Water and Sanitation Corporation (WASAC)
Republic of Rwanda

THE PROJECT FOR WATER SUPPLY MASTER PLAN FOR CITY OF KIGALI IN THE REPUBLIC OF RWANDA

FINAL REPORT (Pre-release Version)

VOLUME 3

Feasibility Study for the Project for Expansion of Karenge Water Supply System

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Average value of the telegraphic transfer middle rates at the end of each month between October 2020 and March 2021 published by the National Bank of Rwanda

USD 1 = RWF 973
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Preface

The Final Report (F/R) of the Water Supply Master Plan for City of Kigali (KWSMP) consists of the following separated volumes, namely:

- Volume 1: Executive Summary
- Volume 2: Kigali Water Supply Master Plan
- Volume 3: Feasibility Study for the Project for Expansion of Karenge Water Supply System
- Volume 4: Feasibility Study for the Project for Construction of Masaka Water Supply System

This report is the "Volume 3: Feasibility Study for the Project for Expansion of Karenge Water Supply System" of the F/R

THE PROJECT FOR WATER SUPPLY MASTER PLAN
FOR
CITY OF KIGALI
FINAL REPORT
Volume 3
Feasibility Study for the Project for Expansion of Karenge Water Supply System

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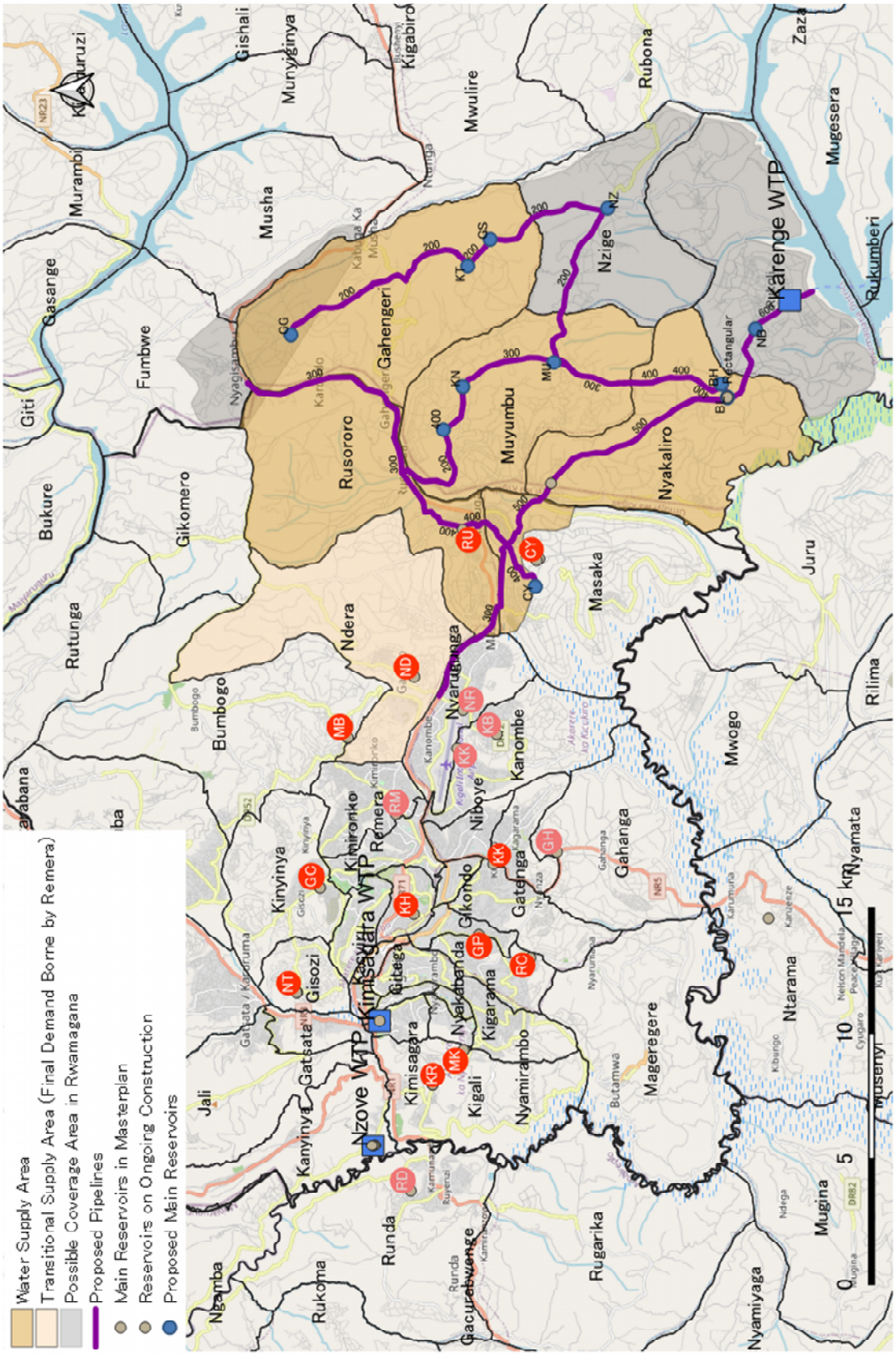
Location Map



Abbreviations

CoK	City of Kigali
DF/R	Draft Final Report
DIP	Ductile Iron Pipe
EICV	Integrated Household Living Conditions Survey
EIRR	Economic Internal Rate of Return
EMP	Environmental Management Plan
ESIA	Environmental and. Social. Impact. Assessment.
FIRR	Financial Internal Rate of Return
F/R	Final Report
FS, F/S	Feasibility Study
FY	Fiscal Year
GDP	Gross Domestic Products
GOR	Government of Rwanda
IMF	International Monetary Fund
JICA	Japan International Cooperation Agency
JST	JICA Study Team
KWSMP	Kigali Water Supply Master Plan
MININFRA	Ministry of Infrastructure
MINECOFIN	Ministry of Finance and Economic Planning
MINEMA	Ministry in charge of Emergency Management
M/P R	Masterplan Report
MUSD	Million United States Dollars
ND (DN)	Nominal Diameter (Diamètre Nominal)
NPV	Net Present Value
NRW	Non-Revenue Water
NST	National Strategy for Transformation
NTU	Nephelometric. Turbidity Unit
O&M (OM)	Operation and Maintenance
PBT	Pressure Break Tank
PG/R	Progress Report
PRV	Pressure Reduce Valves
PVC	Polyvinyl Chloride (Pipe)
QA/QC	Quality Assurance/Quality Control
REMA	Rwanda Environment Management Authority
RURA	Rwanda Utilities Regulatory Authority
RWF	Rwanda Franc
RWB	Rwanda Water Resource Board
RWFA	Rwanda Water and Forestry Authority
SEA	Strategic Environmental Assessment
SDGs	Sustainable Development Goals
UWSSD	Urban Water and Sewage Service Department
VAT	Value Added Tax
WASAC	Water and Sanitation Cooperation
WHO	World Health Organization
WTP(s)	Water Treatment Plant(s)
WSA	Water Supply Area

CHAPTER 1 INTRODUCTION

1.1 INTRODUCTION

Water supply is an essential service for the people as well as the key national target to meet basic human needs and to achieve economic development. Water and Sanitation Cooperation (WASAC), together with the Government of Rwanda, has made significant efforts to increase water coverage over the past few years and has committed to providing 100% coverage by the year 2024, thereby ensuring universal and equitable access to safe and affordable drinking water for the people aimed at achieving the goals raised by NST-1 along with Sustainable Development Goals (SDGs). The WASAC, in consultation with MININFRA, MINECOFIN and MINEMA, has established a water supply masterplan toward 2050 in order that the water infrastructure will be constructed from the aspect of long-term development in line with the Masterplan of the City of Kigali and adjacent sectors.

This Project for Construction of Karenge Water Treatment Plant is one of the most urgent components of the Water Supply Masterplan to serve essential water to the people, especially those living in the growing east in the City of Kigali (CoK) and the Rwamagana District. The Project intends to expand the existing Karenge WTP sourcing water from Lake Mugesera from a capacity of 12,000 m^3/day to 48,000 m^3/day in Phase 1 and will further expand it to 120,000 m^3/day. The Project is urgent because the water demand is high and growing rapidly in the service area; the existing plant is forced into overloaded operation, with being used beyond the design capacity, in a yearly average water supply amount over 15,000 m^3/day. The Karenge WTP has already obtained the water intake permission from RWB (former RWFA) for 48,000 m^3/day, so it is necessary to make the most use of the permitted amount as early as possible.

Table 1-1 Summary of the Expansion Stage and the Plants

Name	Total Capacity	Remarks
Existing Karenge WTP	12,000 m^3/day	(Currently over-used 15,000 m^3/day in a yearly average supply)
New Karenge WTP (Karenge 2)	Phase 1: 36,000 m^3/day (Total 48,000 m^3/day)	Subject to Preliminary Design and Cost Analysis
	Phase 2: 72,000 m^3/day (Total 120,000 m^3/day)	Conceptualized in the F/S for Future Expansion

Note: "Expanded Karenge WTP" refers to the Existing + New Karenge WTP in this report.

1.2 OBJECTIVE AND SCOPES OF THE FEASIBILITY STUDY

The objective and the scope of the study is to evaluate the feasibility of the **Phase 1 expansion of the New Karenge WTP (total 48,000 m^3/day)** from the following aspects;

1. Background and emergency of development from the existing situation
2. Preliminary technical planning and design for the facilities
3. Environmental and social impact and necessary consideration
4. Feasibility of the Project in terms of financial and economic aspects

In this study, the phase 2 expansion is conceptualized in order that the land acquisition and the necessary consideration for the future expansion can be arranged at the same time as the Phase 1 expansion.

1.3 STUDY AREA

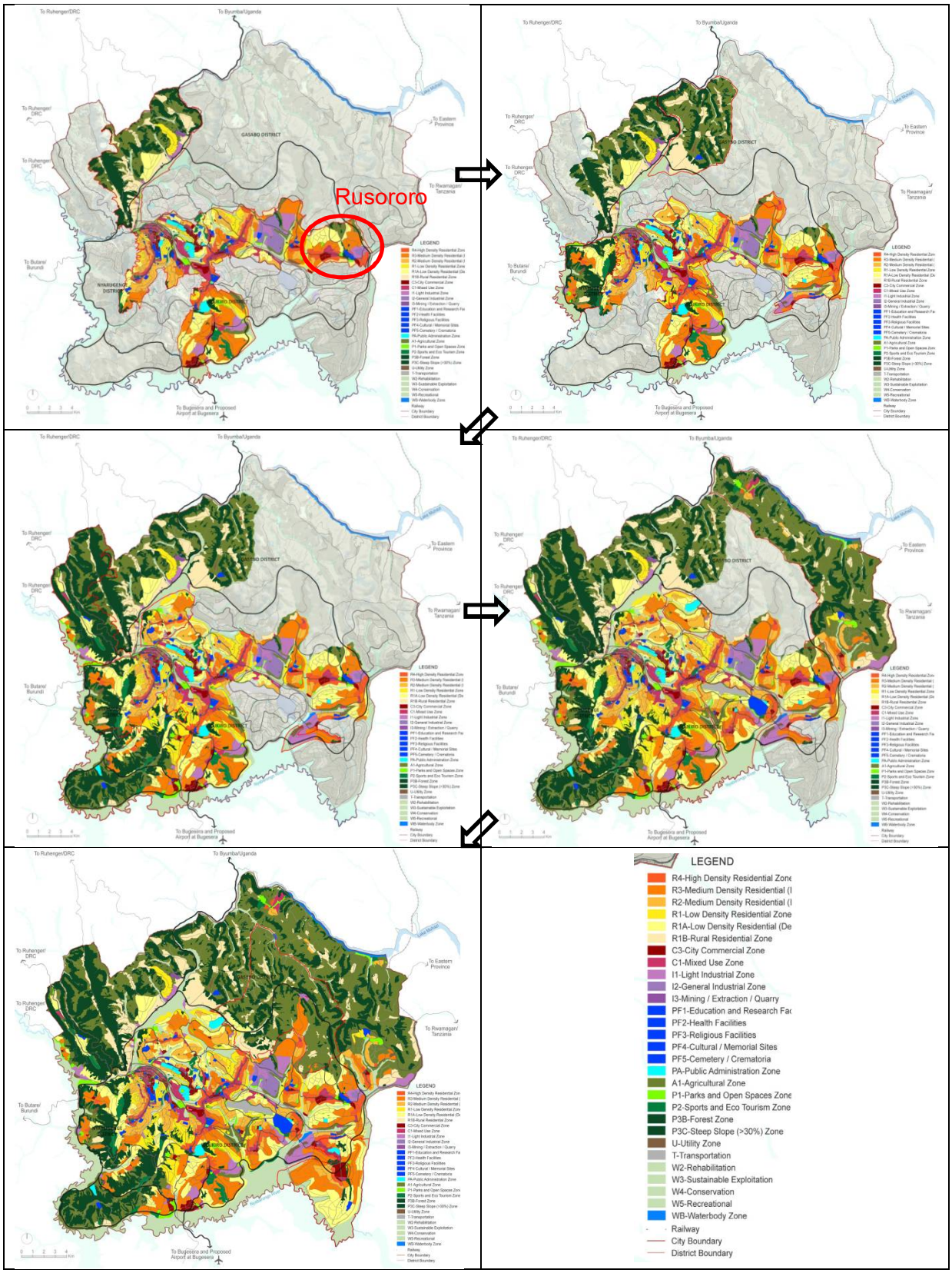
The study area consists of the coverage area of the new Karenge WTP (Karenge 2); Namely Rusororo and Ndera sectors in the CoK and the Gahengeri, Muyumbu and Nyakaliro sectors in the Rwamagana district. The study area is shown in **Location Map**.

1.4 BACKGROUNDS AND ISSUES OF STUDY AREA

1.4.1 The rapid development of the Study area

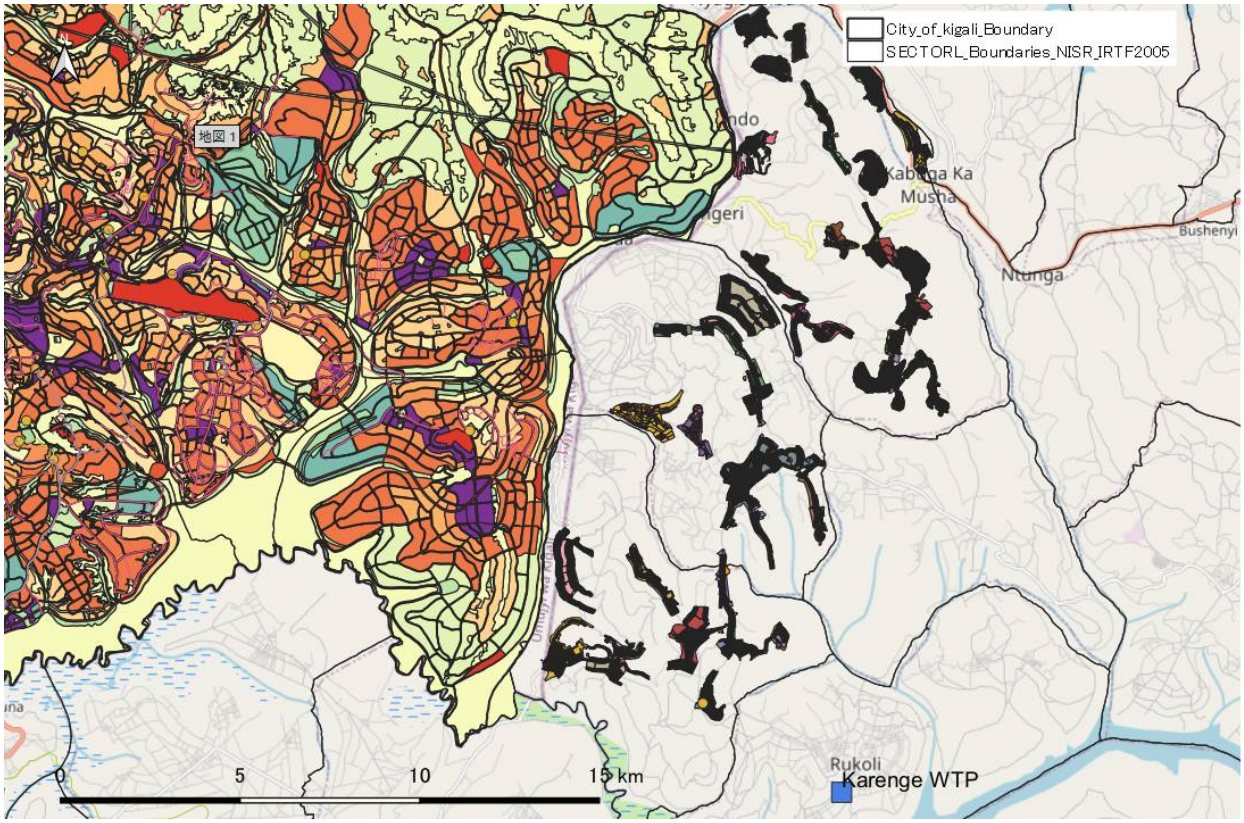
Population projection in the City of Kigali is based on the High Growth Scenario of the City Masterplan (2019). The CoK M/P also presents a phased development plan that is divided into five phases (Phase 1: 2019 – 2024, Phase 2: 2025 – 2031, Phase 3: 2032 – 2038, Phase 4: 2039 – 2045, Phase 5: 2046 – 2050), and indicating priority areas for development (**Figure 1-1**).

As shown in the abovementioned figures, the Masterplan Report of the CoK M/P pointed out that the trend of development and growth in the City of Kigali would be moving towards the eastern and southern parts of the city. In particular, the Rusororo sector is one of the areas that the earliest development is expected (Phase1). Adjacent sectors, including the Gahengeri, Muyumbu and Nyalaliro sectors, are also expected to be developed along with the CoK's development. The Masterplan (sectoral development plan) for those sectors is as shown in **Figure 1-2** and elaborated in **Appendix B**.



Source: Masterplan Report (2019 Edition) of CoK M/P

Figure 1-1 Transition of Development Phase with Land Use Details



Source: JST

Figure 1-2 Karenge WTP and adjacent sectors' development

1.4.2 Water Supply Coverage

The water supply coverage in the target area is very low compared to the adjacent regions of the City of Kigali as well as the urban areas in the Rwamagana districts. The low water supply coverage is mainly due to the lack of water sources in the surrounding area. Water supply coverage by the WASAC is quite low in this area; existing water supply connections in the Target Areas are estimated to be only 6,300 as of 2019. Other populations may get water from "other improved sources" such as protected/unprotected springs and private wells. Meanwhile, there is only limited information for the water supply coverage of the target area. The EICV V (2018) shows that the water supply coverage by the piped water supply into dwellings is 34.0% in the CoK and only 4.7% in the Eastern province. Given that we take "Total improved" populations as the water supply coverage, the population with access to safe water supply (at least Basic) is **127,000** in the Target Area.

Table 1-2 Water Supply Coverage of Target Area

	Piped into dwelling/yard	Public standpipe	Total improved
Kigali City	34.0	46.3	80%
Eastern	4.7	41.4	46%

Source: EICV V (2018)

1.4.3 NRW and Ineffective Water Ratio

Ineffective water ratio is defined as the sum of leakages and the deducted water amount from the bills due to the leakages and water quality accidents. The water supply capacity includes the actual water demand by the customers and this ineffective water mostly consisted of leakages.

The target for the ineffective water percentage was assumed as in **Table 1-3.**

- The ineffective water percentage is set as the same value as the target NRW percentage defined in the Kigali Water Supply Masterplan. This is because most of the reasons for NRW consists of the leakages in the CoK.
- The NRW target is ambitious compared to the current status of the NRW (38.8 % in CoK), but it is achievable for the newly expanded Project in this area. The value of 23% (in 2035) from 25% (in 2025) is conservative given that the water supply systems are new.

Table 1-3 Target Ineffective Water Percentage in the Expanded Karenge Water Supply System

	2019	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Ineffective water percentage (NRW percentage)	35%	25%	24%	24%	24%	24%	24%	23%	23%	23%	23%	23%

Source: JST

CHAPTER 2 DESIGN CONDITIONS

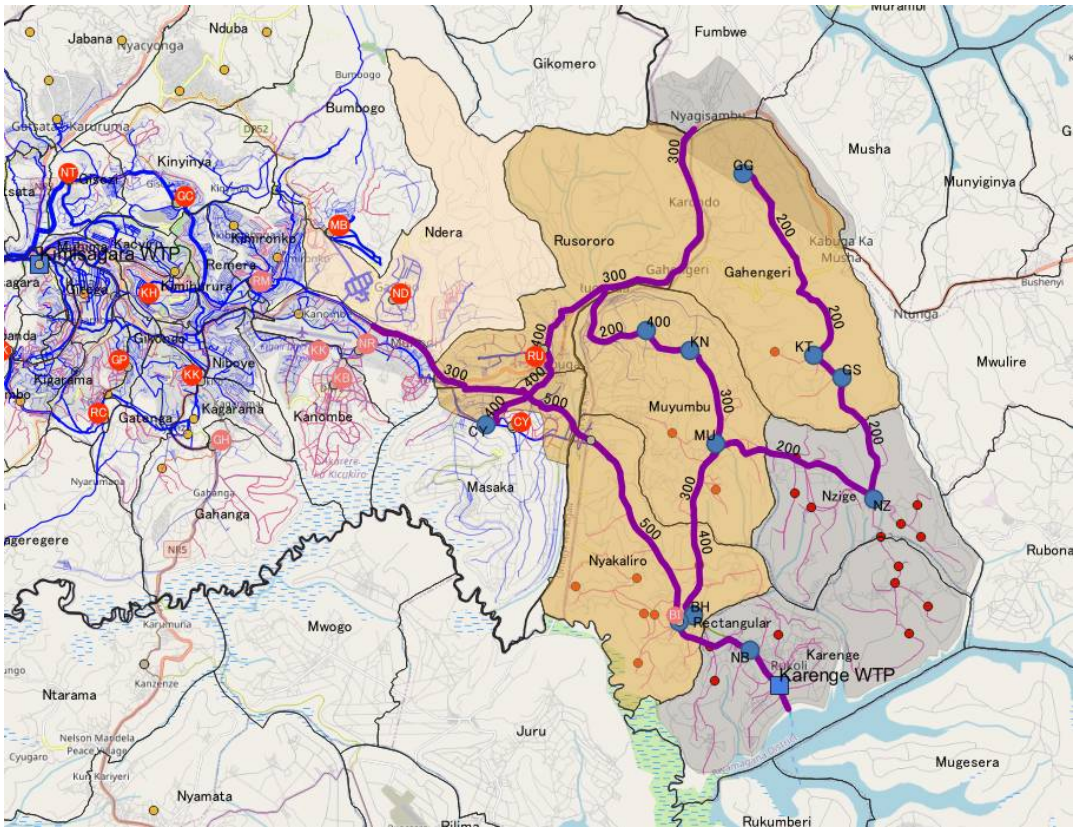
2.1 WATER SUPPLY AREA AND WATER DEMAND

Water Supply Area (WSA) is illustrated in **Source:** JST
Figure 2-1**.** WSA of existing Karenge WTP includes Ndera, Rusororo, Kanombe, Nyarugunga, and Masaka sectors in the CoK and some part of Muyumbu and Nyakaliro sectors in the Rwamagana district. According to the Kigali Water Supply Masterplan Project (KWSMP), Masaka, Nyarugunga, and Kanombe are to be supplied from the Masaka WTP and the Kanzenze WTP (Kigali Bulk Water Supply), so the water demand for those sectors is omitted. There is some unidentifiable coverage area in the Rwamagana district where the demand value is set as a given condition (9,500 m^3/day in 2035 and 272,000 m^3/day in 2050). The WSA can be flexible to that demand but assumed that area in the Karenge and Nzige sectors considering the topography.

