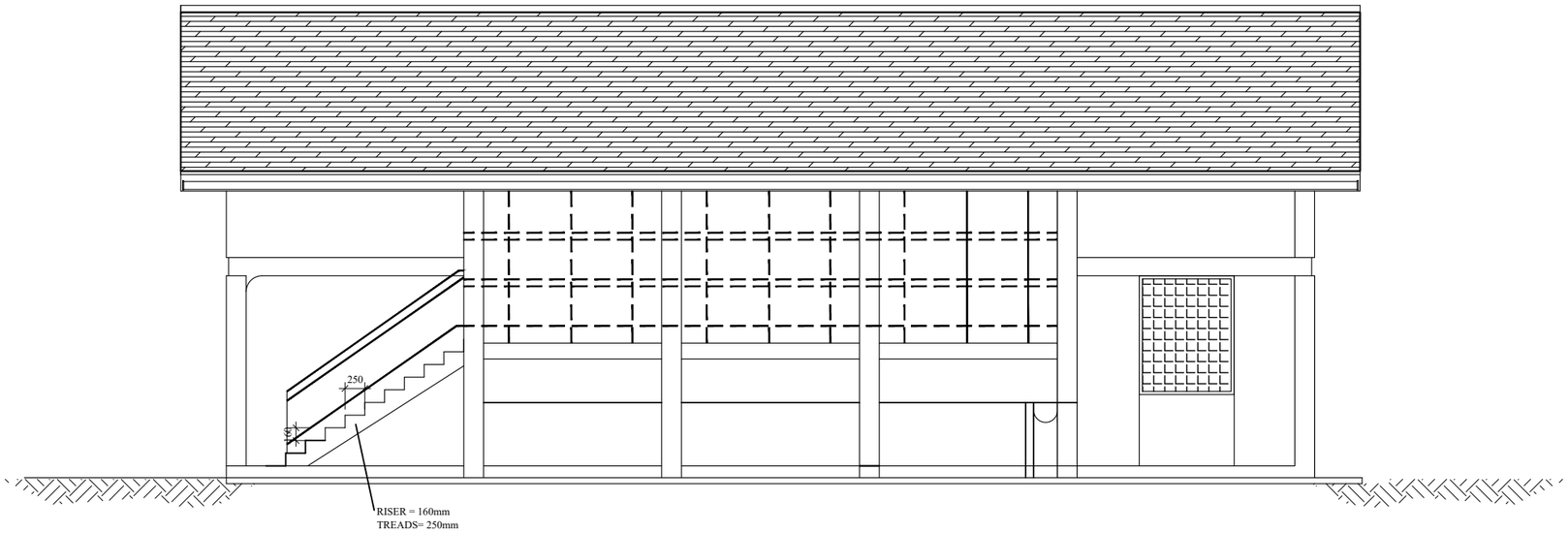
No	Date	Description

DETAILED ENGINEERING DESIGN

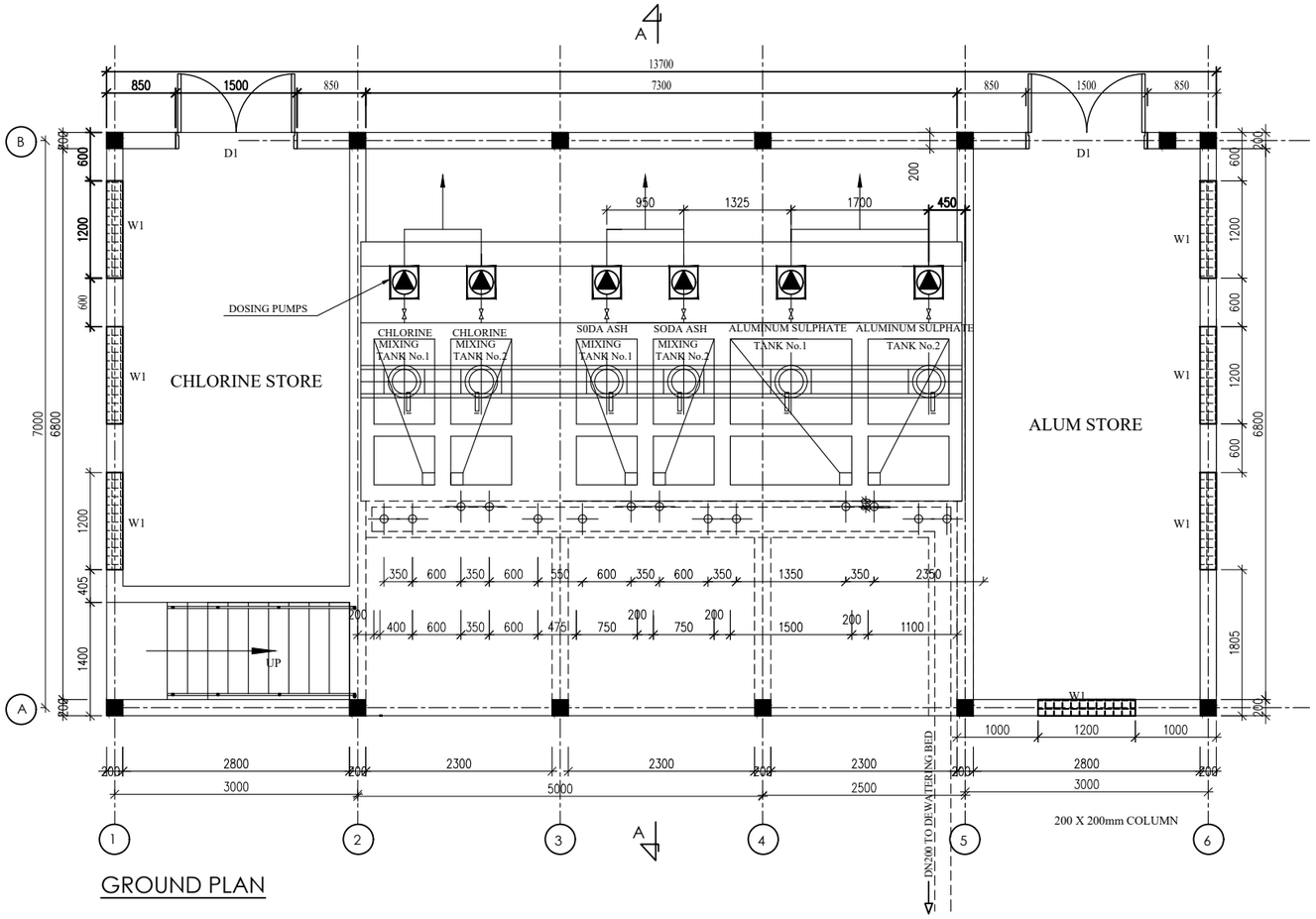
DRAWING TITLE

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

SCALE	1:100	DRAWING No.	SGI-MWE-LUG-3.4.0
SURVEYED	GW	DESIGNED	ORD
DRAWN	CDE	CHECKED	ORD
DATE	SEPT 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

CLIENT

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

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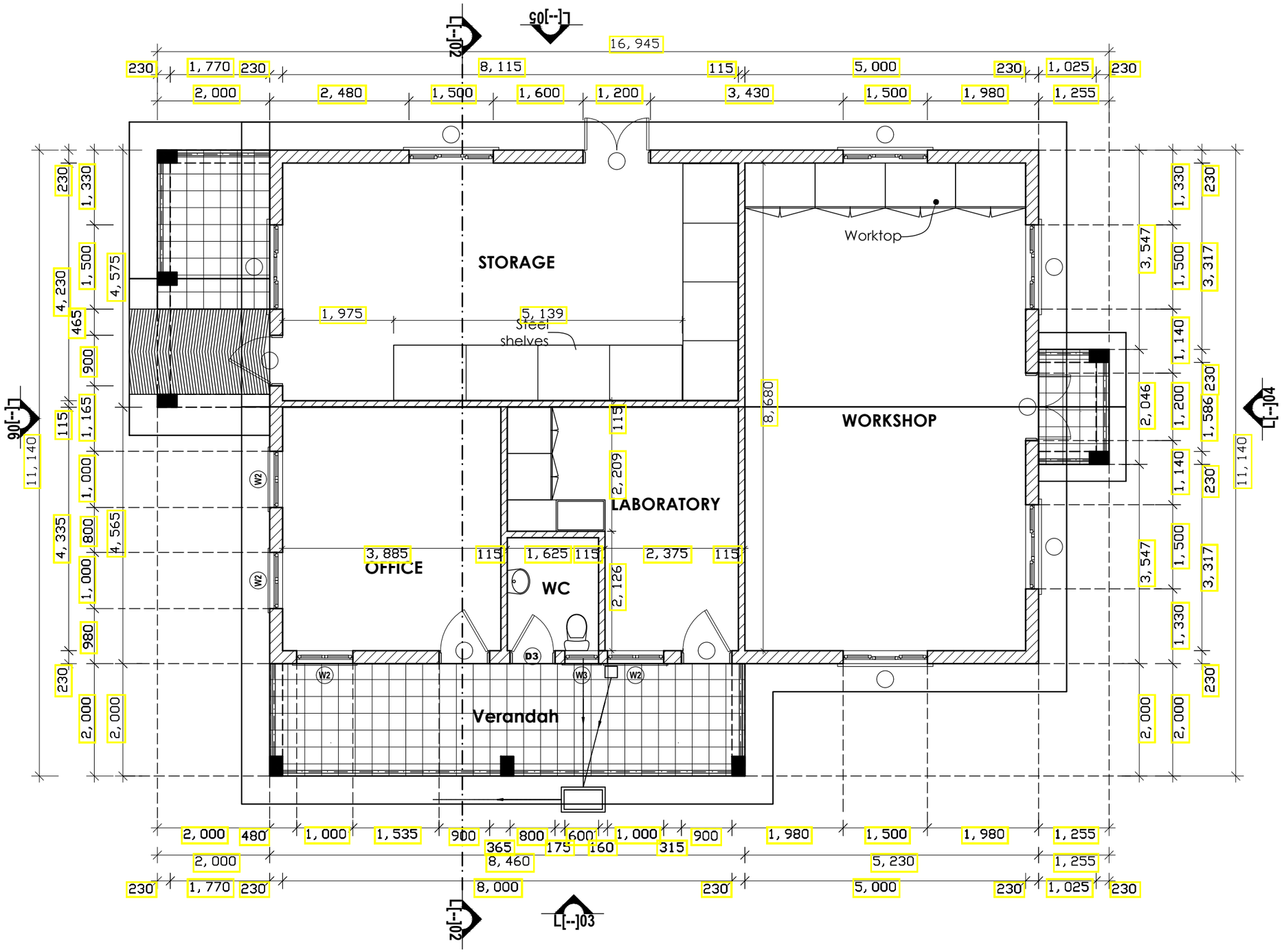
REVISIONS :

No	Date	Description

DETAILED ENGINEERING DESIGN

DRAWING TITLE
CHEMICAL HOUSE
SECTIONAL PLAN & ELEVATION

SCALE	AS SHOWN	DRAWING No.	SGI-MWE-LUG-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