The projected water demand is as shown in **Table 2-1**. The data and methodology for the water demand projection are in accordance with the KWSMP. The target year 2035 and 2050 is also in line with the KWSMP.

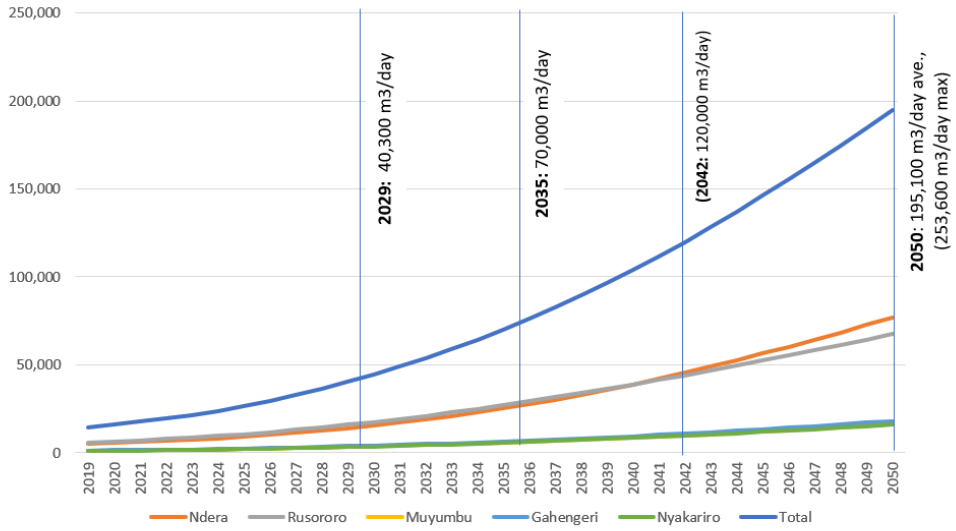
The total projected demand for the supply is 68,303 m^3/day, which is far beyond the existing water supply capacity of 12,000 m^3/day, as well as the currently permitted water withdrawal of 48,000 m^3/day from the Lake Mugesera. Considering the existing pipeline capacity, the full capacity of the 20,900 m^3/day can be transmittable from the existing Remera reservoir through the Masoro-bas station. Therefore, WSA of Karenge WTP should be set as the Rusororo, Muyumbu, Gahengeri, Nyakaliro and other provisional demands in the Rwamanaga district for 48,000 m^3/day.

For the target year 2050, the estimated water demand is 222,303 m^3/day in the WSA. Though the city's development may be uncertain, it is necessary to allocate the water right from the long-term perspective. In view of water transmission efficiency, approximately 100,000 m^3/day can be transmitted from other water sources such as Gahanga and the Nzove. The other area near the Karenge, of which water demand is 120,000 m^3/day, should be covered by Karenge WTP development in Phase 2. While the target year for the Phase 2 expansion is set as the year 2050, the development is necessary by 2042: The timing that the demand in the study area reached 120,000 m^3/day.



Source: JST

Figure 2-1 Water Supply Area (WSA) for the expanded Karenge WTP



	Year	2020	2025	2026	2029*	2035	2050
a	Total Demand	16,200	26,600	29,600	40,300	70,000	253,600
b	Supply From Ntora-Kanzenze/Remera	0	14,000	14,000	1,800	10,600	0
c	Supply From Masaka	0	0	0	0	21,000	0
d	Supply From Gahanga/Remera	0	0	0	0	0	161,000
e=a-(b+c+d)	Supply from Karenge to Kigali	16,200	12,600	15,600	38,500	38,400	92,600
f	Other Area (Provisional)				9,500	9,500	27,200
g=e+f	Total	16,200	12,600	15,600	48,000	47,900	120,000

Source: JST

Figure 2-2 Water Demand Projection for the WSA for Expanded Karenge WTP

Table 2-1 Water Demand Projection for the WSA for Expanded Karenge WTP

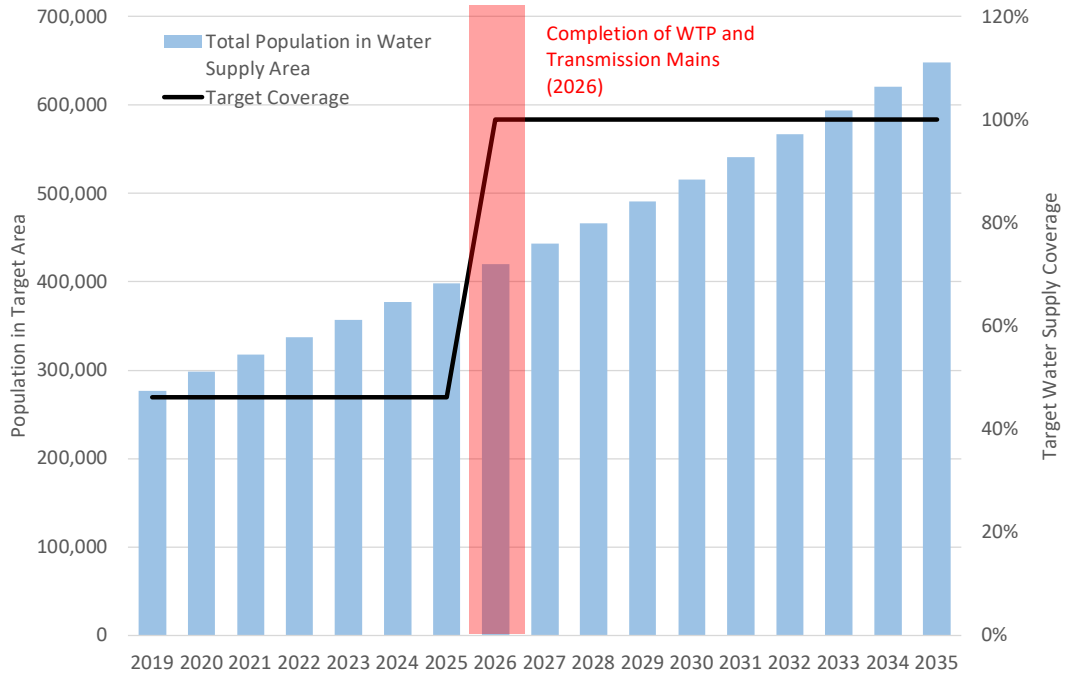
	2035				2050			
	Demand (m3/day)	Supply (Rounded, m3/day)			Demand (m3/day)	Supply (Rounded, m3/day)		
		Remera	Masaka	Karenge		Remera	Masaka	Karenge
Ndera	20,859	20,900			77,062	77,100		
Rusororo	22,874			22,900	67,335	25,000		42,300
Muyumbu	4,880			4,900	16,371			16,400
Gahengeri	5,397			5,400	18,106			18,100
Nyakariro	4,792			4,800	16,229			16,200
Rwamagana	9,500			9,500	27,200			27,200
Total	**68,303**	**20,900**		**47,500**	**222,303**	**102,100**		**120,000**

Source: JST

2.2 TARGET POPULATION AND COVERAGE

Target population and water supply coverage by the Project is as shown in **Figure 2-3** and **Table 2-2**. The target year for the completion of the WTPs and major water transmission systems is 2026, and the population in the target area is then 405,000. Until the target year of the Project (2030), the number of the beneficiaries by the Project will be increased to 493,500 people as ineffective water decreases year by year.

Note that we assume the Working Ratio of the expanded water treatment plant is 100% right after the completion of the Project because a large part of the water produced can be transmitted to the Remera Golf 8 reservoirs where the water is scarce permanently.



Source: JST

Figure 2-3 Population Projection and Target Water Supply Coverage by the Project

Table 2-2 Projected Population in Target Area

Year	2019	2025	2030	2035
Ndera	91,550	127,209	169,268	223,536
Rusororo	104,736	154,263	198,512	246,094
Muyumbu	26,073	37,926	47,803	57,680
Gahengeri	28,836	41,945	52,869	63,793
Nyakaliro	24,938	36,864	46,802	56,740
Total	**276,133**	**398,207**	**515,253**	**647,843**

Source: JST

2.3 WATER SOURCE AND WATER RIGHT

The current situation of the water source was elaborated in Section 1.5. It is recommendable to make the most of existing water permission for the withdrawal from Lake Mugesera is **48,000 m^3/day** as shown in **Appendix C** due to the lack of scientific evidence on the fact how much water can be withdrawn sustainably. The sustainable water supply withdrawal should be further studied considering the water balance of Lake Mugesera, which would be conducted by the Rwanda Water Resource Board.

2.4 STATE OF EXISTING FACILITIES

The Karenge WTP is located in the Rwamagana District, about 50 km southeast of the City of Kigali. The Karenge WTP abstracts raw water from Lake Mugesera. The outline of Lake Mugesera is summarized in **Table 2-3**. The intake pump station is located at the Lakeshore edge, about 1 km from the Karenge WTP (**Figure 2-4**).

Table 2-3 Outline of the Lake Mugesera

Item	Content	Remarks
Altitude	1,360 m	City of Kigali: 1,400-1,600 m
Surface area of the lake	21 km^2	
Average storage	253 million m^3	Estimated from the surface and mean depth.
Inflow river	5 rivers	Nyirabidibili, Rwangunda, Mwanbu, Ruvomo and Nyabarongo rivers.
Outflow river	No	Overflow to Nyabarongo River in high water level
Rainfall	951 mm	
Water level fluctuation	3-4 m	2.7m from Jan. to Jun. of 2019 (hearing information)
Pollution sources of catchment area	Non-point source	

Source: Development of National Integrated Water Supply and Sanitation Master Plans for Rwanda (Baseline Data Report) and JST

Water source and intake (center of the Lake, app. 500m from the Lakeshore edge) for Karenge WTP.

Pump station (left) of Karenge WTP, which is facing the risk of inundation during the rainy season.

Source: JST

Figure 2-4 Raw Water Intake Pump Station of the Karenge WTP

The Karenge WTP was constructed in 1975 by the AIDR (Association International de Development Rural) with 3,800 m^3/d capacity for rural water supply and expanded in 1985 by the SADE to 7,200 m^3/d. In 2008, another extension and rehabilitation were conducted by the SOGEA-SATOM to increase the capacity to 12,000 m^3/d for supplying water to the City of Kigali. The current capacity of the WTP is 15,000 m^3/d, which has exceeded its original design capacity.

Furthermore, the Intake Pumping Station is always at a risk of flooding every year. The flooding water level in the rainy seasons is higher than the floor level of existing pumping stations. The water levels are not normally recorded both at the pumping station and even at the nearest hydrological stations at the Lake Mugesera (Rubago stations). The emergency sandbag embankment was constructed by the WASAC which is vulnerable to collapse by rain. In case the dike was washed out, it would cause extensive water supply suspension because the pumping station would be submerged.

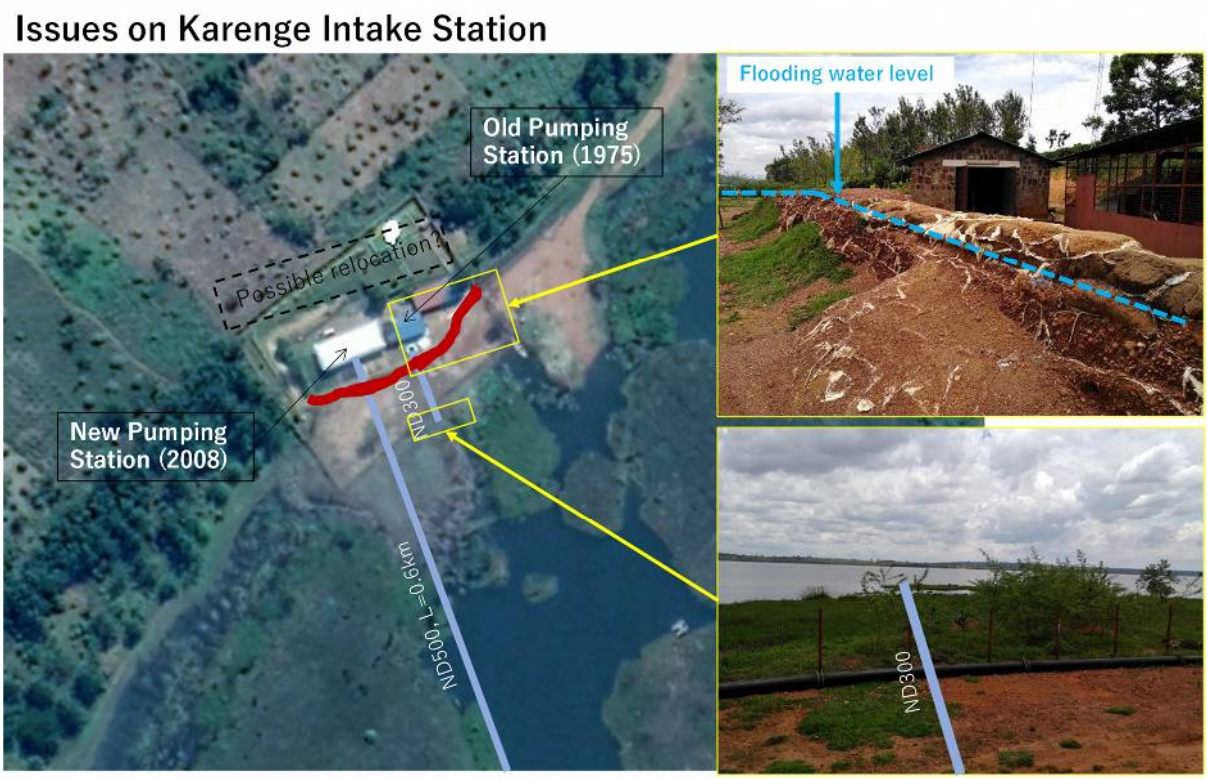
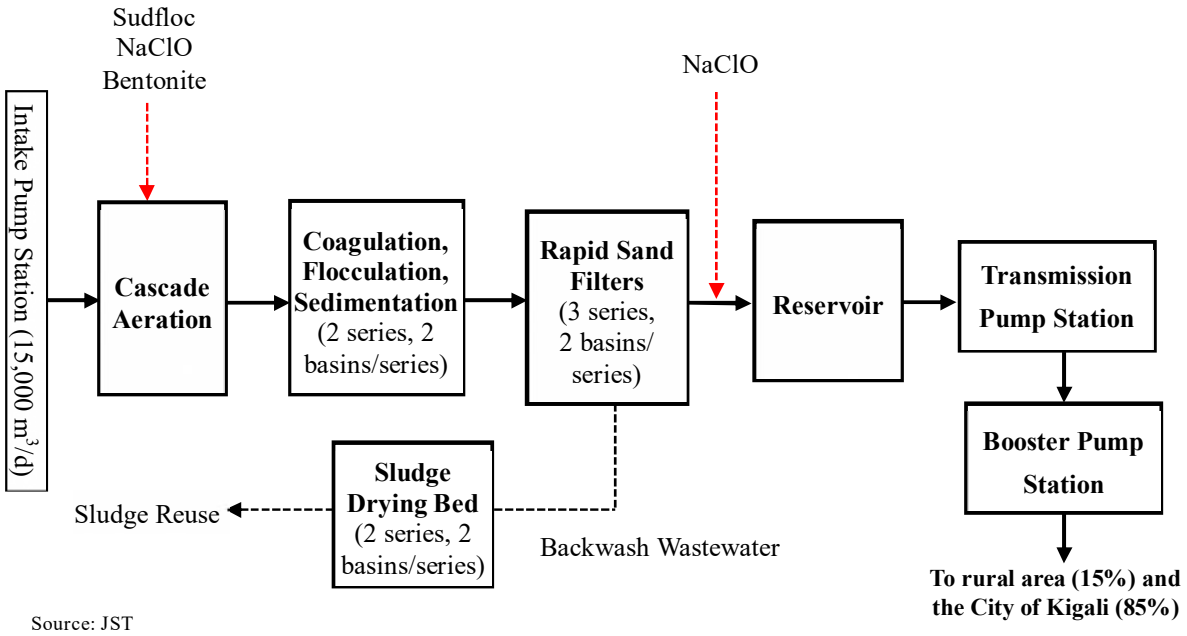


Figure 2-5 and **Figure 2-6** show the treatment process and treatment facilities of the Karenge WTP, respectively. To reduce the cost of production, sodium hypochlorite production is done at the WTP, and the capacity of sodium hypochlorite production is about 90 kg/d. The average dosage of sodium hypochlorite in 2018 is 3.4 mg/l.



Source: JST

Figure 2-5 Treatment Flow Chart of the Karenge WTP

Cascade aeration (in the back), followed by coagulation, flocculation, sedimentation facilities (2 series, 2 basins/series)
Source: JST

Rapid sand filters (3 series, 2 basins/series)

Figure 2-6 Treatment Facilities of the Karenge WTP

2.5 RAW WATER QUALITY

Raw water quality and treated water quality are presented in **Table 2-4**. As shown in **Table 2-4**, the turbidity of raw water is very low, which resulted in poor coagulation and sedimentation. In addition, although color, iron, manganese, nitrogen, phosphorus and cyanide show higher levels in raw water, the treated water can still meet the drinking water quality standard of Rwanda. It should be pointed out that Lake Mugesera is in the eutrophic state as the total nitrogen and phosphorus concentrations are 5.96 mg/L and 0.99 mg/L, respectively and have exceeded the eutrophication limit of nitrogen (0.6 to 1.5 mg/L) and phosphorus (0.03 to 0.1 mg/L).

Table 2-4 Raw Water and Treated Water Quality of Karenge WTP

Parameter	Unit	Current Raw Water Quality	Treated Water Quality	Rwanda Standard
pH	-	7.3-8.2 8.0	7.4-7.8 7.6	6-9
Turbidity	NTU	Dry: 19-32 Wet: 20-34	0.7-1.5 1.0	5
Color	TCU	209-1,865 371	8.3-14.2 11.2	15
DO	mg/L	8.1-16.7 14.3	-	
Organic mater	mg/L	3.1-12.5 8.5	0.9-2.0 1.2	
Iron (Fe)	mg/L	0.5-1.9 1.0	0.04-0.06 0.05	0.3
Manganese (Mn)	mg/L	0.28-0.84 0.47	0.009-0.015 0.013	0.1
Fluoride (F^-)	mg/L	1.2-5.2 3.4	0.3-0.5 0.4	1.5
Ammonia (NH_3-N)	mg/L	0.09-0.35 0.22	0.001-0.1 0.004	0.5
T-N	mg/L	0.85-9.21 5.96	-	
T-P	mg/L	0.59-1.70 0.99	-	
Cyanide (CN^-)	mg/L	0.07-0.52 0.27	0.000-0.015 0.006	0.05
Coliform	CFU/100mL	5.8×10^3-1.1×10^4	<1	Nil
Cl_2	mg/L	-	0.2-0.9 0.7	0.2-0.5

Source: WASAC
Up figures: min.-max. values
Low figures: average values

The operation and maintenance system of the Karenge WTP is summarized in **Table 2-5**.

Table 2-5 Summary of Operation and Maintenance System in the Karenge WTP

Item	Content	Remarks
Total number of staff	33 (including OM on distribution network)	Permanent: 16 Temporary: 17 (one year contract)
OM system	2 shift/day (07:00 – 17:00: 4 staff/shift) (17:00 – 07:00: 4 staff/shift)	One shift including 2 staff for process and E&M[1)], 1 for laboratory, 1 workers.
Water sampling location	1: Raw water 2: After sedimentation 3: After filtration 4: Reservoir	Raw water sampling at receiving well.
Sampling frequency	1 sample/hr (raw water) 1 sample/2 hr (filter)	
Analysis items	➢ pH, turbidity ➢ pH, turbidity, residual chlorine (Cl_2) ➢ Turbidity, Cl_2, coliform, E. coli ➢ Others (such as Fe, Mn, organic matter, NO_2, NO_3, PO_4, F^-, CN^- and heavy metals)	Raw water Filtered water and reservoir Distribution network Monthly monitoring

Source: WASAC
1) E&M: electricity and machinery.

Chemicals and electricity consumption of the Karenge WTP is summarized in **Table 2-6**. Unit power

consumption in the Karenge WTP is 1.74 kWh/m^3-water production and transmission, which is much higher than that of the average values in Japan (0.3 to 0.4 kWh/m^3-water production and transmission). Major reason for this is due to the high-power consumption of the intake pump station and transmission pump station as well as booster pump stations.

Table 2-6 Summary of Chemicals and Electricity Consumption in Karenge WTP

Item	Unit	2018	Remarks
Treated water volume	m^3/d	14,200	Average production in 2018
Dosage of Sudfloc	mg/L	14	Annual average dosage in 2018
Dosage of NaClO	mg/L	3.4	Annual average dosage in 2018
Power consumption	kWh/year	9,031,321	Raw pumping station, WTP and booster pumping station consume 38%, 41% and 21% of electricity, respectively.
Unit power consumption	kWh/m^3	1.74	53.8% of total OM cost.
Unit operation & maintenance (OM) cost	Rwf/m^3	481	Chemicals, power, personnel and other costs

Source: WASAC

Major challenges for operation and maintenance (O&M) are summarized in **Table 2-7**.