0 1.0 2.0 3.0 4.0 5.0
Scale 1:75 Metres

CLIENT

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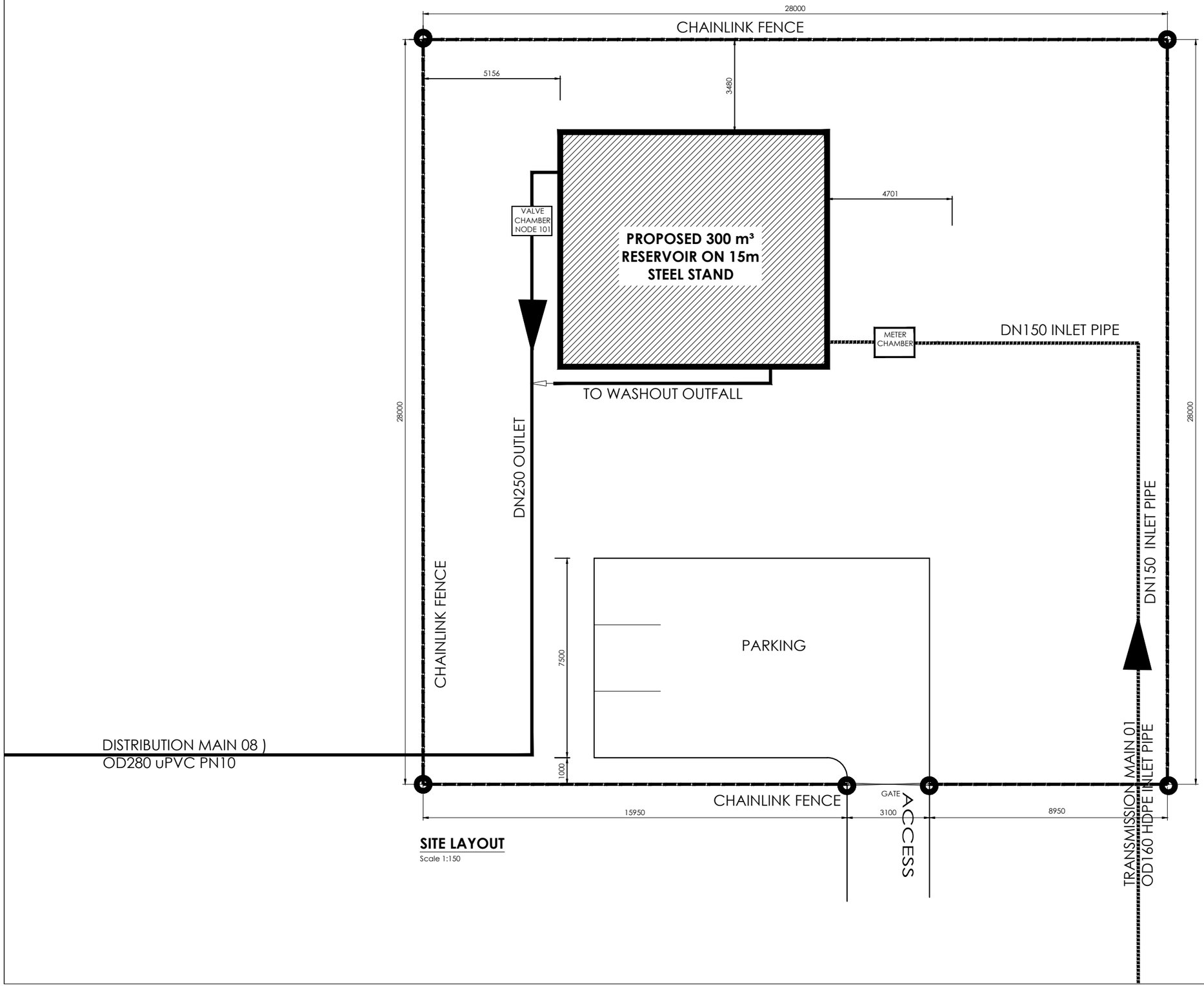
REVISIONS :

No	Date	Description

DETAILED ENGINEERING DESIGN

DRAWING TITLE
WORKSHOP & OFFICE GROUND PLAN

SCALE	AS SHOWN	DRAWING No.	SGI-MWE-LUG-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-LUG-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.

CLIENT

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REVISIONS :

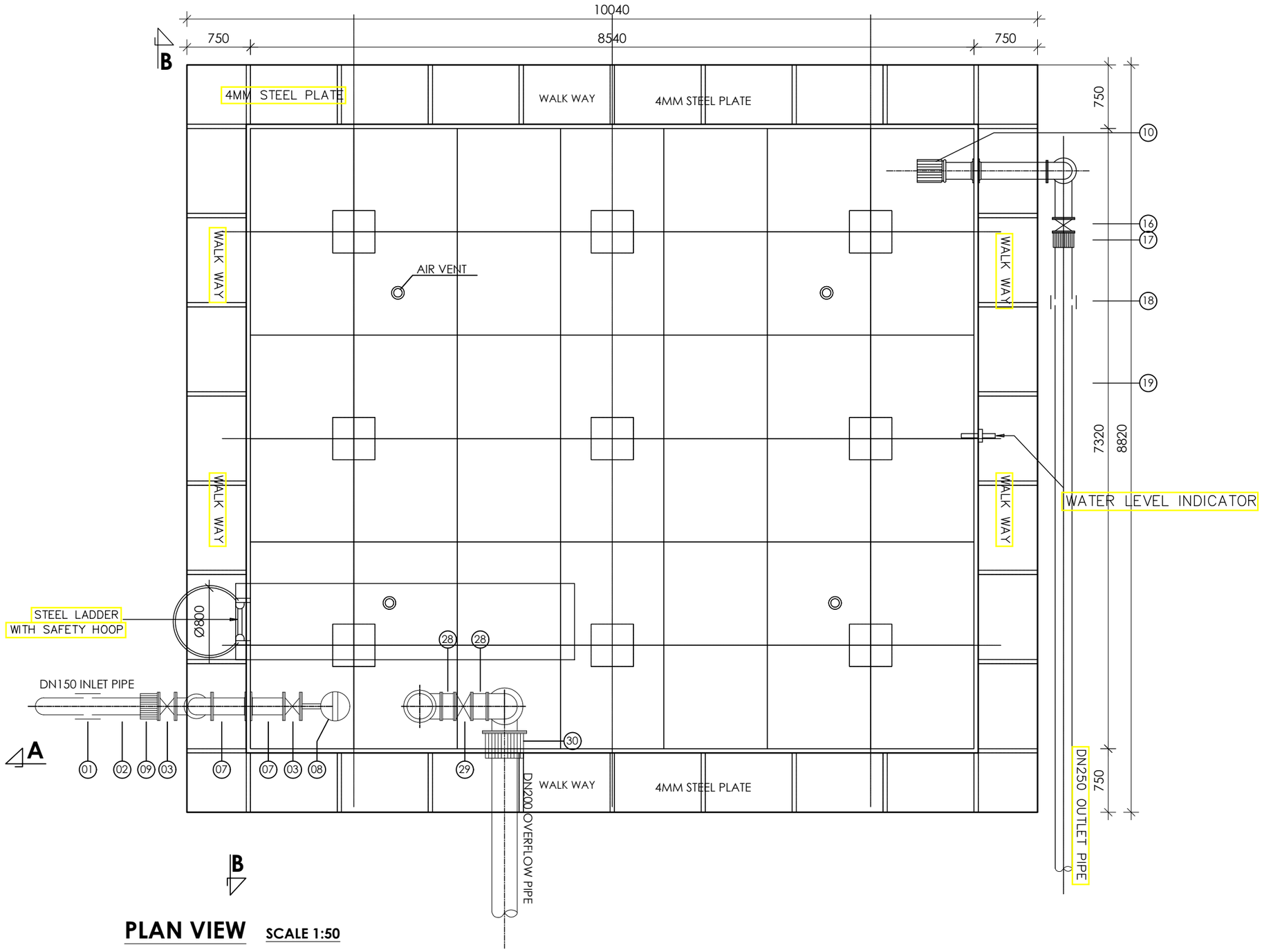
No	Date	Description

DETAILED ENGINEERING DESIGN

DRAWING TITLE

300M³ RESERVOIR TANK
SITE LAYOUT PLAN

SCALE	1:150	DRAWING No.	SGI-MWE-LUG-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-LUG-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.DN250 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.DN200 All Flanged 90° bend.
28. 1No.DN200 Double Flanged Pipe not exceeding 0.4m.
29. 1No.DN200 Flanged Gate Valve.
30. 1No.DN200 Flanged Adaptor,Maxi type or similar.