Table 2-7 Major Challenges for O&M in the Karenge WTP

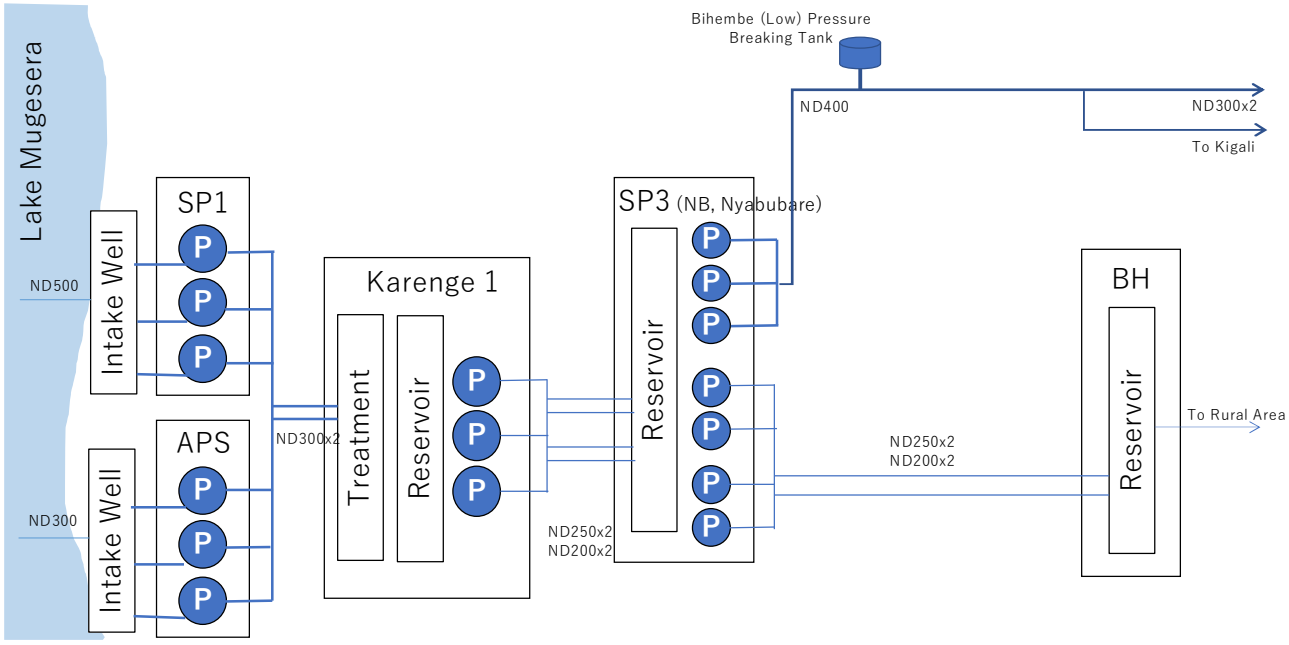
Item	Content	Remarks (Urgency)
Technical aspect	1. Lack of stable intake from the lake	High
	2. Intake pump station exposed to the risk of inundation during the rainy season (Mar. to Jun.)	High
	3. Insufficient algae removal	High
	4. Insufficient capacity of storage reservoir for production and distribution with the risk of intermittent overflows in case of a blackout.	High-Medium
Organizational aspect	5. Capacity development of OM staff	Low
	6. Shortage of staff number	Medium
Financial aspect	7. High OM cost, especially high-power consumption	High
Others	8. Improvement of standard operation procedure (SOP)	Low
	9. Limitation land for an extension.	Low

Source: JST

2.6 EXISTING TRANSMISSION SYSTEMS

Existing WTP transmit water to Nyabubare Pumping Station (SP3) and transmit water to CoK by a pipeline with DIP ND400 for approx. 10.5 km. The water is also transmitted to Bihembe reservoir by different pumps and supplied to the Muyumbu sector direction by gravity.

The pipeline to CoK is then bifurcated at a location in Nyakaliro into two pipelines with ND300; namely Karenge 1 and Karenge 2. Those two pipelines were constructed at different period (**Table 2-8**). According to the interview from the WASAC technicians, Karenge 1 have caused leakage accidents more often than the Karenge 2, in the pipelines between Nyabubare-Nyakaliro.



Source: JST

Figure 2-7 Water Transmission Systems from Existing Karenge WTP

Above all, those pipelines are designed for the existing system with a capacity of 12,000 m^3/day. Therefore, the water supply system is overused for 15,000 m^3/day on average,

Table 2-8 Property of Pipelines from Existing Kanrege WTP

Name (Route)	Materials and Diameter	Year of Laying	Remarks
(From Nyabubare-Nyakaliro)	DIP ND 400	1975-2008	Leakages are happening occasionally at valves and fittings.
Karenge 1 (via Masaka to Remera)	DIP ND 300	1985	Many leakages.
Karenge 2 (along NR4 road to Remera)	SP ND 300	2008*	Less leakage events compared to Karenge 1. Leakages are happening at the lower marshland.

Note: Verbal information from UWSSD
Source: JST

The existing pipeline cannot convey 48,000 m^3/day without booster pumping station because the hydraulic

loss is too high at the flow rate. Even if there is a booster pumping station, the velocity is beyond the normal range of the internal speed allowed for the DIPs (less than 3 m/sec). It is not recommended to use the pipe in such a high speed because it will accelerate the deterioration of the internal pipe coating and causes water quality disruption by peeled-off lining materials. Considering the topography along the pipeline, approximately 25,000 m^3/day can be transmitted from the Kimichanga reservoir to Nyakaliro until the Kabuga (Rusororo) reservoir (at 18 permil hydraulic gradient, which is slightly over the highest location of Nyakaliro hill). Yet it is not highly recommended because the peeling-off may happen due to repetition of such a change of velocity over the period, and the risk of leakage will increase as we have visually observed at some chambers along the Karenge 1 and 2.

Source: JST

Photo (Left) Leakage at Chamber along Karenge 1 and 2 at Nyakaliro (Right) Leakage event at Karenge 2 (near Inyange factory)

Yet, the pipe may be possibly used at least sectionally. Especially for the Karenge 2 pipeline, the pipe was constructed in 2008, and not aged. The leakages of this pipeline are concentrated on the specific part, particularly at the lower marshland (Photo; Right). Meanwhile, a Karenge 2 section between Nyarugunga existing airport and Remera Golf 8 are already highly developed and construction for the larger diameter pipe will have large barrier both in terms of cost, land expropriation and public acceptance. Approximate amount to be transmit to Remera Golf 8 is 10,000 m^3/day. In this sense, it is recommended to utilize existing Karenge 2 between the Ndera area to the Remera Golf 8.

Therefore, 1) The existing pipelines do not have enough capacity to convey water with 48,000 m^3/day to water supply area, 2) The Karenge 1 has many leakage problems especially at air-valves and pipe bridges, 3) The Karenge 2 can be utilized for some interval (from Nyarugunga to Remera Golf8) to transmit water to Remera.

CHAPTER 3 DEVELOPMENT PLAN

3.1 SUMMARY LIST OF FACILITIES

The facilities to be constructed are summarized in **Table 3-1**.
The details of the facilities are as described in **Appendix-A Drawings**.

Table 3-1 Summary of the Facilities to be Constructed

Summary of the List of Facilities	
Intake Pumping Stations	
Intake Pipes	ND800, L= 300m Buried/Fixed on the lake bottom with Intake Screen and Connecting well (D=4m)
Intake Pumping Station Building	W=8m, L24m
Intake Pumps	ND300/ND200 x 12m^3/min x 115.6m x 340 kw x 3 units +1 standby
Raw Water Transmission Pipeline	DIP ND600, L=1.1km
Miscellaneous	Earthwork, Retaining Wall, Access road (L=100m)
Water Treatment Plant	
Receiving Well	V = 84 m^3, L=10.3m x W=5.0m x H=4.5m
Coagulation-Flocculation Basin	Horizontal-mixed flow, L=18.4m x W=10.6m x H=4.5m
Sedimentation Basin	Baffled wall, Up-flow inclined tube settler L=18.4m x W=18.4m x H=4.5m
Rapid sand filter Basin	Sand Filter 56 m^2 x 6 (t=1.0m, D_{ave} =1.0 mm) L=32.9m x W=24.4m x H=4.5m
Clear Water Reservoirs and Pumping Station	V=3,400 m^3, He=5.0m, L=40.4m x W=25.7m
Clear Water Transmission Pumps	300 ϕ /250 ϕ x 6.66 m^3/min x 214.7m x 345 kW x （5unit +1 standby） with Flywheel
Backwash Tank	V=400 m^3
Sludge Basin	V=200 m^3 x 2 nos.
Drainage Basin	V=250 m^3 x 2 nos.
Sludge Drying Bed	V=500 m^3
Administration Building	With the Branch Office
Transmission and Distribution Systems	
a-1. Transmission pipelines from Karenge WTP to Kimichanga reservoir	
Transmission Pipelines	DIP, ND700, L=5.7 km
a-2. Transmission pipelines from Kimichanga to Rusororo and Ndera	
Transmission Pipelines	HDPE, ND315, L=2.5 km DIP, ND400, L=7.6 km DIP, ND500, L=14.5 km Connecting to existing Karenge II pipeline
b. Transmission Pipelines from Rusororo Kabuga to the Rwamagana District	
Transmission Pipelines	HDPE, ND315, L=13.4 km DIP, ND400, L=1 km
c. Kimichanga Pumping Station and Transmission to Rwamagana	
Kimichanga Pumping Station (Pumping Station Building and Pumps)	Pumps: 300/200 x 8.3 m^3/min x 59.8m x 120 kw x (1unit +1 standby)
Transmission Pipelines	HDPE, ND225, L=23.6 km HDPE, ND315, L=8.1 km DIP, ND400, L=7.4 km
Booster Pumping Station	BPS1, MU-NZ BPS2, NZ-GS BPS3, KT-GG
d. Water Distribution Systems d-1. Water Distribution Systems in Ndera and Rusororo	
Ndera, Pipelines	HDPE, ND50-63, L=72.2 km HDPE, ND75-90, L=75.2 km HDPE, ND100-110, L=48.3 km

Summary of the List of Facilities	
Rusororo, Distribution Reservoirs	V=100 m^3, 4 nos V=500 m^3, 1 nos V=2000 m^3, 2 nos
Rusororo, Pipelines	HDPE, ND50-63, L=85.8 km
	HDPE, ND75-90, L=89.3 km
	HDPE, ND100-110, L=57.4 km
d-2. Water Distribution Systems in Gahengeri and Muyumbu	
Muyumbu, Distribution Reservoirs	V=100 m^3, 3 nos, V=500 m^3, 2 nos
Muyumbu, Pipelines	HDPE, ND50-63, L=20.4 km
	HDPE, ND75-90, L=21.2 km
	HDPE, ND100-110, L=13.6 km
Muyumbu, Civil and M&E	V=100 m^3, 2 nos, V=500 m^3, 3 nos
Gahengeri, Pipelines	HDPE, ND50-63, L=22.5 km
	HDPE, ND75-90, L=23.4 km
	HDPE, ND100-110, L=15.1 km
d-3. Water Distribution Systems in Nyakaliro	
Muyumbu, Civil and M&E	D V=100 m^3, 2 nos, V=500 m^3, 3 nos
	Distribution Reservoirs
Nyakaliro, Pipelines	HDPE, ND50-63, L=20 km
	HDPE, ND75-90, L=20.8 km
	HDPE, ND100-110, L=13.4 km

Source: JST

3.2 SUPPLY CAPACITY OF INTAKE AND WATER TREATMENT PLANT

The water supply capacity of the expansion is based on the water demand elaborated in **Section 2.2**. The existing and planned capacity of the WTP and the Intake is summarized in **Table 3-2.** The intake pump and pipe capacity are marked up 10% from the target treated water capacity for the internal water usage at the WTP as well as the loss at the intake pumping stations and raw water transmission pipelines.

Table 3-2 Supply Capacity of Existing and Future Facilities

		Expansion, m3/day	Total Capacity (Treated Water), m3/day	Plant consumption + Loss at Intake-Raw Water Transmission, m3/day	Intake Structure and Pump Capacity Expansion (Rounded), m3/day	Total Intake Capacity, m3/day
Karenge 1	(Existing)	12,000	12,000	-	-	
Karenge 2	Phase 1	36,000	48,000	10%	40,000	52,000
	Phase 2	72,000	120,000	10%	80,000	132,000

Source: JST

3.3 LAND ACQUISITION FOR NEW EXPANSION

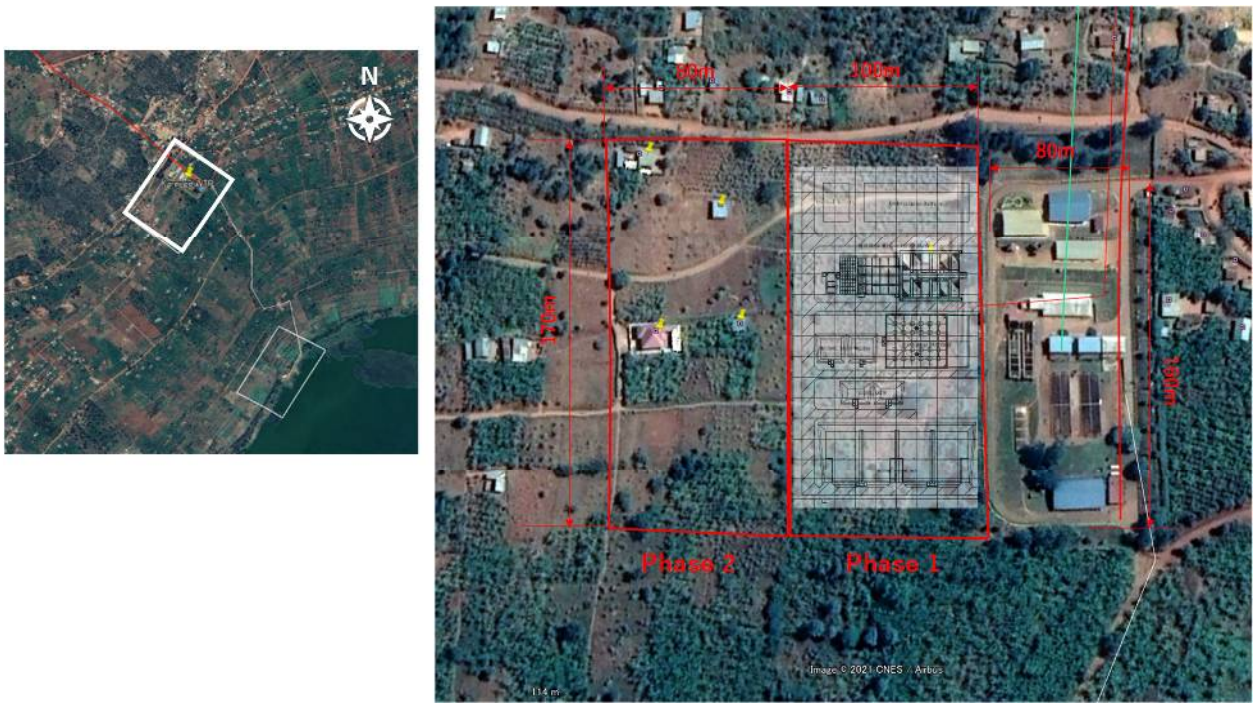
Land acquisition is necessary for the expansion of both the Water Treatment Plant and the Intake. The facilities to be constructed are elaborated in the drawings in the **Appendix A**.

The required land for the expansion of WTP is listed in **Table 3-3** and illustrated in **Figure 3-1**. The proposed land for the WTP is located just adjacent to the existing Karenge WTP site. There is only one household for the Phase 1 expansion, and four households for the Phase 2 expansion are anticipated. Note that the land for Phase 2 is not planned to be expropriated until the preparatory phase of the expansion, which is expected to be the year 2039.

Table 3-3 Required Lands for the Expansion of WTP

Item	Approximate Dimensions	Necessary before	Existing Household
Existing Land	80 m x 160 m (1.28 ha)	-	
Expansion Phase 1	100 m x 170 m (1.7 ha)	July 2022	1
Expansion Phase 2	80 m x 170 m (1.36 ha)	(Year 2039)	4

Source: JST



Source: JST

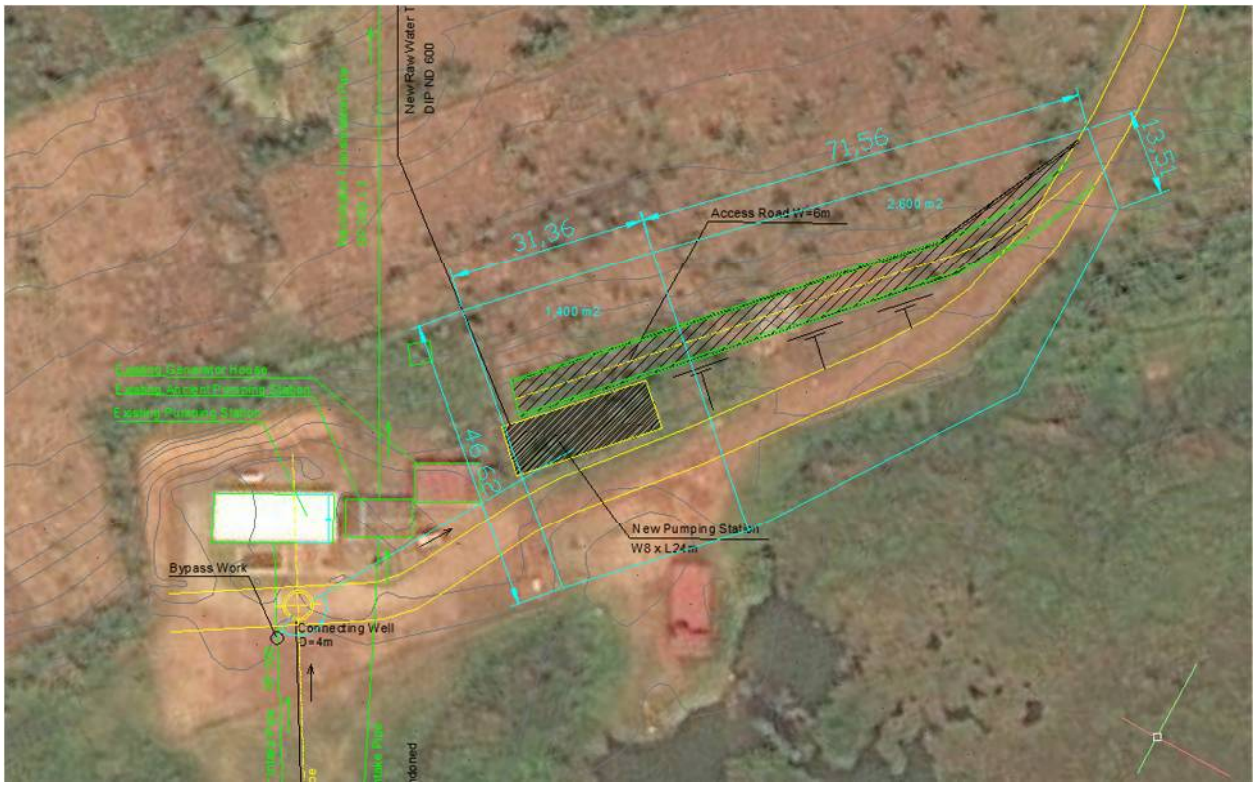
Figure 3-1 Land for the Existing Karenge WTP and Required Land for Expansion

The required land for the expansion of the intake at Lake Mugesera is listed in **Table 3-4** and illustrated in **Figure 3-2**. The proposed land for the Intake is just adjacent to the existing Intake Pumping Station. The land is in a buffer zone of the Lake Mugesera within 50 m and therefore subject to approval by the REMA and related authority. The Project also incurs the expansion of the intake pipelines to approx. 500 m far from the shore of the Lake Mugesera near to the existing intake location.

Table 3-4 Required lands for the Expansion of Intake

Item	Approximate Dimensions	Necessary before	Existing Household
Existing Land	55 m x 63 m (1.28 ha)	-	-
Expansion Phase 1	47 m x 31 m (0.14 ha)	July 2022	0
Expansion Phase 2	71 m x 14 to 47 m (0.26 ha)	July 2022	0

Source: JST

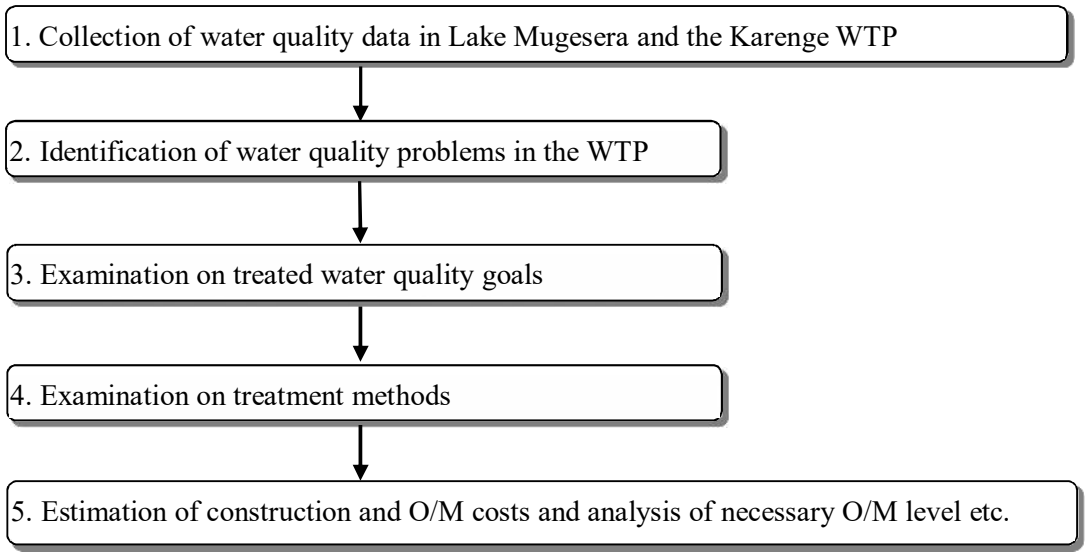


Source: JST

Figure 3-2 Area for Development at the Intake Expansion in front of Lake Mugesera

3.4 TREATMENT PROCESS DETERMINATION

In order to determine an appropriate treatment process, basic technical approach and methodology for determining the water treatment process are proposed as shown in **Figure 3-3**.



Source: JST

Figure 3-3 Technical Approach and Methodology for Designing Water Treatment Process

The outline of Lake Mugesera, raw water quality and treated water quality are presented in **Table 2-3** and **Table 2-4**. In addition, water quality surveys on Lake Mugesera have been conducted and the results are summarized in **Table 3-5**.