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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

LUGALA WATER SUPPLY AND SANITATION SYSTEM IN NAMAYINGO DISTRICT

CONSULTANTS

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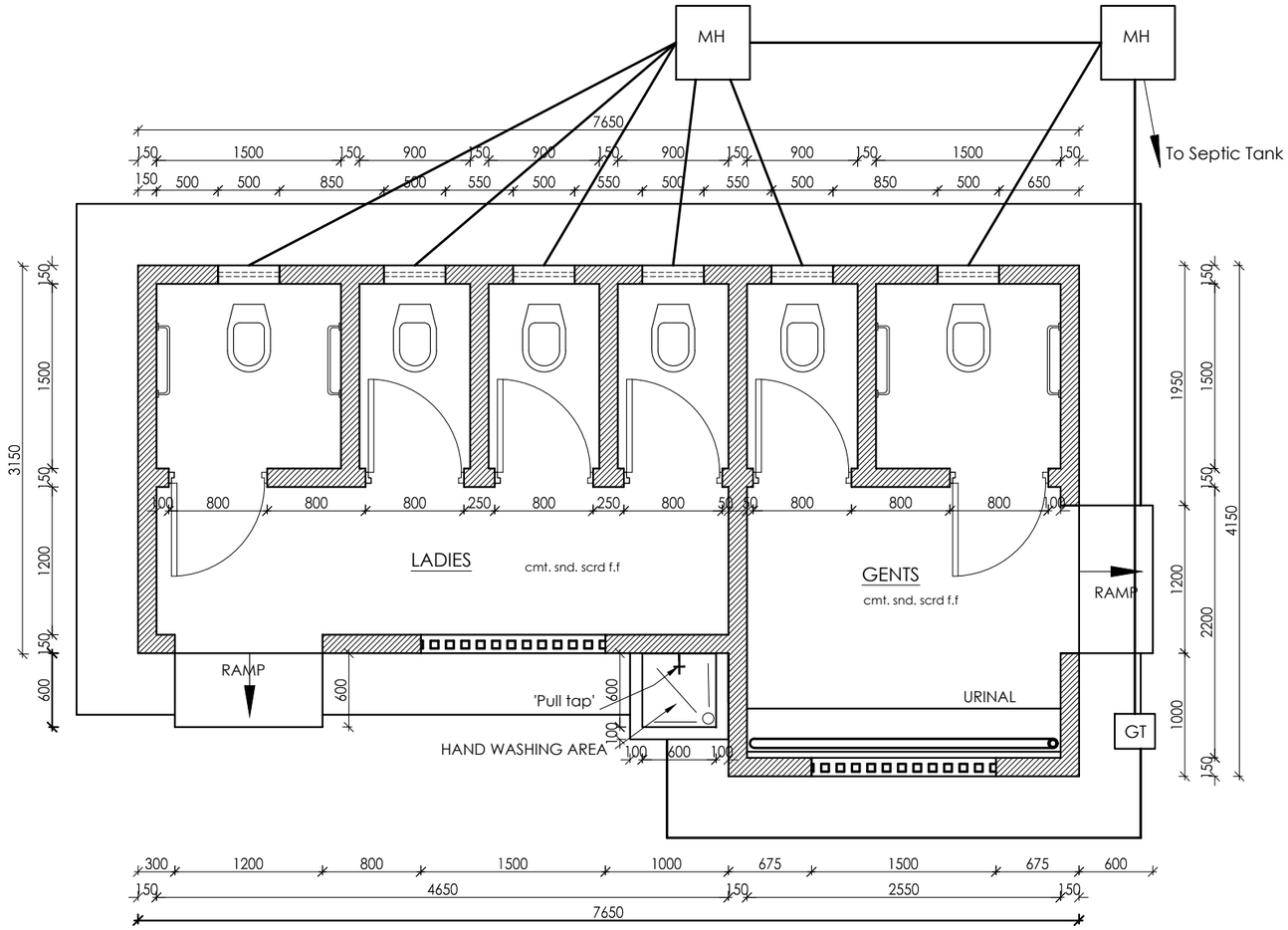
REVISIONS :