Table 3-5 Summary of Water Quality Survey for Lake Mugesera

No.	Sampling No. / Sampling Date	Unit	Dry Season 2019/09/12	Rainy Season 2019/09/12	RDWQS [1]	WHO (2017)
1	pH	-	8.93	7.54	6.5-8.5	-
2	Turbidity	NTU	10.5	5.75	5	5
3	BOD_5	mg/L	12.0	9.30	-	-
4	Ammonia nitrogen (NH_4-N)	mg/L	0.05	0.805	0.5	-
5	Nitrate nitrogen (NO_2^--N)	mg/L	<0.01	0.837	0.001	0.9
6	Nitrite nitrogen (NO_3^--N)	mg/L	0.016	0.008	10	11.3
7	Fluoride (F^-)	mg/L	0.49	0.41	1	1.5
8	Manganese (Mn)	mg/L	0.254	0.368	0.1	0.4
9	Iron (Fe)	mg/L	0.41	0.11	0.3	0.3
10	Zinc (Zn)	mg/L	0.21	0.13	-	-
11	Calcium (Ca)	mg/L	17.8	17.42	150	-
12	Magnesium (Mg)	mg/L	13.3	13.49	100	-
13	Standard plate count bacteria	cfu/ml	1×10^4	1.7×10^5	100	-
14	E. coli	cfu/100ml	1×10^1	4.7×10^3	-	-
15	Cyanide (CN^-) [3]	mg/L	<0.001	<0.001	0.01	0.5
16	Chromium (Cr^{6+}) [3]	mg/L	<0.005	<0.002 [4]	0.05	0.05
17	Cadmium (Cd) [3]	mg/L	<0.0003	<0.0003	0.003	0.003
18	Lead (Pb) [3]	mg/L	<0.001	<0.001	0.01	0.01
19	Mercury (Hg) [3]	mg/L	<0.00005	<0.00005	0.001	0.006

Source: JST

1) RDWQS: Rwanda Drinking Water Quality Standard
2) 10.5 means the value exceeding Rwanda Drinking Water Quality Standard
3) Items analyzed in Japan.
4) Total Chromium

Based on the results of **Table 2-4** and **Table 3-5**, the target water quality items for treatment are identified and their individual treatment methods are also studied as shown in **Table 3-6**.

Table 3-6 Summary of Target Water Quality Items and Their Individual Treatment Methods

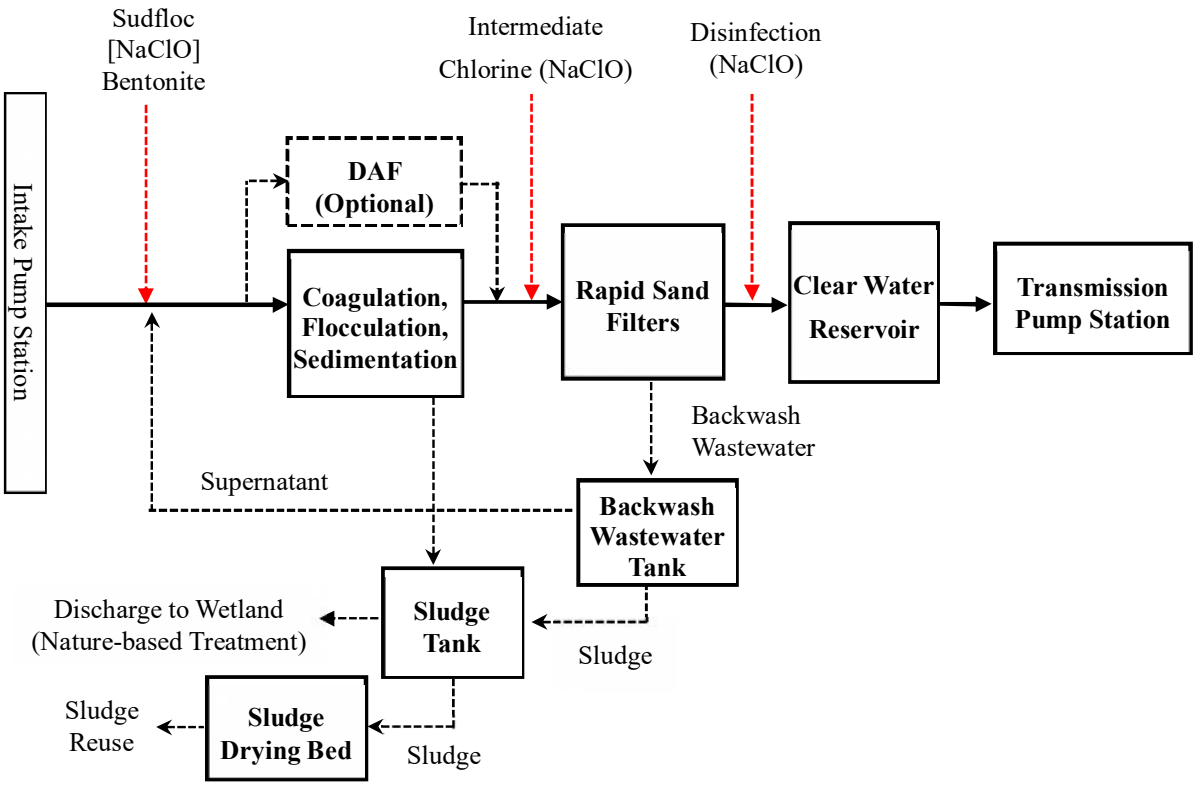
No.	Target Water Quality Items	Pollution Level	Possible Unit Treatment Processes (Selected Process: Bold)	Remark
1	Color	Middle-High (209-1,865)	**Coagulation-sedimentation, filtration,** O_3, activated carbon, membrane	
2	Turbidity	Low (5-35)	**Coagulation-sedimentation, filtration,** membrane	
3	Ammonia nitrogen (NH_4-N)	Low-Middle (0.05-0.8)	Aeration, biologic treatment, **chlorination**	
4	Iron (Fe)	Low (0.5-1.9)	Coagulation-sedimentation, biologic treatment, chlorination, contact oxidation	
5	Manganese (Mn)	Low-Middle (0.3-0.8)	Coagulation-sedimentation, biologic treatment, **intermediate-chlorination,** contact oxidation	
6	Bacteria	Middle (10^3-10^4)	Coagulation-sedimentation, filtration, O_3, UV, **chlorination,** membrane	
7	Algae	Middle[1)]	**Selective Intake,** Dissolved air floatation (DAF), micro-strainer, membrane, pre-chlorination and sedimentation in case of algae without toxins	Intake raw water at middle layer in the Lake

1) Microscope observation, but no Species and quantitative analysis
Source: JST

Regarding drinking water quality standard, there are no significant difference between Rwanda Drinking Water Quality Standard and WHO guidelines as shown in **Table 3-5**. Therefore, it is proposed to use Rwanda Drinking Water Quality Standard as treated water quality goals for this F/S.

Water quality data of treated water at existing Karenge WTP in 2018 has been collected and studied as shown in **Table 2-4**, which indicated that the treated water quality of the existing Karenge WTP could comply with Rwanda drinking water quality standards by conventional treatment process. Based on careful evaluatoin of the following aspects as well as the treatment performance of the existing unit treatment process, the best suited treatment process for the WTP for the F/S is proposed and its flow is presented in **Figure 3-4**.

1) Efficacy of removal for target water quality items;
2) Potential risk of formation/development of byproducts with adverse health effect;
3) Economic efficiency (including both construction costs and O&M costs);
4) Required resources (land requirement and O&M levels etc.), and
5) Environmental sustainability of the considered alternative.



Source: JST

Figure 3-4 Proposed Treatment Process

The purpose of each unit treatment process is summarized in **Table 3-7**.

Table 3-7 Summary of Unit Treatment Process

No.	Unit Treatment Process	Purpose of Unit Treatment Process
1	Pre-NaClO	1) Removing color, ammonia, iron (Fe), manganese (Mn), odor compounds, bacteria 2) Removing algae (as an auxiliary measure to remove algae in sedimentation tank, but not being used for removing cyanobacteria with toxins)
2	Coagulation, Flocculation, Sedimentation	1) Removing color, turbidity, organic matters, Fe, Mn etc. 2) Removing part of ammonia, odor compounds and bacteria etc.
3	(DAF) *Alternative	Removing algae especially for cyanobacteria with toxins (The DAF process is an optional unit treatment process which may be introduced in case eutrophication and cyanobacteria become severe in the future, therefore, area for DFA process should be considered)
4	Rapid Sand Filters	Removing color, turbidity, organic matters, Fe, Mn, bacteria etc.
5	Disinfection	Removing bacteria
6	Backwash Wastewater Tank	Separating sludge and backwash wastewater and recovering supernatant of backwash wastewater
7	Sludge tank	Separating sedimentation sludge and wastewater.
8	Sludge drying bed	Dewatering sludge
9	Wetland along lakeshore	Treating wastewater from the WTP before discharging into the Lake Mugesera

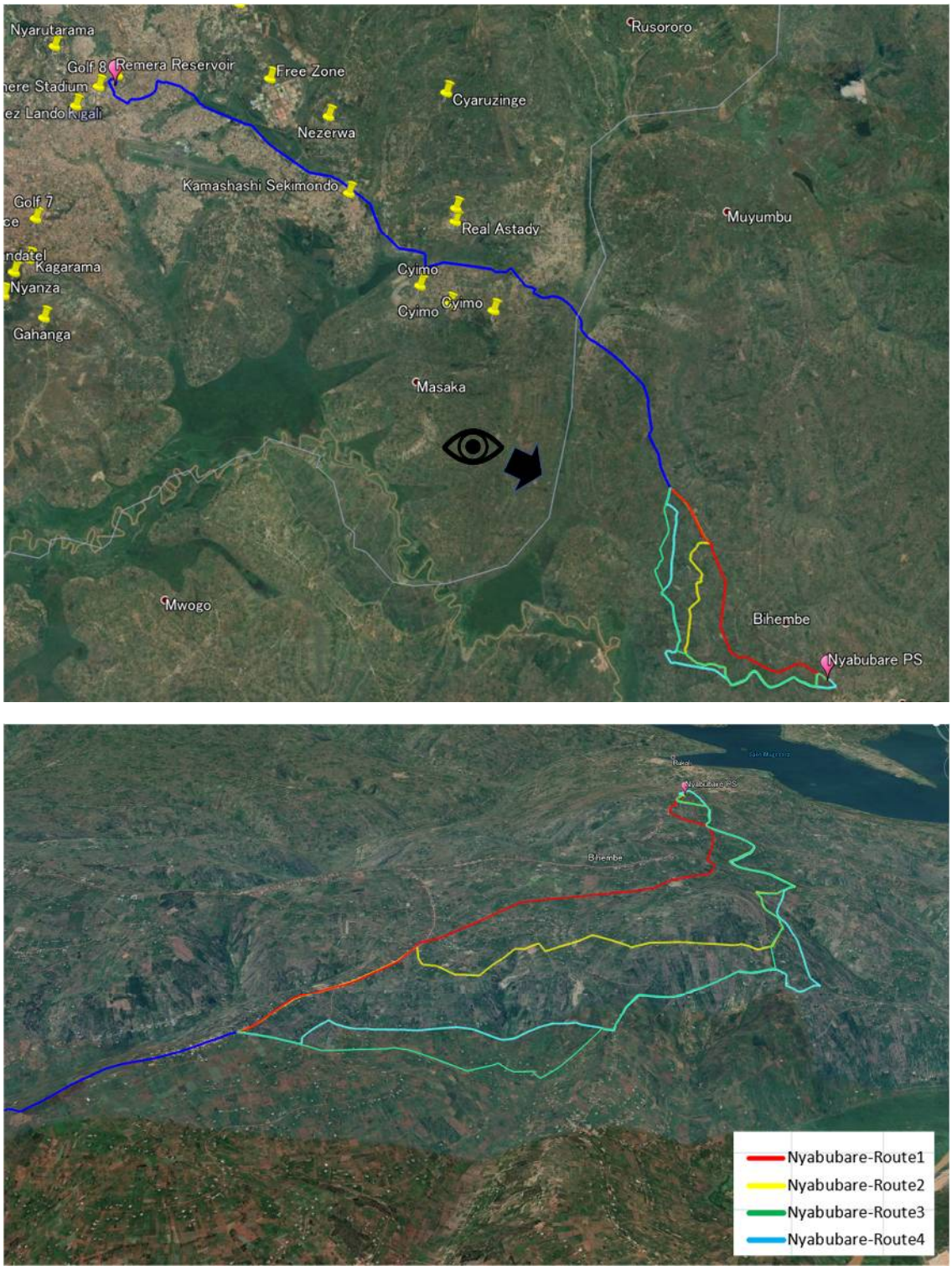
Source: JST

CHAPTER 4 WATER TRANSMISSION AND DISTRIBUTION

4.1 ROUTES OF TRANSMISSION PIPELINES

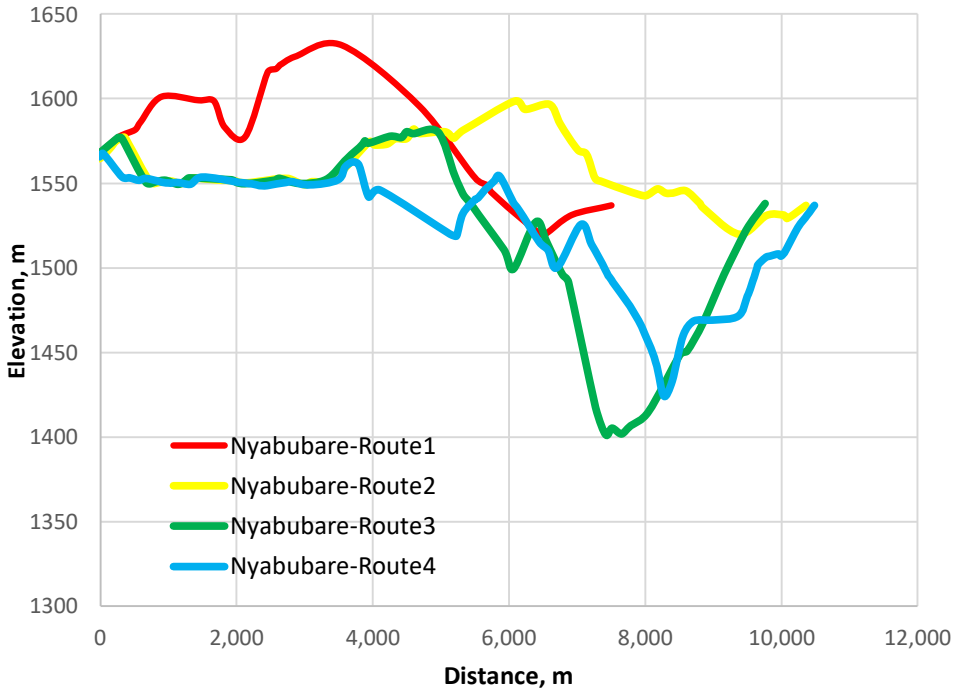
The routes and the diameters of the transmission pipelines were determined based on the hydrological models established in this study. The water demand in each sector was divided (**Table 4-2**) and allocated to the nodes in the model according to the water demand as shown in section **2.4** (**Table 4-3**). Due to the uncertainty of the study area's future development, the demand allocation was simplified and modeled as follows;

To Remera: Alternative routes between Karenge-Kigali were examined in this F/S. There are four alternative routes between Nyabubare Pumping Station and the area at Nyakaliro. Their routes and the profiles of the pipeline are as shown in **Figure 4-1** and **Figure 4-2**. As a result of the selection, Alternative 1 (existing route) was selected because other routes have rough terrain where there is no existing public road. Route 3 is the second shortest road but still more than 2.2 km longer than the existing routes. Therefore, it is judged that the route 1 (existing route) is the best optimal route in terms of economic and technical grounds among all possible alternatives.



Source: JST

Figure 4-1 Alternative Routes for the Main Pipeline from Karenge Nyabubare to Nyakaliro



Source: JST

Figure 4-2 The Profiles of Alternative Routes

Table 4-1 Selection of Alternative Routes

ID	Maximum Hight	Length (m)	Remarks	Selection
Route 1	1631.7	**7,508**	**Existing Route**	○
Route 2	1598.7	10,360	No road during the route	×
Route 3	1580.5	9,758	No road during the route	△
Route 4	1567.7	10,479	No road during the route	×

Source: JST

Rusororo; The water demands in the Rusororo were divided into three nodes; Rusororo-Kabuga (RU, where there is existing Meson de Juvenile Kabuga), Masaka-Cyimo (CY), and Rusororo Kabuga 2 (KB). Note that the Masaka Cyimo is not in the Rusororo but in the Masaka sectors located on the opposite side of Kabuga across National Road (NR4). However, the development in Kabuga, Rusororo is seamlessly spread to the north side of Masaka covered by the Cyimo reservoir; low-middle rise establishments are stretched across both sectors' boundary. This area is currently the most developing area in the Rusororo sector therefore it can be regarded as an inseparable township in the Rusororo. In the future, the development is expected to stretch to the north along the NR4. The demand along the NR4 up to the boundary is mainly located in the low-elevation area, from the Kabuga to the sector and the Fumbwe sector in the Rwamagana district located in the west. The Kabuga (RU) has enough elevation to supply water to the Fumbwe sector by gravity; Therefore, the important main reservoir should be located in the RU.

Muyumbu; most of the demand is centered at the hilly area through Muyumbu-Gatsata, Ryabahesha to Muyumbu-Murehe. Those areas can be supplied from the Bihembe-high reservoir by gravity. The demand was allocated to the Murehe and Ryabahesha, splitting it into two.

Gahengeri; The known water supply route is only from Nzige, pumping up once at the Gastamo pumping station. The alternative water supply route may be seen from the north through Kabuga to Fumbwe but was not adopted because of no existing pipeline routes.

Nyakaliro; The demand was split into two; one at Bihembe-low and one at the Nyakaliro-Gishore a town next to the CoK.

Other areas in Rwamagana; 9,500 m^3/day of the given demand was allocated to the end of Kabuga-Fumbwe line and Nzige.

Table 4-2 Sectors and Water Demand in 2035

Sector	Demand	Allocation	Demand Code	Demand m3/d
Rusororo	22,900	40%	RU1	9,200
		30%	RU2	6,900
		30%	RU3	6,800
Muyumbu	4,900	50%	MU1	2,500
		50%	MU2	2,400
Gahengeri	5,400	50%	G1	2,700
		50%	G2	2,700
Nyakariro	4,800	50%	NY1	2,400
		50%	NY2	2,400
Rwamagana	9,500	50%	RW1	4,800
		50%	RW2	4,700
Total				47,500

Source: JST

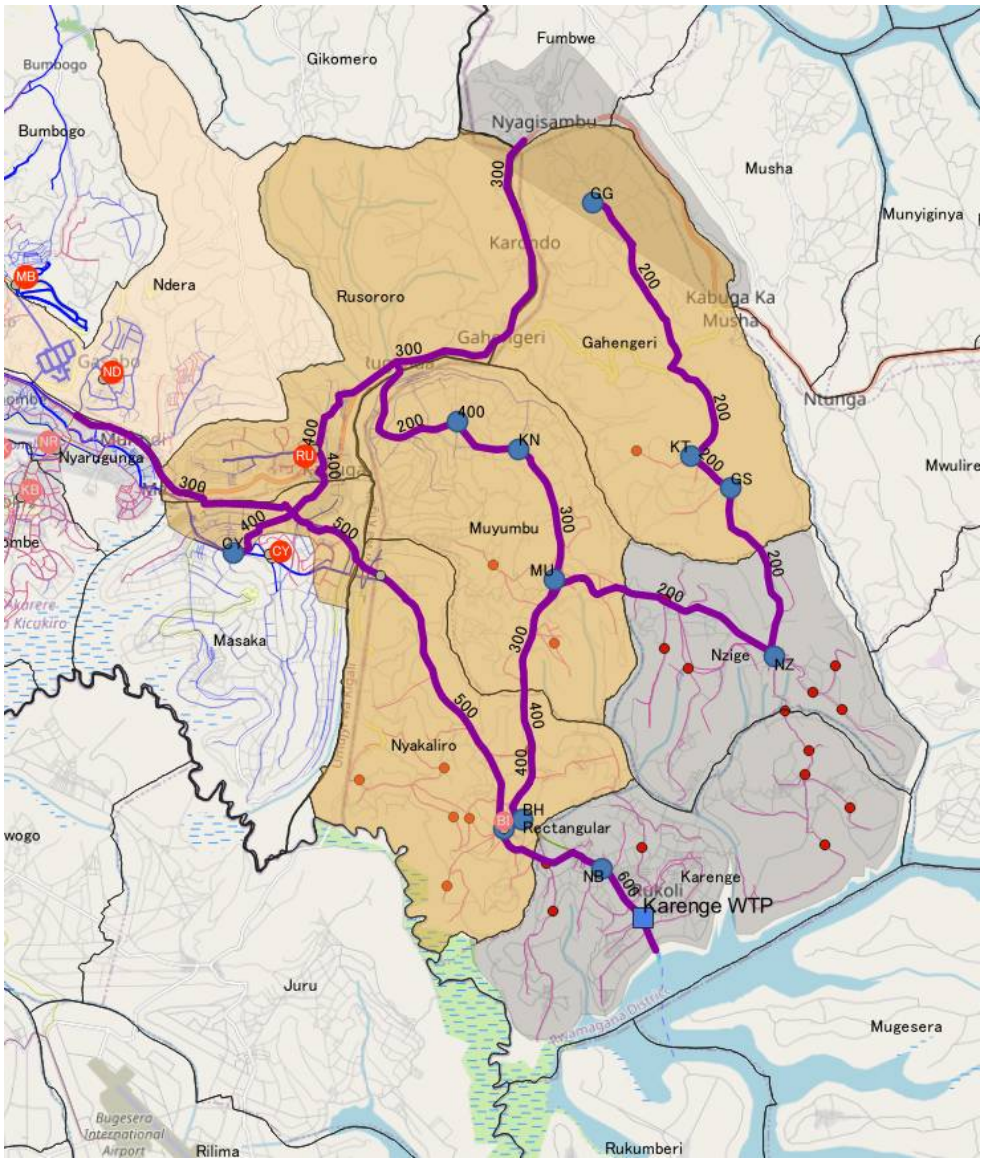
Table 4-3 Nodes and demand allocation

Node	Demand Code	Demand m^3/d	Elevation	Location
NL	NY1	2,400	1,480	Nyakaliro
BL	NY2	2,400	1,644	Bihembe-Low
BH			1,698	Bihembe-High
MU	MU1	2,500	1,647	Muyumbu (Murehe)
RY	MU2	2,400	1,606	Muyumbu-Ryabahesha
NZ	RW1	4,800	1,666	Karenge-Nzige
GG	G1	2,700	1,652	Gahengeri-Rugarama
RU	RU1	9,200	1,468	Rusororo-Kabuga
KB	RU2	6,900	1,440	Rusororo-Kabuga 2 (New development Area)
CY	RU3	6,800	1,490	Masaka-Cyimo
NS	G2+RW2	7,400	1,440	Rwamagana-Nyagasambu
RM	-		1,524	Remera Golf 8
GS			1,637	Gahengeri-Gastamo (PS)
KT			1,751	Gahengeri-Karutimbo (RS)
Total		47,500		

Source: JST

4.2 TRANSMISSION HYDRAULICS

Transmission hydraulics are tested in order to verify the necessity of the booster pumps, and to estimate pipe diameters as well as lengths. The lengths are estimated from the GIS and 10 m resolution DEM. Transmission routes and location of nodes for the hydraulic calculation are indicated as in **Figure 4-3**, and its result is summarized in **Table 4-4**.



Source: JST

Figure 4-3 Water Transmission Models

Table 4-4 Hydraulic Calculation for the Clear Water Transmission Systems

Link Property								Description
Start	End	Demand at end (m3/day)	Demand at link (m3/day)	Link Distance (m)	Mark-up	Pipesline Length (km)	Head Loss at Pipelines at Q (m)	
(1) Karenge-BL-line								
Karenge	BL	2,400	47,600	5,399	1.05	5.7	14.08	Karenge WTP to Bihembe Low
(2) BL-BH to Muyumbu-Gahengeri line								
BL	BH		12,400	623	1.05	0.7	2.19	Bihembe-low to high
BH	MU	2,500	12,400	6,339	1.05	6.7	20.97	Bihembe-low to Murehe
MU	RY	2,400	2,400	6,966	1.05	7.3	32.02	Muyumbu-Murehe to Ryabahesha
MU	NZ	4,800	7,500	7,699	1.05	8.1	40.59	Muyumbu-Murehe to Rwamagana-Nzige
NZ	GS	0	2,700	5,266	1.05	5.5	29.99	NZ to Gasutamo PS(GG1)
GS	KT	0	2,700	1,406	1.05	1.5	8.18	Gastamo PS to Kartimbo RS (GG2)
KT	GG	2,700	2,700	8,897	1.05	9.3	50.72	Kartimbo to to Gahengeri-Rugarama
(3) BL-Remera line								
BL	NL	2,400	32,800	8,213	1.05	8.6	22.59	Bihembe-low to Nyakaliro station
NL	L3-Br1		30,400	3,144	1.05	3.3	7.53	Nyakaliro station to Branch at Masaka
L3-Br1	RU	9,200	23,500	2,444	1.05	2.6	3.69	Branch at Masaka to Rusororo (Kabuga)
L3-Br1	CY	6,900	6,900	2,393	1.05	2.5	10.74	Branch at Masaka to Cyimo-Masaka
L3-Br1	RM		0	13,364	1.05	14.0	0.00	Branch at Masaka to Remera
(4) Rusororo line								
RU	KB	6,900	14,300	974	1.05	1.0	4.07	Rusororo (Kabuga) to Kabuga 2
KB	NS	7,400	7,400	12,739	1.05	13.4	65.50	Kabuga2 to Rwamagana (Nyagasambu)

Source: JST

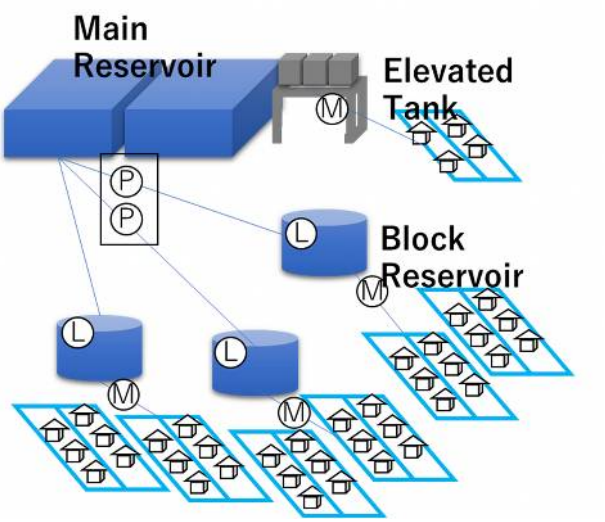
4.3 DISTRIBUTION BLOCKS

4.3.1 Introduction

One of the geographic features of the city is large elevation gap, which makes it difficult to implement control water supply pressure adequately. Nevertheless, WASAC has been forced to construct the water supply facilities as quickly as possible without a comprehensive plan to respond to the rapid growth of water demand. The current water supply network is too complicated to deal with efficiently in operation and maintenance. For the area of high pressure, WASAC has installed PRVs and PBTs in the distribution system however use of those items should be avoided as much as possible because such items generally require frequent maintenance. To tackle these issues, we propose to separate the water supply area hydraulically into several distribution blocks (i.e., introducing 'distribution block system'). The key idea of the distribution block system is to create new water distribution pipeline networks or to review the existing complicated networks under the layer structure. In the system we organize the components of the structures in specific manners, which is useful and effective for easier and simpler operation and maintenance of water distribution facilities.

This system is established under three principles. First, one block has one distribution reservoir. As whole water supply area is large, it is necessary to have a robust system where we control a certain area as one block. Since the control area is small enough, it is easy to find out the cause even if any accident happens. Second, each block is hydraulically isolated from other blocks. It allows us to do easy monitoring and

efficient water control with parameters such as flow rate, pressure, and water quality for each block. Third, the maximum static pressure should be less than 100m. Each block has less than 100m elevation gap. One of the most important objectives of this system is to achieve appropriate pressure control because many leakages are attributed to high pressure.



Source: JST

Figure 4-4 Distribution Block System

The system has the following three types of reservoirs. Main Reservoir (MR) is a large reservoir transmitting water to other reservoirs. The capacity is 8 to 12 hours including the demand for BR or ET considering frequent power suspension. Block Reservoir (BR) is a reservoir that mainly distributes the respective block. The capacity is 3 hours to absorb hourly fluctuation. Elevated Tank (ET) distributes the area in hilltop. It has 3 hours to cover night supply capacity (19:30 – 5:30). Float valves shall be installed at the inlet of reservoirs to prevent water loss due to overflow and flow meters shall be installed at the outlet. PBTs with float valves will be installed in the case block creation is not suitable due to small size. Isolation valves will be installed to hydraulically isolate the blocks.

The main effect of installation of distribution blocks is to minimize leakage by keeping water pressure in a certain range in the block. Other effects are summarized in **Table 4-5**.

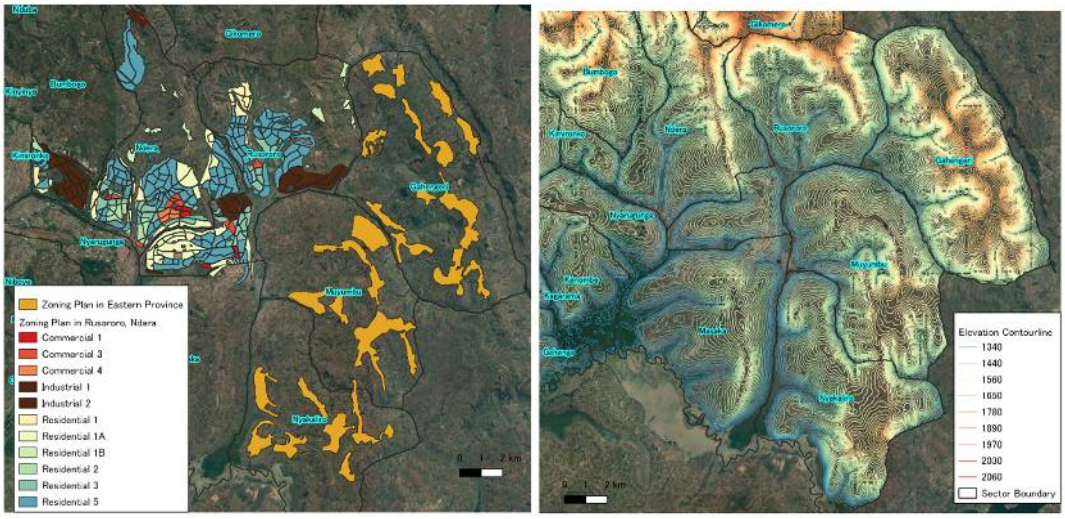
Table 4-5 Key Benefits of Introducing Distribution Block System

Regular Operation	**System Control**	1. Easy to control because each block has one distribution point. 2. Minimize the control range of water pressure because the target area is small.
	Monitoring	3. Clear to monitor flow rate, pressure, and quality of distributed waters.
Emergent Operation	**System Control**	1. Easy to estimate the amount of water we can use flexibly. 2. Easy to implement water supply of reduced pressure. 3. Partial restoration is possible. 4. Localize the leakage area.
	Monitoring	5. Easy to scope in the location of accidents/ number of leakages

Source: JST

4.3.2 Methodology

The block system consists of three structures: blocks, reservoirs, and sub-transmission routes. These structures are created based on four different sets of data: the aerial photo where you can see the existing civil structures, WASAC GIS data of the existing water facilities, the zoning plan by City Masterplan and 10m DEM data produced by WASAC.



Source: JST

Figure 4-5 Zoning Plan by City Masterplan and WASAC 10m DEM

The size of each block is determined by considering residential houses, the zoning plan, and the DEM data. The block sizes are constrained by the DEM data because the elevation gap of the blocks should be less than 70 - 100 m. The block boundaries are basically along the road alignments because it is clear to see and easy for monitoring and operation. We check the existing houses on the aerial photo to roughly estimate number of customers in each block so that we can create block reservoirs with appropriate sizes. The size of each reservoir is estimated precisely considering the water demand for each block. The location of the reservoirs and sub-transmission routes should be not only hydraulically but also economically reasonable. Therefore, reservoirs should be located close to the transmission mains as much as possible. We also see if the location is reasonable according to our observation of the aerial photo. The transmission routes and the locations of main reservoirs are determined as mentioned in the previous chapter. The existing water supply facilities such as pipelines, reservoirs, valves, and chambers are considered to utilize it.
Geographic features of each target sector are summarized in **Table 4-5**.

Table 4-5 Geographic features of target sectors

Sector	Elevation Range	Area (m^2)	Geographic Feature
Nyakariro	1336 m – 1693 m	50.0	The sector is covered by a big mountain which also covers North part of Karenge sector. The ridge of this mountain comes from Karenge sector continuously and split into two routes. One is going to Masaka sector and the other one continues to Muyumbu sector. The boundaries with Juru sector and Masaka sector are along valleys.

Sector	Elevation Range	Area (m^2)	Geographic Feature
Muyumbu	1342 m – 1675 m	50.3	The ridge continues from South (Nyakariro Sector) and split into North route and East route. The East route continues to Nzige sector. The boundaries with Nyakariro sector, Gahengeri sector, Rusororo sector and Masaka sector are along valleys.
Gahengeri	1367 m – 1786 m	63.0	The highest point is more than 1780 m. Most of the sector boundaries are along valleys except the boundary with Nzige sector where the ridge continues from North Nzige sector.
Rusororo	1350 m – 1810 m	52.2	There is a high mountain in North. The ridge continues in East side of the sector. Development areas are in relatively lower elevated area. The sector boundaries are along valleys except North boundary.
Ndera	1347 m – 1774 m	50.4	There is a large hill in East and a relatively small hill in West. Residential and commercial area are planned to develop in North part and South part of the sector.

Source: JST

The procedure for planning the distribution block system is summarized below.

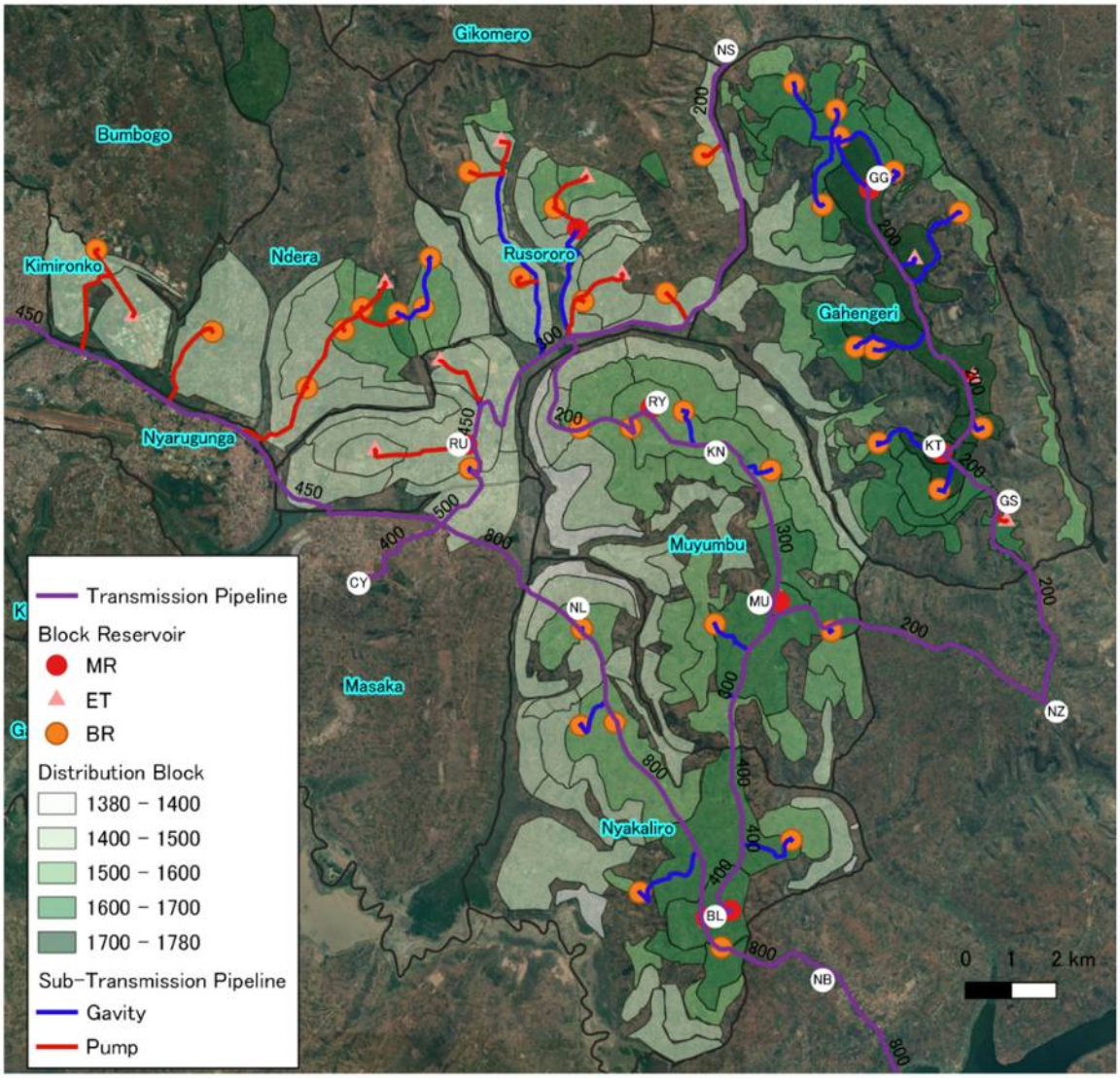
a. Mark 70 m difference of height (altitude) from a hilltop on a map.
b. Set a size and a boundary of the block, considering topography, water demands, zoning plan and road alignment.
a. Find candidates of reservoir location (minimum 10m higher than the altitude of the block) on map taking into consideration of easy access and shorter installation to transmission pipes.
b. Review site condition of each structure such as road and the existing pipe route and reservoir location
c. Decide the location of each structure based on a site survey.

4.3.3 Results

The whole distribution block system is shown in **Figure 4-6**.

The features of the system are summarized.

- Gahengeri and Rusororo have more reservoirs than the others because and these sectors have relatively higher elevation gap.
- Pump-up is necessary at some areas especially in Ndera sector and Rusororo sector where the water supply areas are located at higher elevation than the transmission main.
- Total number of blocks (same with the number of reservoirs) is 56 and the capacity of the largest reservoir is 2,000 m^3 in Rusororo sector.
- The development area in Northern part of Ndera is not included in the water supply area of Karenge WTP. This area can receive water from Bumbogo sector.
- Gahengeri sector needs more PRVs because of the high elevation gap. The water transmission pipe is along the ridge and they distribute water to the down-hill area.



Source: JST

Figure 4-6 Distribution Block System (Block, Reservoir, Pipelines)

The sizes of reservoirs are calculated by the water demand for each block as in **Table 4-6**. Water demand is estimated based on Zoning Plan.

Table 4-6 Number of Reservoirs for Each Size and Type

Sector	Number of reservoirs for each size (m^3)						Number of reservoirs for each type			Total number of reservoirs
	50	100	250	400	1000	2000	BR	ET	MR	
Gahengeri	13	1	1				11	2	2	15
Muyumbu	5	1	2		1		6	1	2	9
Ndera	1	2	6	1			8	2		10
Nyakariro	2	3	2	1			6		2	8
Rusororo		7	6			1	7	5	2	14
Total	21	14	17	2	1	1	38	10	8	56

Source: JST

CHAPTER 5 IMPLEMENTATION SCHEDULE

The implementation schedule for the Project is illustrated in **Table 5-1**. The schedule suggests that the water supply can be inaugurated from the end of the Year 2026 if all procedures go smoothly. The remarks and disclaimers for the implementation schedules are as follows;

- The funding for the Project has based on an international development partner's loan aid which the conditions are unknown. It should be revised based on the required procedures in line with the development partners' terms and conditions as well as the domestic procurement guidelines of the GOR.

- The period for construction (24 months) is based on the past experience of the New Nzove construction by WASAC. Normally, construction for this scale of the project may take approximately 30 Months, including the commissioning before full delivery. A shorter period was selected for the schedule in order that the delivery of water shall be accelerated. In general, it is recommended to have a longer period in order that the quality of work should be secured. Therefore, the period for the construction may be revised during the Detailed Design, comparing the quality and time for delivery.

- The time for selection of the Consultants and Contractors should be closely related to the budget for the Project, the country risk regarding political and economic stability. The schedule would be delayed in case of re-bidding and dismissal of the bid. The effect of the COVID-19 and the similar pandemic situation may also affect the schedule of procurement and construction.

Table 5-1 Implementation Schedule for Karenge Expansion Project

This Page is closed due to the confidentiality.

CHAPTER 6 ENVIRONMENTAL AND SOCIAL CONSIDERATION

6.1 OBJECTIVES OF THE ESIA

The overall objective is to develop an Environmental and Social Impact Assessment (ESIA) for the "Rehabilitation and Expansion of Karenge WTP and Transmission & Distribution Facilities in Rwamagana District" in order to ensure the sustainability of proposed infrastructure, by avoiding, minimizing negative impacts, and enhancing positive impacts. Further, the ESIA shall ensure that the Project is implemented in an environmentally and socially sustainable manner and in full compliance with Rwanda's regulations as well as and JICA guidelines for environmental and social considerations. The full ESIA report is shown in **Appendix E**.

6.2 APPROACH AND METHODOLOGY

To achieve the above objectives, the consultant team who prepared the ESIA followed procedures stipulated in General Guidelines and Procedures for Environmental and Social Impact Assessment. The methodology used involves a number of stages from scoping phase that includes a preliminary assessment to understand and establish boundaries of the study; the desk review of available literature, field visits to establish baseline data, analysis of all available data (secondary and primary data), prediction of positive and negative impacts, analysis of alternatives as well as the proposal of mitigation measures leading to an Environmental and Social Management Plan and Monitoring plan. Approach and methodology used include (a)Literature review and primary data collection, (b)Field Survey and measurements and (c) stakeholder consultation and engagement.

6.3 ENVIRONMENTAL AND SOCIAL IMPACT PREDICTION

The Project is expected to have both positive and negative impacts on ecosystems and local communities. Positive impacts expected from the proposed Project include the availability of treated water in both Kigali and Rwamagana, improvement of sanitation conditions, the sustainable and wise use of natural resources (Lake Mugesera), temporary and permanent job creation and employment, income generation to the local population, transfer of knowledge from skilled to non-skilled people who may interact with the project activities, availability of potable and drinking water in the project areas of interventions, increasing of social welfare, etc.

Expected adverse impacts range from the physical environment, biological environmental and social environment. These include potential pollution of water in Lake Mugesera, air pollution and noise during construction works, possible soil erosion from excavation works of pipes trenches and other water storages facilities, modification of water table flows, generation of sludge from the treatment plant and other waste, loss of biodiversity at water distribution lines and at water reservoirs and encroachment of buffer zone etc. Social impacts of the project implementation will also include loss of land at WTP and new reservoir, Physical resettlement (one household for phase one and 5 households in phase 2) at the water treatment

area, loss of trees and crops at WTP, water intake, water reservoirs (81households) and acquisition of easement along water pipelines. Other Project related impacts include onsite occupational health and safety, especially during the construction phase.

Mitigation measures for identified and projected impacts were proposed for each of the adverse impacts projected. Expected adverse impacts can be avoided, reduced, limited or eliminated to the extent, and, therefore, manageable. In this context, the Environmental Management Plan (EMP) and an Environmental Monitoring Plan indicate the mitigation measures, the procedure to be followed, monitoring indicators, the responsible institutions to implement these measures and estimated cost of implementing each of these mitigation measures.

Given the nature, location of the proposed Project, proposed works and the potential impacts associated with the implementation of Project, the consultant can conclude the nature and extent of adverse impacts identified that can be avoided, mitigated and eliminated by the implementation of appropriate mitigation measures. In fact, the rehabilitation and extension of the Karenge water treatment Plant and supply system are bound to be executed in a sustainable manner and in compliance with national environmental regulations, JICA environmental and social considerations. However, this requires full implementation of proposed mitigation measures and regular monitoring done as per proposed EMP.

CHAPTER 7 OPERATION AND MAINTENANCE (O&M)

7.1 REQUIRED O&M IN WTP

O&M of WTP is to maintain the condition of facilities and equipment so that it can be operated smoothly by performing maintenance and repairs, and replenishing fuel, oils and fats, reagents, etc. Also, it requires patrolling and inspecting the condition of water treatment facilities, discovering abnormal/troubled parts at an early stage, and inspections to maintain a hygienic environment for water treatment facilities and to ensure the safety of workers and visitors.

Table 7-1 Function of WTP

Function	Work Contents
WTP Operation	• Operation: securing and operation of raw water and treated water • Maintenance: maintenance of facilities, design and construction of simple construction, wastewater treatment
Water Laboratory	• Water quality test, treatment process research, facility maintenance

Source: JST

7.2 REQUIRED PERSONNEL AND RESPONSIBLE WORK FOR O&M

Personnel and responsible work for O&M at both of the existing and new plant is drafted as the following table below.

- The number of personnel in WTP will be increased to 54 from the 33 due to an increased workload of water as the volume of water purification is expected 42,000m^3/day at new plant, up from 15,000m^3/day of the existing plant.
- Working at dual site of the existing and new WTP.
- One officer for investment management and accounting is deployed.
- One specialized electrician is deployed.
- Three working shift team (early morning, daytime, and night) is planned.

Table 7-2 O&M Personnel in WTP

O&M Personnel in WTP		Existing Plant	New Plant	
Status	Position & Responsible Work	No. of personnel	No. of personnel Existing Plant	No. of personnel New Plant
Open End Contract	Head of Plant	1	1	
	Plant Officer	1	1	
	Laboratory Technician	6	8	
	Operation Technician (Purifier)	5	5	5
	Operation Officer (Inventory Management)		1	
	Operation Technician (Pump Attendant)	3	3	3
	Electrician		1	

O&M Personnel in WTP		Existing Plant	New Plant	
One Year Contract	Purifier helper	3	3	3
	Electrician Helper	7	10	
	Maintenance Helper	2	4	
	Night Watchman	4	4	
	Driver	1	2	
Total Number of Personnel		33	54	

Source: JST

7.3 SKILL AND KNOWLEDGE INPUT FOR O&M FROM IN-HOUSE AND THE EXTERNAL TRAINING

It is necessary to have proper training methods to develop O&M capacity of managers and concerned staff at working at WTP.