No	Date	Description

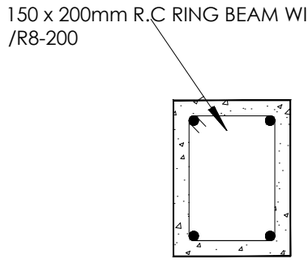
DETAILED ENGINEERING DESIGN

DRAWING TITLE
300M³ RESERVOIR TANK
PLAN

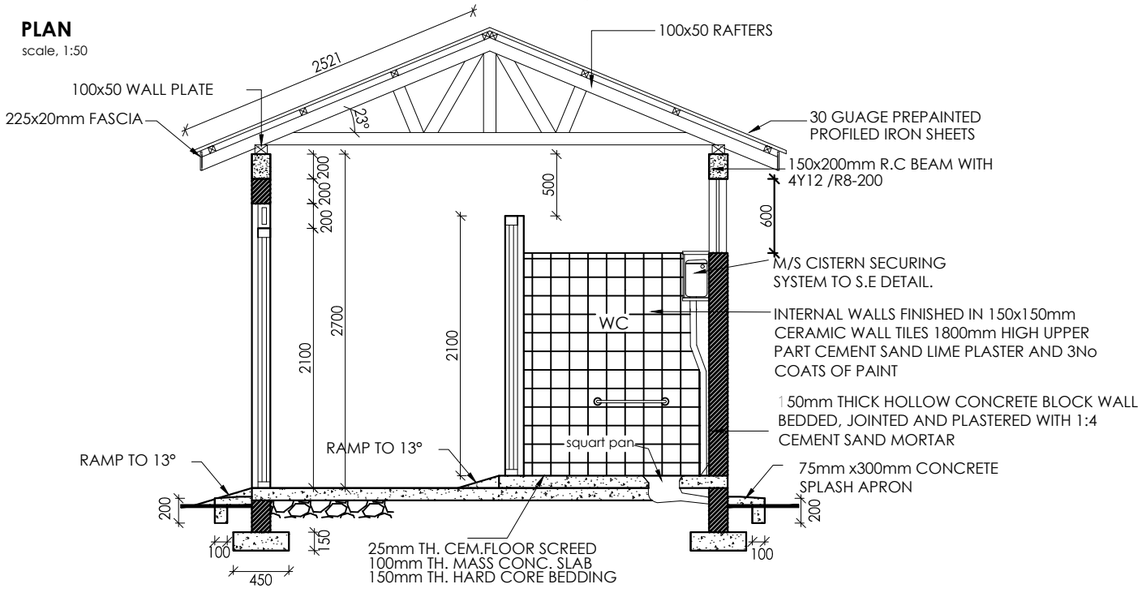
SCALE	1:50	DRAWING No.	SGI-MWE-LUG-5.1.1
SURVEYED	GW	DESIGNED	ORD
DRAWN	CDE	CHECKED	ORD
DATE	SEPT 2020	APPROVED	CP



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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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

LUGALA WATER SUPPLY AND SANITATION SYSTEM IN NAMAYINGO DISTRICT

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REVISIONS :