- On the Job Training (OJT) is important for staff training, but in countries where OJT is difficult due to lack of experience. In such case, a training facility is to be built inside the business entity or facilities, then an outside lecturer is to be invited to transfer technology and knowledge.
- Training centers are required to develop training facilities, formulate training plans based on needs, select and assign instructors, and aim to implement effective training by introducing fresh lecture content, and improving the skills of instructors.
- Inviting external instructors, development experts or having external overseas training by Development Partners is effective for practical skill development.

Source: JST

Figure 7-1 Skills and Knowledge Inputs

Table 7-3 Training for O&M Capacity Development

Training Method	Training Contents
In-house Training	• Establishment of training facility Training facility • Strengthening human resources for training management • Lecturer training • Teaching material development
External Training	• Training Seminar, Overseas Training by Development Partners/Experts • Workshop by Educational institutions/College

Source: JST

Suggested Training Program by the Developing Partners/Experts is stated in **Table 7-4**.

Table 7-4 Suggested Training Program by the Developing Partners/Experts

Training Modules	Target Employee	Trainer	Training Program
International Water Quality Standards	Directors, Managers, Engineers	Development Partners/Experts	• Program to draw the WASAC's executives' attention to the issues on water quality control. • Program for capacity development training on water quality control for the concerned staff.

Source: JST

CHAPTER 8 COST ESTIMATE

8.1 PRINCIPLES

The costs for the projects were estimated under the feasibility accuracy basis, not considering the specific routes or the site-specificity of the plants and the pipelines. The cost principles are shown in **Table 8-1** and **Table 8-2**.

Table 8-1 Principles on Cost Estimate as per Facilities

Facilities	Approaches
Water Treatment Plant	The cost was estimated from the past WTP construction project in Rwanda and adjacent countries. The cost for water source development is included in the WTP construction cost since it is deemed to be not significant; large structures such as the dams are not included in the development plan.
Transmission Mains	The cost was estimated from the length of planned routes in the GIS multiplied by the Unit price of the pipelines. The cost includes materials, equipment, labor, construction overhead.
Distribution Mains and Sub-mains	Pipeline length was estimated from the existing pipelines considering the diameter size.
Customer Water Meters	The cost was estimated from the number of new customer connections.
Customer Connections	Length estimated from the actual length per customer connection and proportionally increased as the number of connections.

Source: JST

Table 8-2 Principles on Cost Estimate as per the Cost Items

Cost Items	Description
Construction Cost	Plant: Estimated from other previous project costs in adjacent countries. Pipelines: Calculated from the quotation by manufacturers taken in 2019. All price adjusted for 2021
Construction Overhead	Assume 15% of direct construction costs.
Consulting Services	Assumed 8% of the construction cost.
Land Acquisition Cost	Assumed 1,041 RWF/m^2 (mean prices in Karenge, Rwamagana, quoted from Institute of Real Properties Values in Rwanda)

Source: JST

Cost for O&M: Chemical cost, salaries and maintenance costs are based on the yearly average cost of each WTP administrative area (the Nzove, the Kimisagara and the Karenge) of WASAC (WASAC Annual Report 2018/2019). Electricity costs are calculated assuming the pump head, which was calculated based on the pipeline routes and elevation differences. The topography is based on the WASAC's GIS data or Google Earth. The electricity tariff is fixed at the current average tariff paid by WASAC (148.68 RWF/kW).
The basic Conditions of the cost estimate are as described in **Table 8-3**.

Table 8-3 Basic Conditions for the Cost Estimate

Assumption	Conditions
Base Year for Cost Estimation:	2021
Exchange Rates	973 RWF/USD
Price Escalation:	FC:1.7%, LC: 5%
Physical Contingency for Construction	5%
Physical Contingency for Consultant	5%
Administration Cost	0.2%
VAT	18%
Import Tax	25%

Assumption	Conditions
Loan interest during const. (Grace Period)	0.00%
Loan interest after Grace Period	0.01%
Front End Fee	Not Applicable
Total period for implementation	9

Source: JST

8.2 CAPITAL COST AND ANALYSIS

The cost for the Project was calculated based on the scope of work as described in the **Chapter 3 Development plan**. The breakdown of the cost is as described in **Table 8-4**.

Table 8-4 Project Cost Breakdown by the Scope of Work

This Page is closed due to the confidentiality.

8.3 PACKAGING PLAN

The construction project should be appropriately packaged so that the Project attracts as many quality tenderers as possible. In this project, original packaging plan was designed for contractual packaging, then it was revised according to the actual financial arrangement provided by WASAC.

The original packaging plan was designed according to the contractual packaging as shown in **Table 8-5.** A contractual package consists of a bid such as International Competitive Bidding (ICB) and Local Competitive Bidding (LCB) schemes.

Whereas the packaging plan was revised as shown in **Table 8-6** according to the financial arrangement provided by WASAC.

Table 8-5 Contractual Packaging Plan for the Project (Before Revision)

This Page is closed due to the confidentiality.

Table 8-6 Revised Packaging Plan considering financial arrangement for the Project

This Page is closed due to the confidentiality.

8.4 O&M COST AND ANALYSIS

Unit O&M Cost (Cost per produced water supply amount) is estimated as **Table 8-7**. The electricity for WTP can be reduced to 1.34 kW/m^3 for Kigali direction (via Kimichanga) and 1.50 kW/m^3 for Bihembe direction as per water produced, which is reduced by 13–23% from the level of the existing Karenge System (1.74 kW/m^3) (**Table 8-8**). Cost for O&M estimated from the existing cost for the personnel will be increased however the expansion will reduce the unit cost by the WTP capacity by 51% (2.2 persons/'000 m^3/day to 1.125 persons/'000 m^3/day) (**Table 8-9**). As a result, the O&M Cost can be targeted at 300 RWF/m^3 [1], reduced by 13% from the current level.

Table 8-7 O&M cost for the Existing and Expanded Karenge WTP

	Energy cost /m^3	Chemical Cost	Maintenance	Salary	Total
	RWF/m^3	RWF/m^3	RWF/m^3	RWF/m^3	RWF/m^3
Existing WTP (from the data in 2019)	269	54	2	21	346
Estimated O&M Cost for Expansion	207	43	2	11	263

Source: JST

Table 8-8 Calculation for Energy Consumption by New WTP

Electricity 0.9

Items	kVA	kW	Unit	Amount, m3	kWh/m3	RWF/m3
Intake Pumps	340	306	3	52,000	0.42	62.99
Water Treatment	-		-	-	0.14	20.71
Clear Water Transmission: to Kimichanga	345	311	5	48,000	0.78	115.41
Clear Water Transmission: to Bihembe	120	108	1	16,200	0.16	23.79

Energy to Kimichanga 1.34 kW/m3
Energy To Bihembe 1.50 kW/m3

Table 8-9 O&M Cost Estimate for Expanded Karenge Water Treatment Plant

	Nos. Personnel		WTP Capacity		Persons per capacity	
Existing WTP	33	persons	15,000	m^3/day	2.2	persons/('000 m^3/day)
Expansion	54	persons	48,000	m^3/day	1.125	persons/('000 m^3/day)

Source: JST

[1] Not including the inflation and unpredictable energy unit cost increase in line with the inflation.

CHAPTER 9 FINANCIAL AND ECONOMIC EVALUATION

Both financial and economic evaluations are conducted in this Chapter to ascertain the viability of the Project.

9.1 FINANCIAL EVALUATION

9.1.1 Assumptions

The assumptions as shown in **Table 9-1** are set to carry out the financial evaluation.

Table 9-1 Assumptions for Financial Evaluation

<table>
<tr><th>Standard Items for Evaluation</th><th colspan="2">Assumptions</th></tr>
<tr><td rowspan="2">1. Project Cost</td><td>Capex and Opex</td><td>Details in Chapter 8</td></tr>
<tr><td>Import tax and VAT</td><td>Included</td></tr>
<tr><td>2. Foreign exchange rate</td><td>1 US$ = RWF 973</td><td>National Bank of Rwanda: average of medium rate as at end of month during 6 months from October 2020 up to March 2021.</td></tr>
<tr><td rowspan="2">3. Economic Life</td><td>1) Water Treatment Plant: 45 years on weighted average</td><td><table><tr><th colspan="2">Composition</th><th>Life</th></tr><tr><td>Facilities</td><td>70%</td><td>50 years</td></tr><tr><td>Machinery & Equipment</td><td>30%</td><td>15 years</td></tr></table></td></tr>
<tr><td>2)Pipeline: 40 years</td><td>-</td></tr>
<tr><td>4. Replacement cost</td><td>In every 15 years</td><td>Machinery & Equipment</td></tr>
<tr><td>5. Salvage Value</td><td colspan="2">The residue value of capital cost calculated from the above economic life is salvaged at the last year of evaluation time horizon up until FY 2069/70.</td></tr>
<tr><td>6. Revenues</td><td colspan="2">• Incremental revenues generated by the projects
• Tariff: 910 RWF/m^3 – reviewed considering the incremental cost incurred by the Project and the recurrent cost projected by WASAC</td></tr>
<tr><td>7. Opportunity Cost of Capital</td><td colspan="2">Real interest rate of 6.3% is applied, that is generally calculated:
= (long-term interest rate) – (expected inflation.)
✓ Long-term interest rate: 11.25%, yields of 7-years' Rwandan government bond issued in 2019 quoted at the Rwanda Stock Exchange in 2021
✓ Expected Inflation rate: 5% estimated by IMF</td></tr>
<tr><td>8. Evaluation Time Horizon</td><td colspan="2">43 years: from the start year of operation up to completion year of loan repayment</td></tr>
</table>

Source: JST

9.1.2 Results of Financial Evaluation

Table 9-2 shows the results of the financial evaluation by applying the above assumptions. The FIRR of the base case shows 2.2% which is a lower rate than 6.3% of the opportunity cost of capital (see **Appendix A.9-1**). Meanwhile the study revealed that the FIRR goes down to 0.4% if the current tariff of 730 RWF/m^3 is applied to the evaluation. However, it is noted that the FIRR will soar to 9.7% provided that the concessional loans by the development partners are financed (see **Appendix A.9-2**).

Table 9-2 Results of Financial Evaluation

Case	FIRR	NPV (million RWF)	B/C
Base Case	2.2%	-51,285	0.66
Financing with donor's concessional loan*	9.7%	7,267	1.04

Source: JST

*Assumptions for concessional loan

- Loan amount: Construction and engineering only, exclusive of administration and taxes
- Loan terms and conditions are assumed as follows:
  40 years of loan period including grace period, 10 years' grace period and 0.5% of interest rate per annum

<Sensitivity Analysis on Base-Case: variation in capex and revenues for FIRR break-even point >

The minimum variation that can get the FIRR to attain the feasible level over 6.3% is examined as follows.

✓ Capex: if decreased by more than 55%, the FIRR goes up over 6.3%

✓ Revenues: if increased by more than 50%, the FIRR goes up over 6.3%

9.2 ECONOMIC EVALUATION

9.2.1 Assumptions

The assumptions are set to carry out an economic evaluation.

Table 9-3 Assumptions for Economic Evaluation

Standard Items for Evaluation		Assumptions
1. Project Costs (Capex + Opex)	1) Financial Cost	Same as Table 9-1
	2) Economic Cost	• The above financial cost is converted to economic cost by utilizing the 'Conversion Factor (CF)' formulated by MINECOFIN • This economic cost is applied for economic evaluation. • Price escalation is not considered. • The land cost is generally disregarded in the economic cost. • Import tax and VAT are not included.
2. Benefits		• Beneficiaries' "Willingness-to-Pay": RWF/month/household x 4% CoK: Urban 15,000 RWF/m^3, Rural 4,500 RWF/m^3; 7 Sectors: Urban 13,500 RWF/m^3, Rural 4,100 RWF/m^3
3. Social Discount Rate		• Generally, the range between 10% and 12% is used for economic evaluation. • Set at the lower rate of 10% in this analysis by considering the nature of the projects from the point of view of basic human needs. • This rate can be referred to the same rate as applied in the "Sustainable Water Supply and Sanitation Program 2017, AfDB".
4. Evaluation Time Horizon		30 years from the starting from the 1st operation year

Source: JST

9.2.2 Results of Economic Evaluation

Table 9-4 presents the results of the economic evaluation. It shows that the EIRR will exceed 10% of the social discount rate.

Table 9-4 Results of Economic Evaluation

Case	EIRR	NPV	B/C
Base Case	10.2%	934 million RWF	1.01

Source: JST

<Sensitivity Analysis>

Table 9-5 illustrates the results of the sensitivity analysis on the economic evaluation of the project. Provided that the capex increases by 5%, the EIRR results in 9.7% for the base case of benefits that is below 10% of opportunity cost of capital; on the contrary, the benefits decrease by 5%, the EIRR goes down to 9.5% for the base case of capex. It is examined that the EIRR is affected by a slight variation of capex and benefits.

Table 9-5 Results of Sensitivity Analysis

Variation Items		Benefits				
		+10%	+5%	Base case	-5%	-10%
Capex	-10%	13.0%	12.2%	11.4%	10.6%	9.8%
	-5%	12.3%	11.5%	10.8%	10.0%	9.3%
	Base case	11.6%	10.9%	10.2%	9.5%	8.7%
	+5%	11.0%	10.4%	9.7%	9.0%	8.2%
	+10%	10.5%	9.8%	9.2%	8.5%	7.8%

Note: Figures in blue cells present the feasible level of EIRR.
Source: JST

CHAPTER 10 CONCLUSION

- Emergent needs and social necessity of the expansion of Karenge WTP and forwarding infrastructures were contextualized in light of the social backgrounds, including the current status of development in the study areas and future development plan in the CoK and adjacent sectors in Rwamagana District.

- The target area of the Project mainly focuses on the Rusororo and Ndera sectors in CoK, and Nyakaliro, Muyumbu and Gahengeri sectors in the Rwamagana district, and other emerging demand equivalent to 9,500 m^3/day in the Rwamagana district. The target water supply coverage by the Project is 100% after the completion, including piped water connections and the public tap. The total target population as beneficiaries is approximately 493,500 populations in the year 2030.

- The F/S defined the scope of work, including the intake expansion, WTP, water transmission and distribution systems. The WTP will involve the conventional coagulation-sedimentation and rapid sand filtration system considering the raw water from Lake Mugesera. It requires water transmission pipelines for 83.8 km. The large pipes (up to ND700) should be laid along the existing pipelines of Karenge 2. The pipes from Kimichanga-Bihembe to Muyumbu and Gahengeri are more than 39km but with a smaller diameter (up to ND400).

- The schedule showed that the water supply could be inaugurated from the end of the **Year 2026** if all procedures go smoothly. The schedule should be reviewed in line with the actual process applied to an international development partner's loan conditions and internal procedures for GoR.

- Preliminary Environmental Impact Assessment shows that the impact from the Project was very limited; their resettlement by the plant construction is small (Only one household) with little concern on the environmental pollution.

- Operation and Maintenance, including the personnel, skills and knowledge input, was assessed based on the scale of the future expansion. The new WTP may be utilized as the training center to develop the skills for WTP operation.

- FIRR was estimated as 2.2% and it would be feasible if the concessional loans (Soft loans: 40 years, 10 years' grace period and 0.5% per annum) were applied. EIRR was estimated as 10.3 %, which was over the social discount rate (10%).

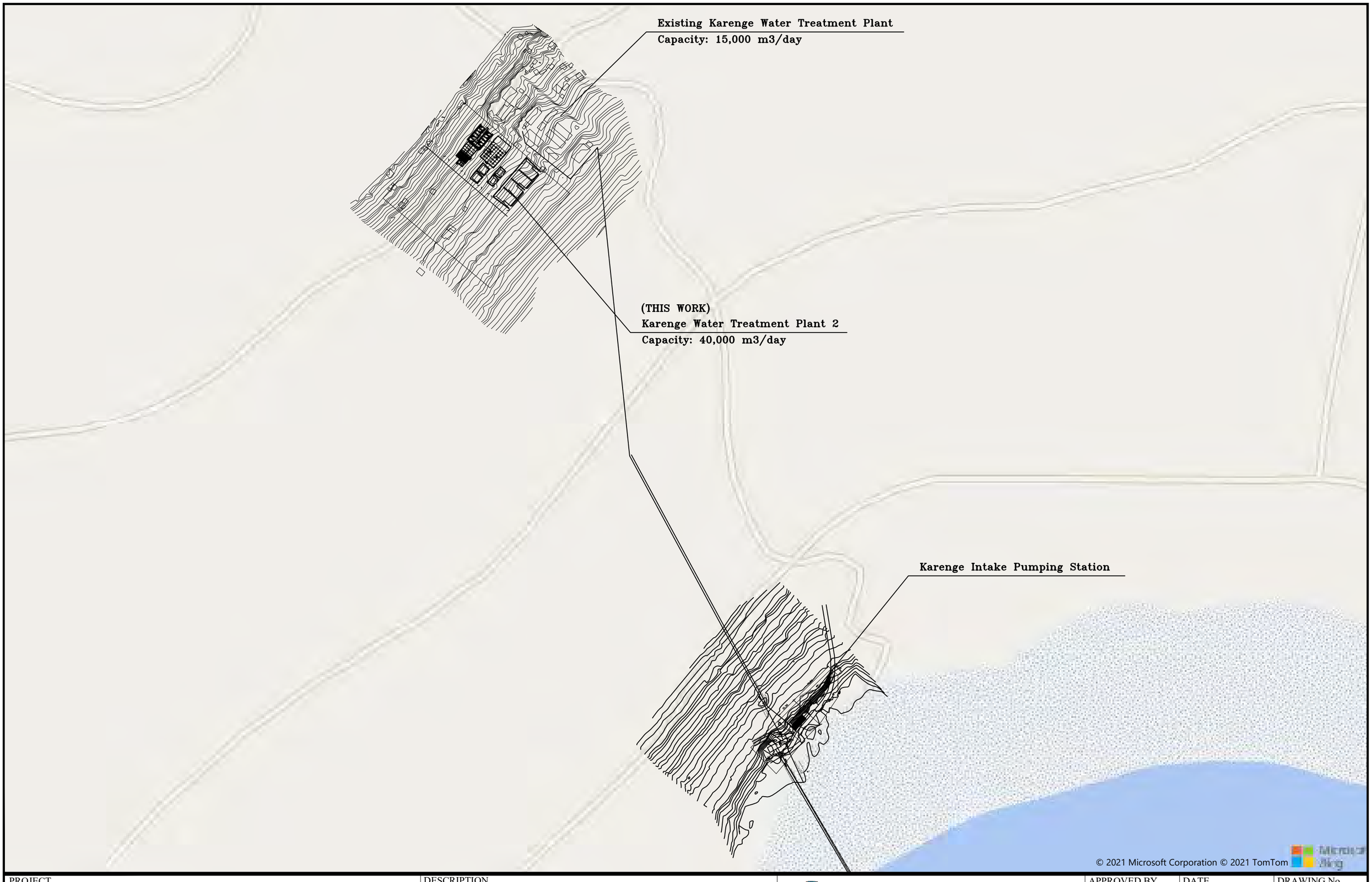
- The final packaging plan was revised based on the actual condition of the financial availability provided by WASAC. Note that both Package 1 and 2 are inseparable and necessary to complete both in parallel to materialize the benefit to the people; the water treatment plant in Package 1 cannot be fully operated before the forwarding infrastructures in Package 2 are completed.