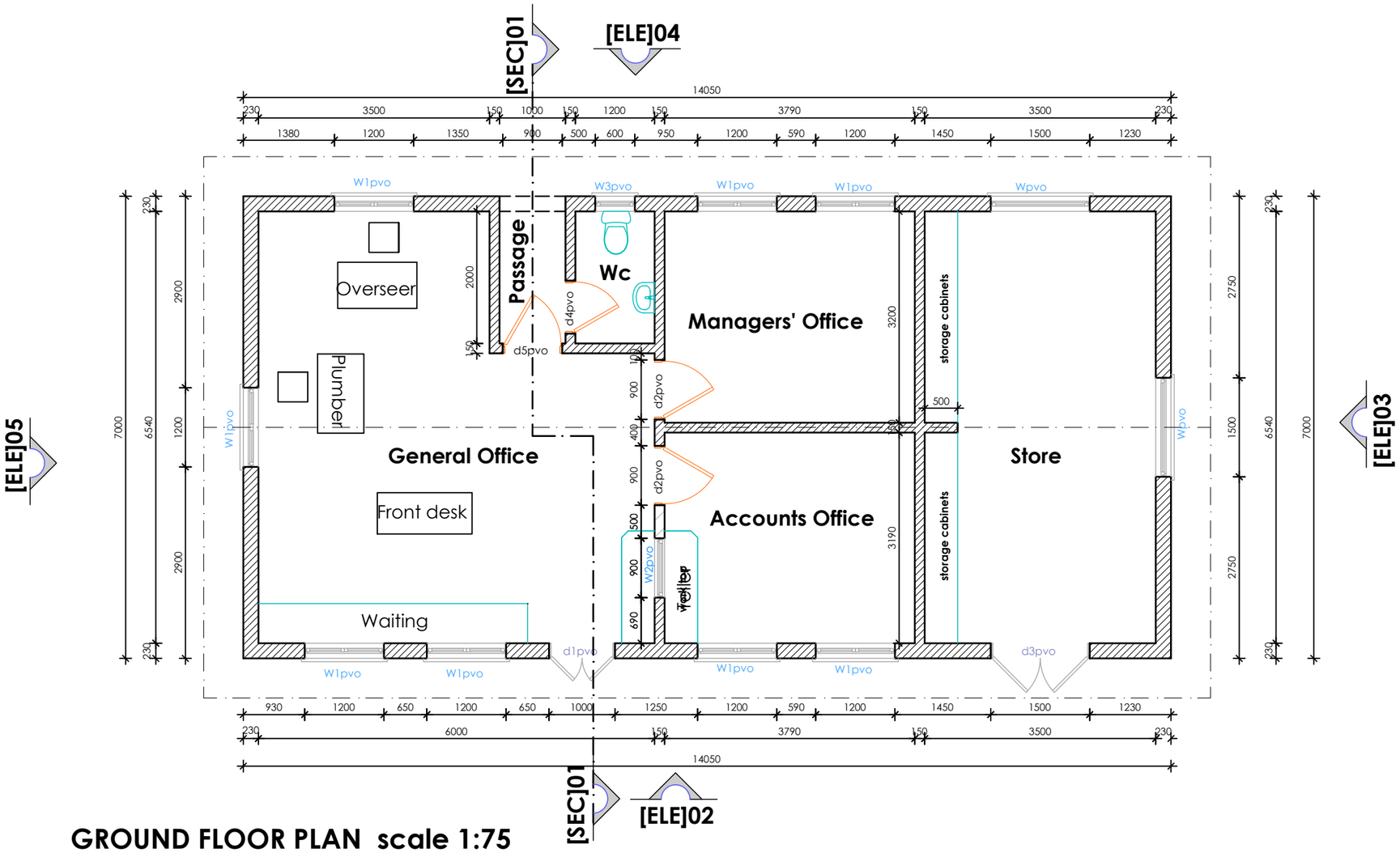
No	Date	Description

DETAILED ENGINEERING DESIGN

DRAWING TITLE
PUBLIC TOILET
PLAN, SECTION AND RING BEAM DETAIL

SCALE	AS SHOWN	DRAWING No.	SGI-MWE-LUG-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-LUG-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
DIRECTORATE OF WATER DEVELOPMENT

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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

LUGALA WATER SUPPLY AND SANITATION SYSTEM
IN NAMAYINGO DISTRICT

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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-LUG-12.0.0
SURVEYED	GW	DESIGNED	ORD
DRAWN	CDE	CHECKED	ORD
DATE	SEPT 2020	APPROVED	CP