APPENDIX

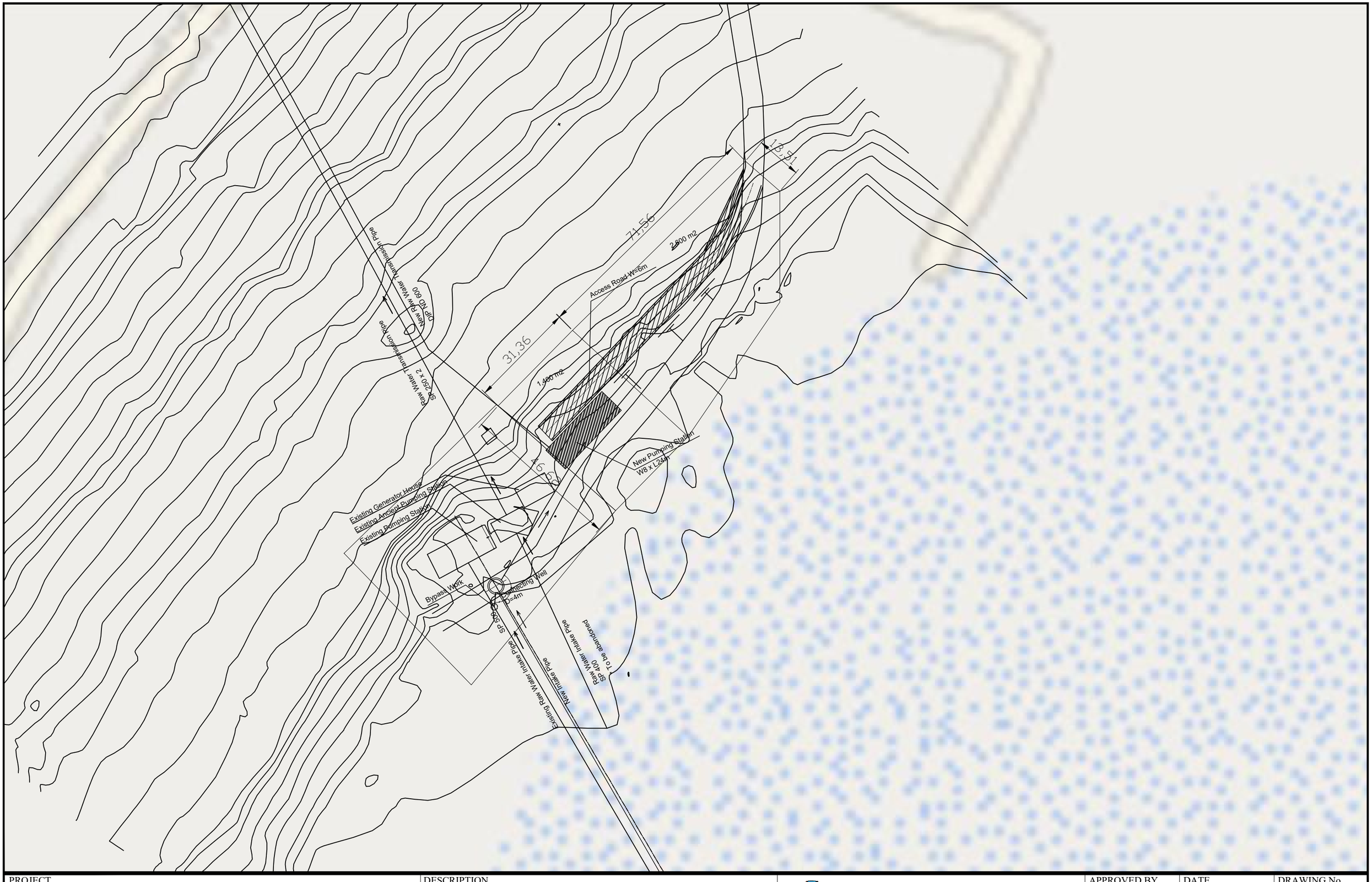
List

APPENDIX A：Drawings

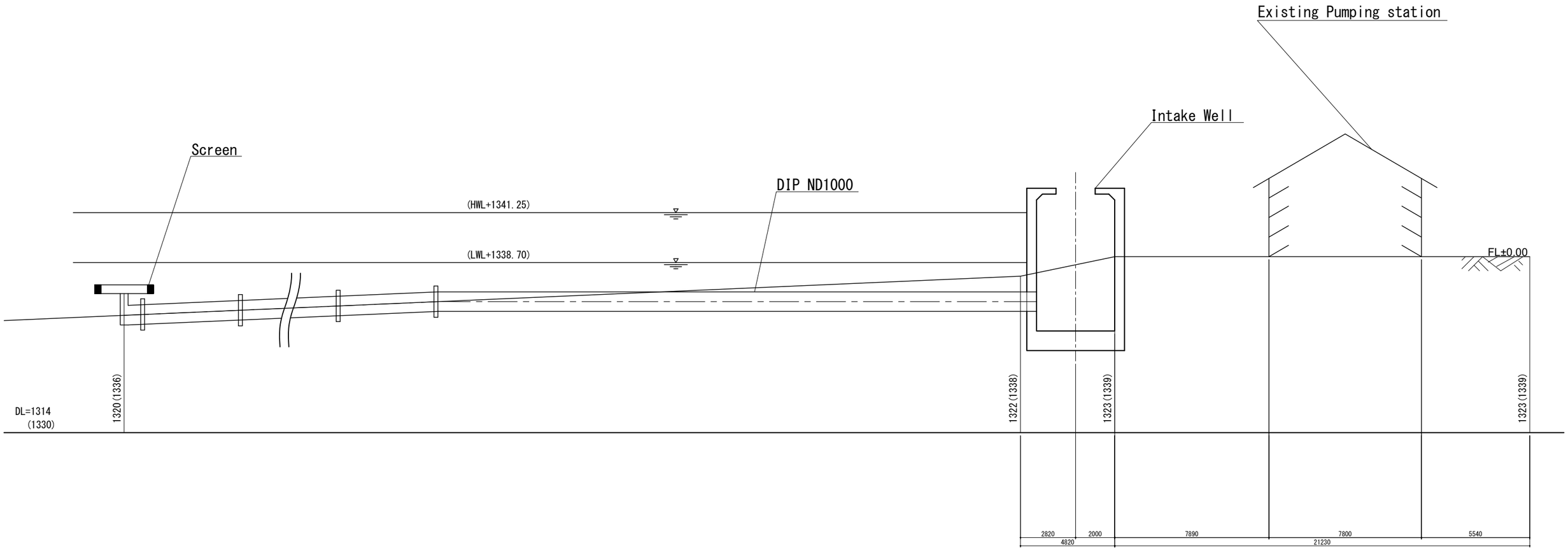
Appendix A Drawings



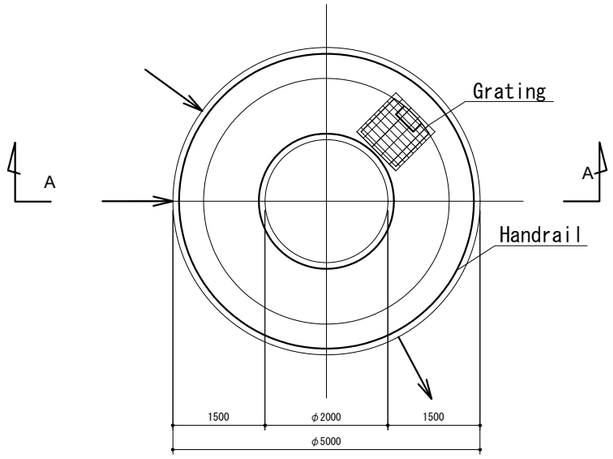
PROJECT *KIGALI WATER SUPPLY MASTERPLAN:* *FEASIBILITY STUDY FOR THE EXPANSION OF KARENGE WTP*	DESCRIPTION General Layout	*Nihon Suido Consultants CO., LTD. and Yachiyo Engineering Co., Ltd. joint venture in cooperation with Water & Sanitation Corporation (WASAC)*	APPROVED BY **MAMIYA Takemasa**	DATE **2021.04.21**	DRAWING No G01
			PREPARED BY **NISHIDA Kosei**	DATE **2021.04.21**	SCALE 1:5000



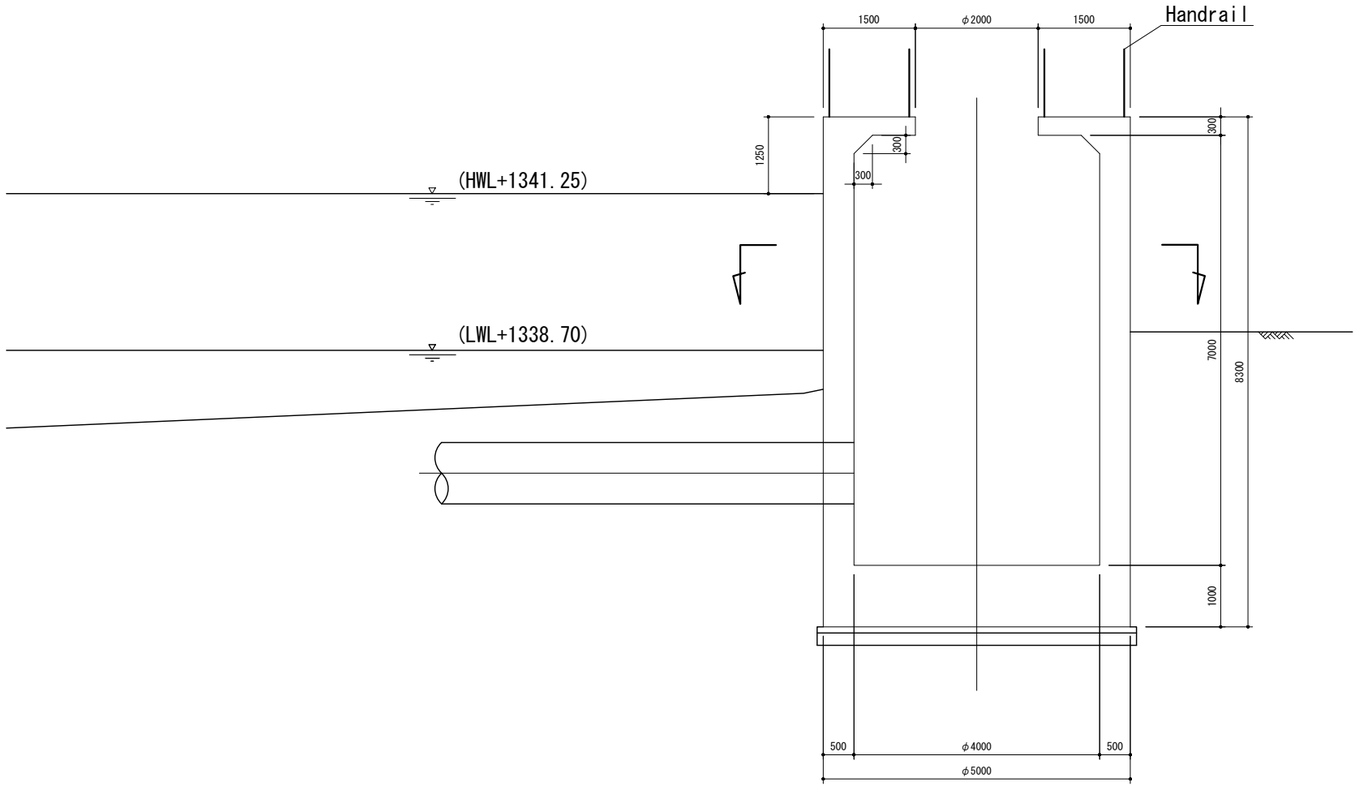
PROJECT	DESCRIPTION		APPROVED BY	DATE	DRAWING No
KIGALI WATER SUPPLY MASTERPLAN: *FEASIBILITY STUDY FOR THE EXPANSION OF KARENGE WTP*	General Layout of Intake Facility	*Nihon Suido Consultants CO., LTD. and Yachiyo Engineering Co., Ltd. joint venture in cooperation with Water & Sanitation Corporation (WASAC)*	**MAMIYA Takemasa**	**2021.04.21**	I01
			PREPARED BY **NISHIDA Kosei**	DATE **2021.04.21**	SCALE 1:1000



PROJECT	DESCRIPTION		APPROVED BY	DATE	DRAWING No
KIGALI WATER SUPPLY MASTERPLAN: *FEASIBILITY STUDY FOR THE EXPANSION OF KARENGE WTP*	Conceptual Layout of Intake Well	*Nihon Suido Consultants CO., LTD. and Yachiyo Engineering Co., Ltd. joint venture in cooperation with Water & Sanitation Corporation (WASAC)*	MAMIYA Takemasa	2021.4.21	I02
			PREPARED BY NISHIDA Kosei	DATE 2021.4.21	SCALE 1:200



PLAN



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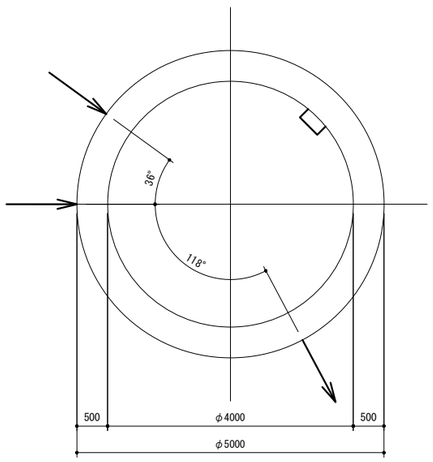
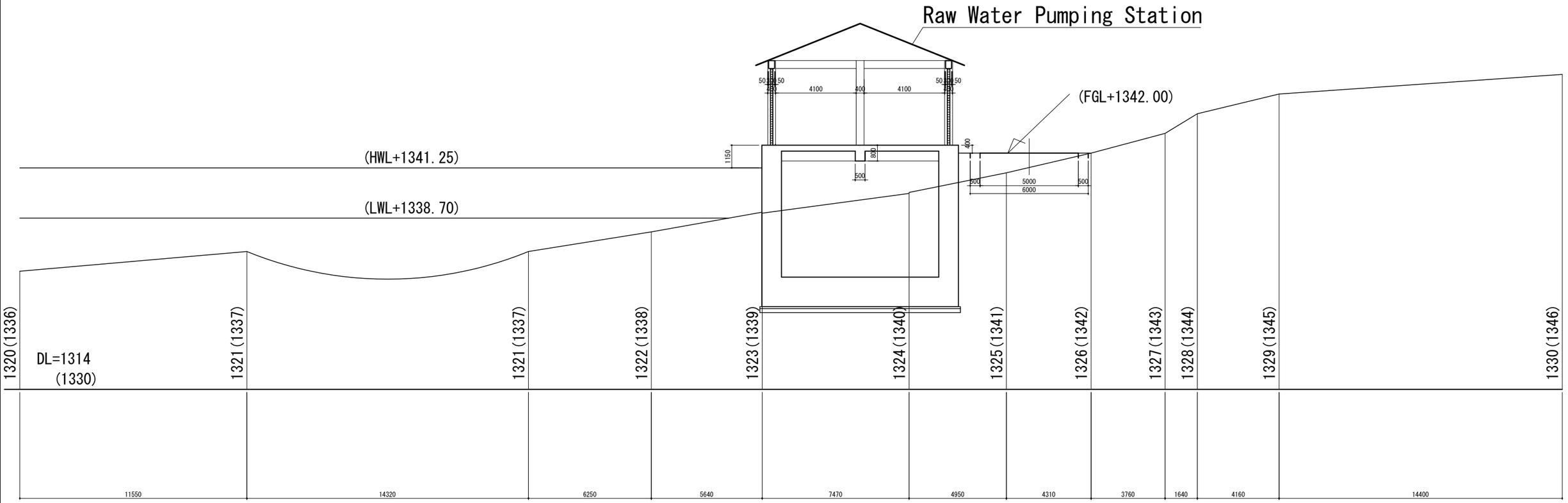


SECTIONAL PLAN

PROJECT	DESCRIPTION		APPROVED BY	DATE	DRAWING No
KIGALI WATER SUPPLY MASTERPLAN: *FEASIBILITY STUDY FOR THE EXPANSION OF KARENGE WTP*	Intake Well Structure	*Nihon Suido Consultants CO., LTD. and Yachiyo Engineering Co., Ltd. joint venture in cooperation with Water & Sanitation Corporation (WASAC)*	MAMIYA Takemasa	2021.4.21	I03
			PREPARED BY NISHIDA Kosei	DATE 2021.4.21	SCALE 1:100



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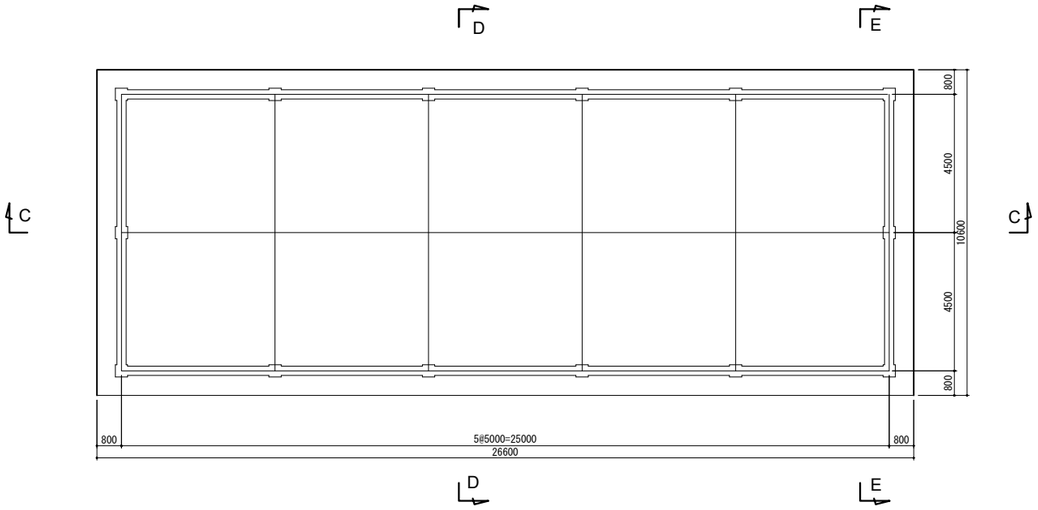
KIGALI WATER SUPPLY MASTERPLAN: *FEASIBILITY STUDY FOR THE EXPANSION OF KARENGE WTP*	Conceptual Layout of Raw Water Pumping Station	*Nihon Suido Consultants CO., LTD. and Yachiyo Engineering Co., Ltd. joint venture in cooperation with Water & Sanitation Corporation (WASAC)*	MAMIYA Takemasa	2021.4.21	I04
			PREPARED BY NISHIDA Kosei	DATE 2021.4.21	SCALE 1:200



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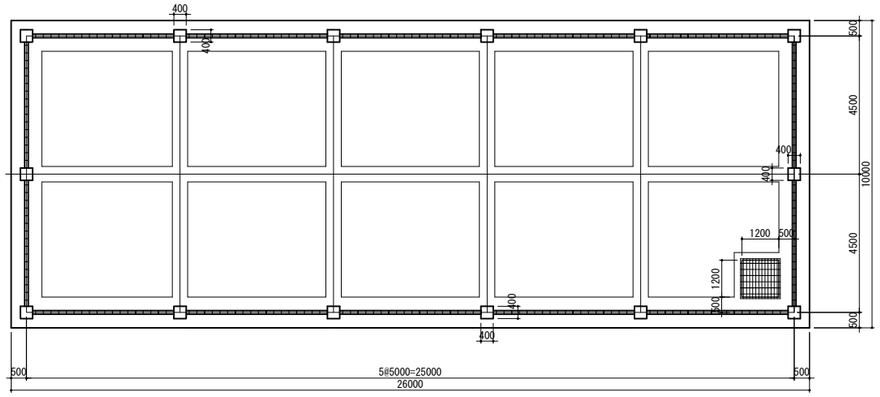
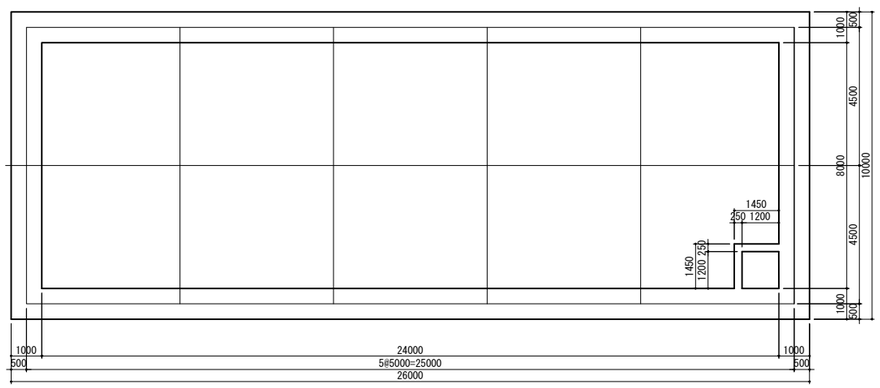


SECTIONAL PLAN A - A



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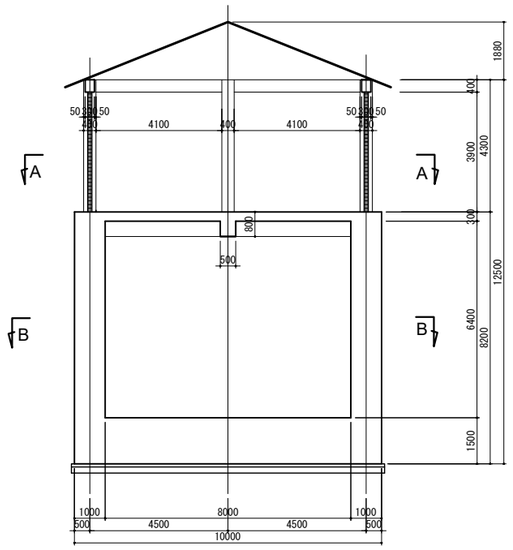

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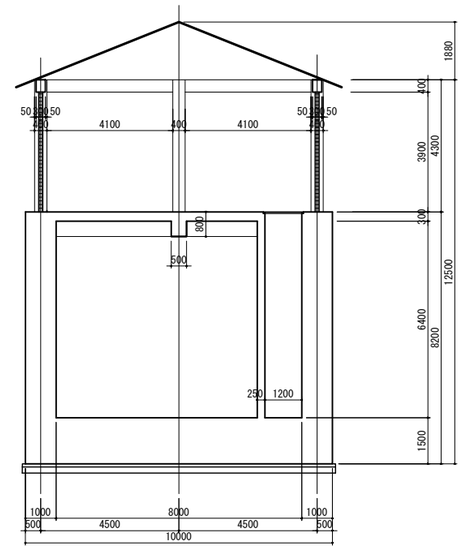

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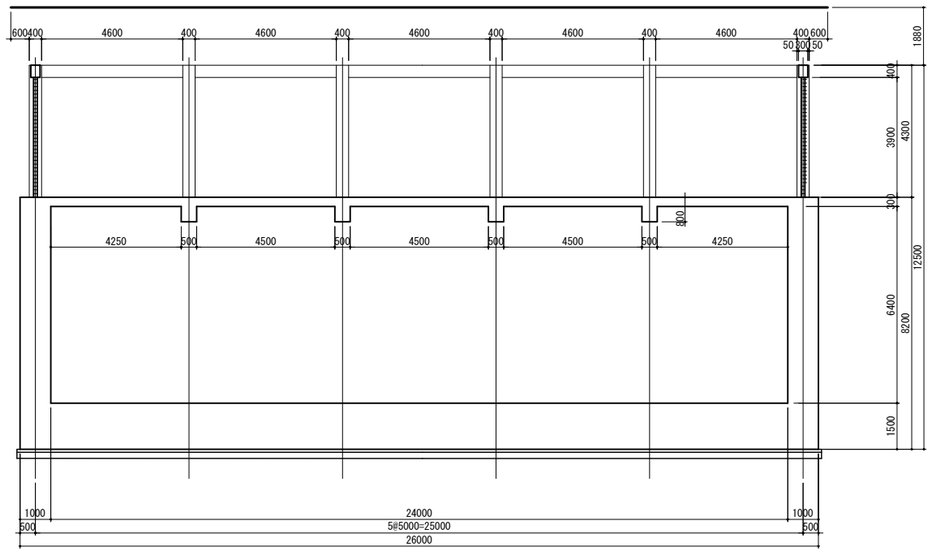

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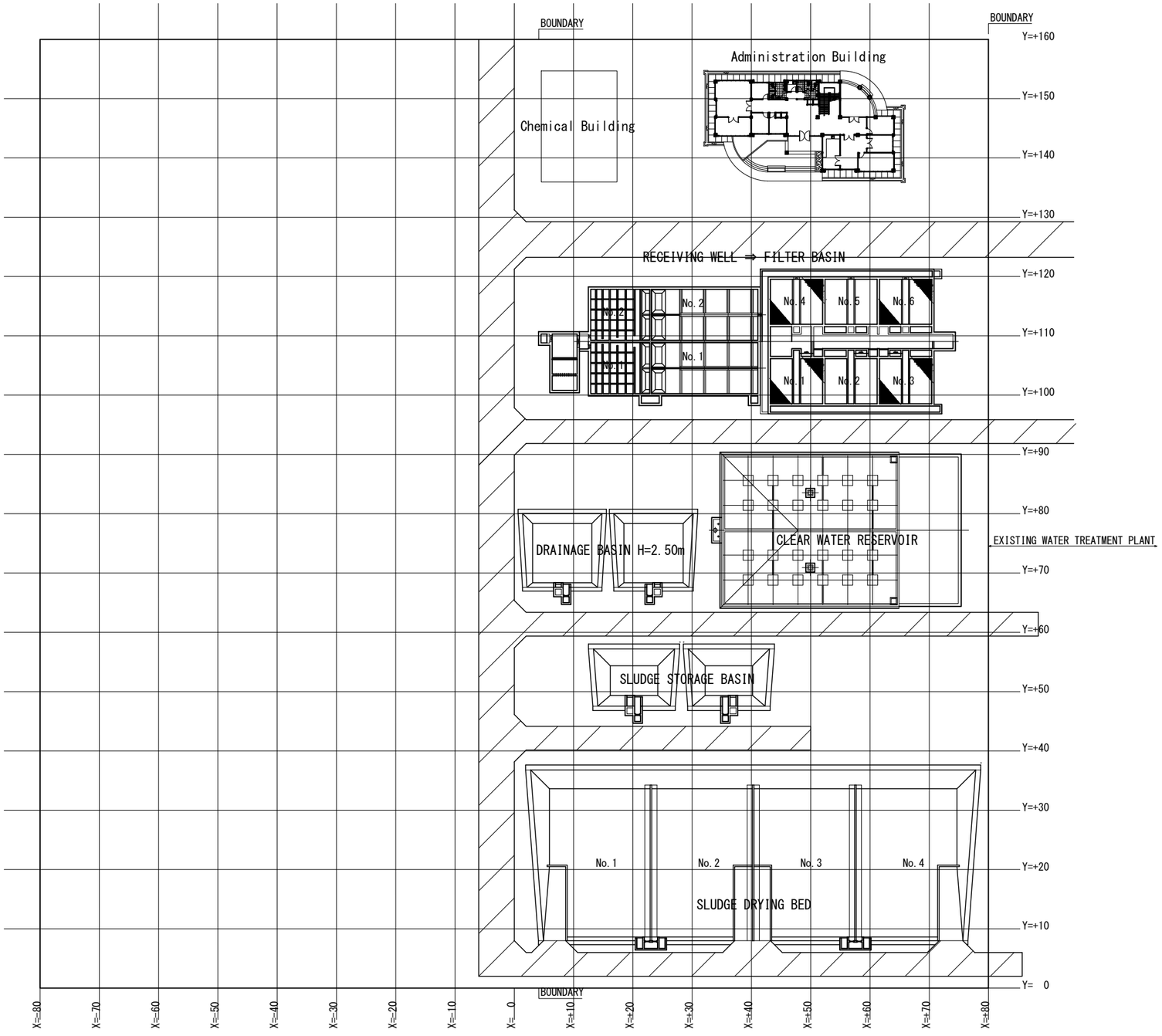
KIGALI WATER SUPPLY MASTERPLAN: *FEASIBILITY STUDY FOR THE EXPANSION OF KARENGE WTP*	Raw Water Pumping Station Structure	*Nihon Suido Consultants CO., LTD. and Yachiyo Engineering Co., Ltd. joint venture in cooperation with Water & Sanitation Corporation (WASAC)*	MAMIYA Takemasa	2021.4.21	I05
			PREPARED BY NISHIDA Kosei	DATE 2021.4.21	SCALE 1:200



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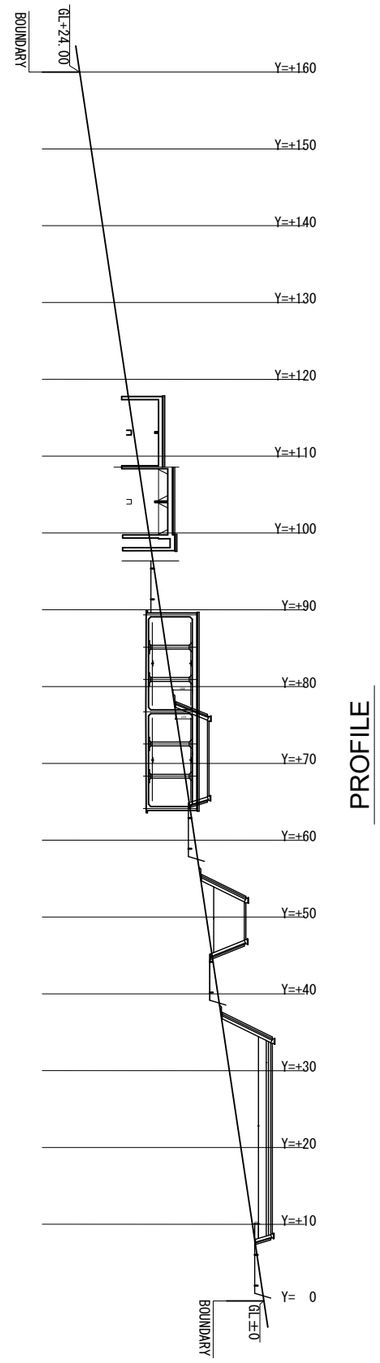

PROFILE

PROJECT *KIGALI WATER SUPPLY MASTERPLAN:* *FEASIBILITY STUDY FOR THE EXPANSION OF KARENGE WTP*	DESCRIPTION General Layout of Water Treatment Plant	*Nihon Suido Consultants CO., LTD. and Yachiyo Engineering Co., Ltd. joint venture in cooperation with Water & Sanitation Corporation (WASAC)*	APPROVED BY MAMIYA Takemasa	DATE 2021.4.21
			PREPARED BY NISHIDA Kosei	DATE 2021.4.21

DRAWING No: W01

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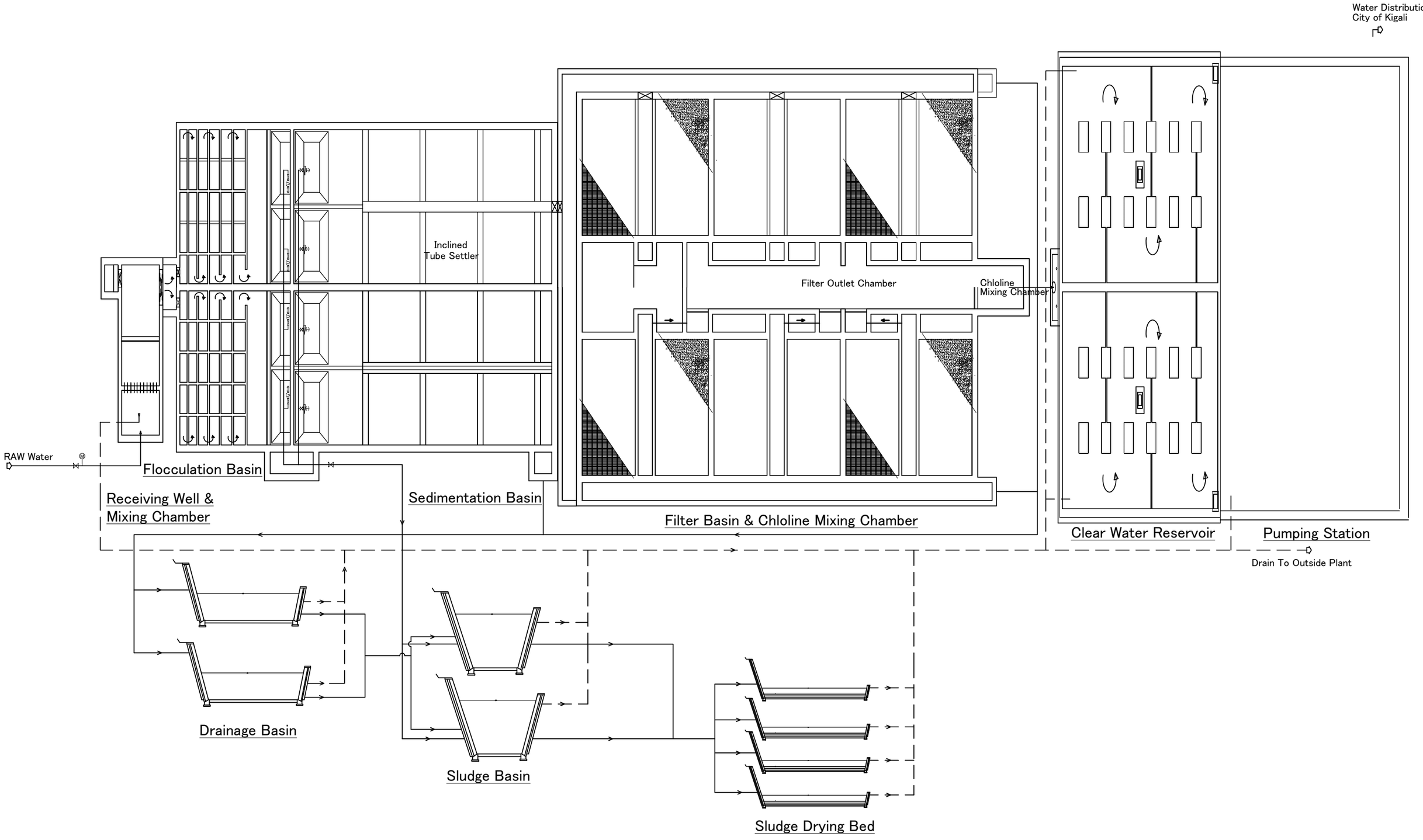
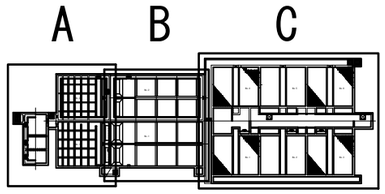
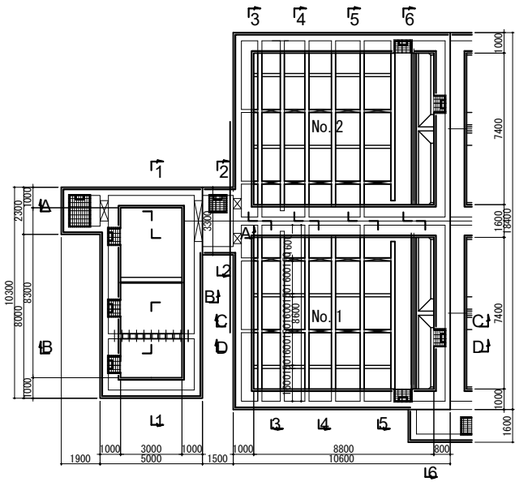


PROJECT *KIGALI WATER SUPPLY MASTERPLAN:* *FEASIBILITY STUDY FOR THE EXPANSION OF KARENGE WTP*	DESCRIPTION System Flow Diagram	*Nihon Suido Consultants CO., LTD. and Yachiyo Engineering Co., Ltd. joint venture in cooperation with Water & Sanitation Corporation (WASAC)*	APPROVED BY MAMIYA Takemasa	DATE 2021.4.21	DRAWING No W03
			PREPARED BY NISHIDA Kosei	DATE 2021.4.21	SCALE None



A: Receiving Well, Mixing Chamber and Flocculation Basin
B: Sedimentation Basin
C: Filter Basin



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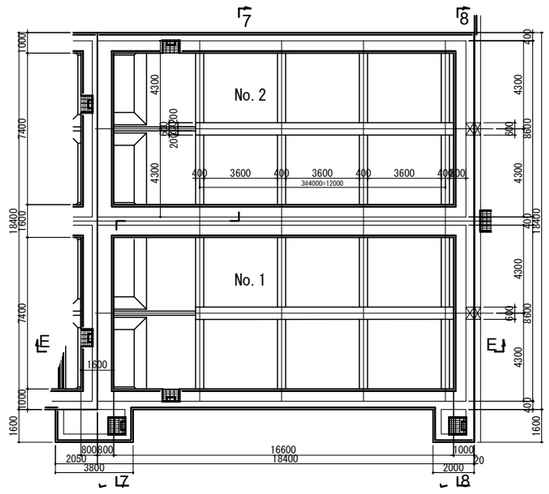

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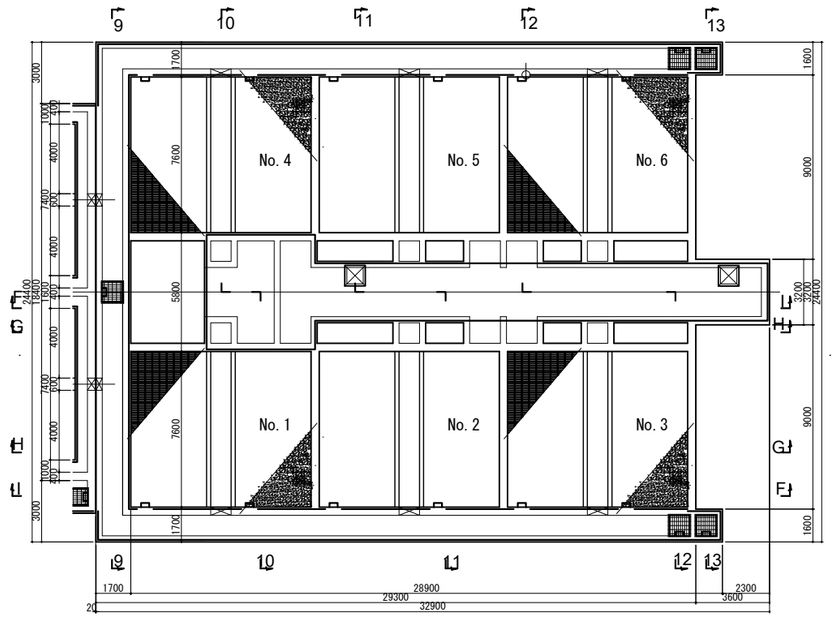

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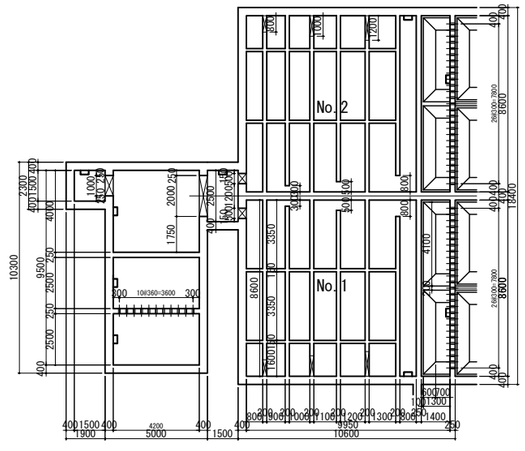

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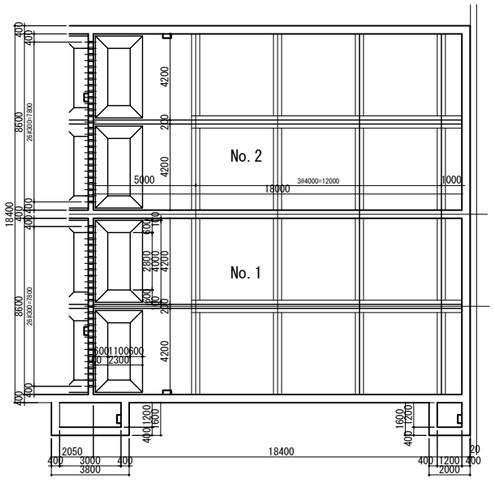

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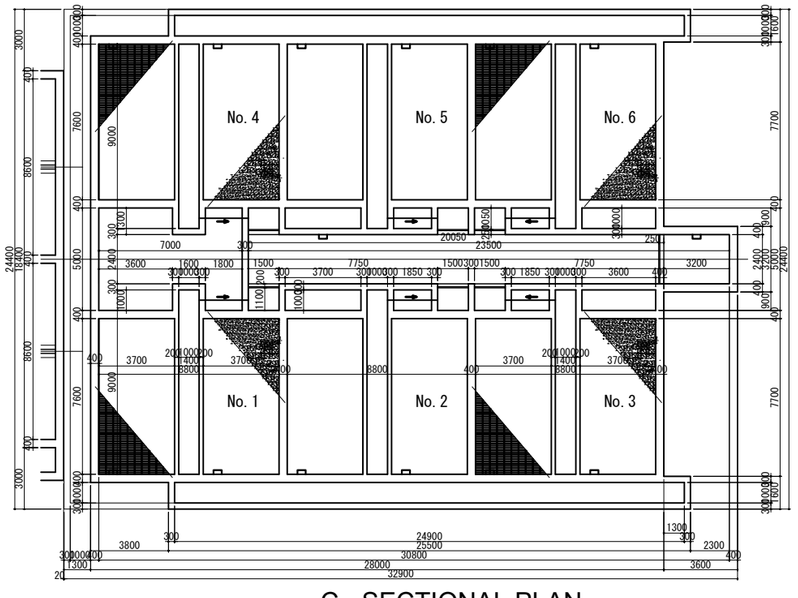
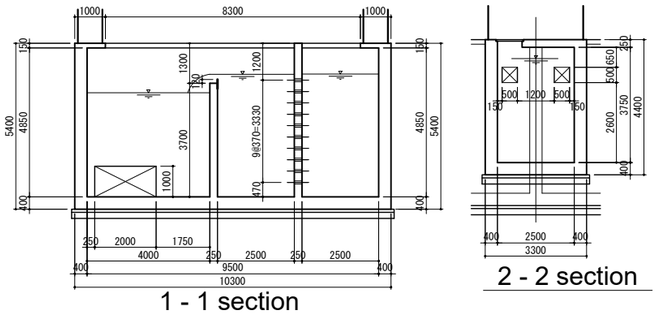


C - SECTIONAL PLAN

PROJECT *KIGALI WATER SUPPLY MASTERPLAN:* *FEASIBILITY STUDY FOR THE EXPANSION OF KARENGE WTP*	DESCRIPTION Water Treatment Facility Structure (1/4)	*Nihon Suido Consultants CO., LTD. and Yachiyo Engineering Co., Ltd. joint venture in cooperation with Water & Sanitation Corporation (WASAC)*	APPROVED BY **MAMIYA Takemasa**	DATE **2021.4.21**	DRAWING No W04
			PREPARED BY **NISHIDA Kosei**	DATE **2021.4.21**	SCALE 1:300



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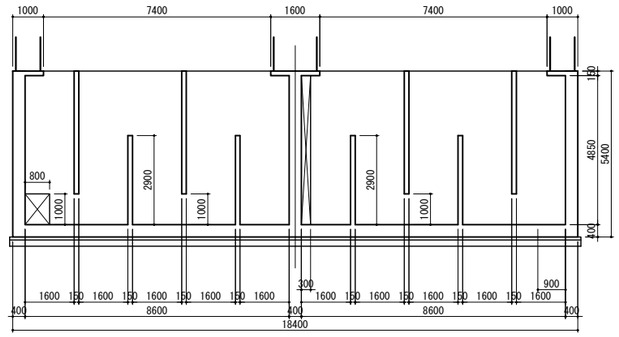

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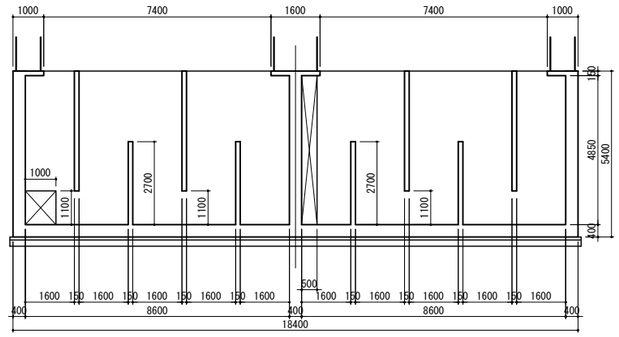

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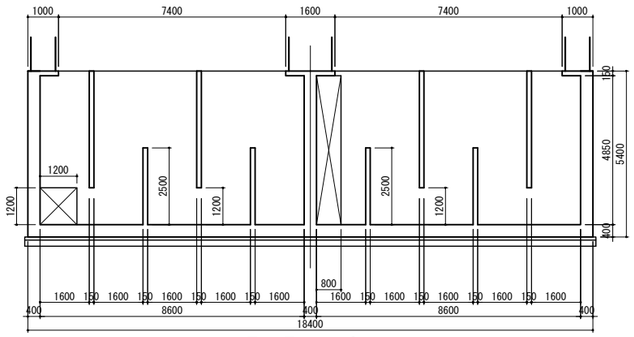

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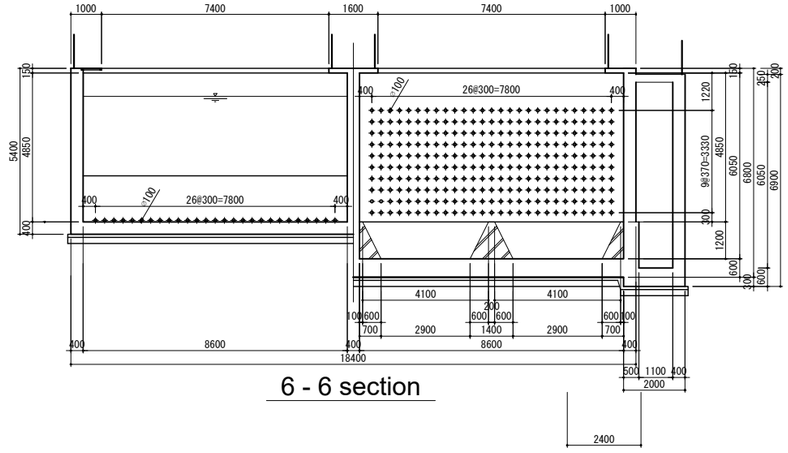

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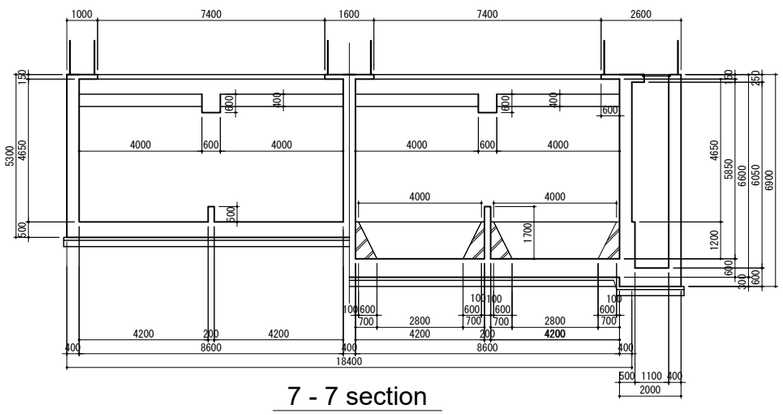

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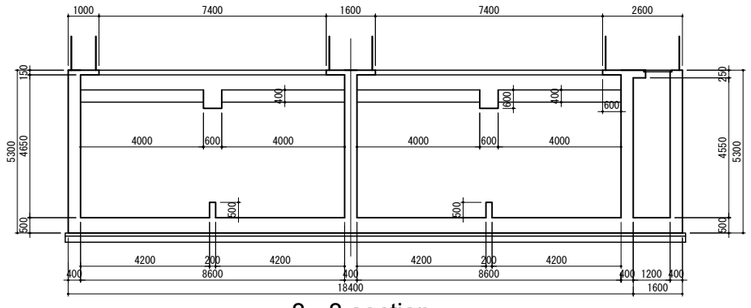

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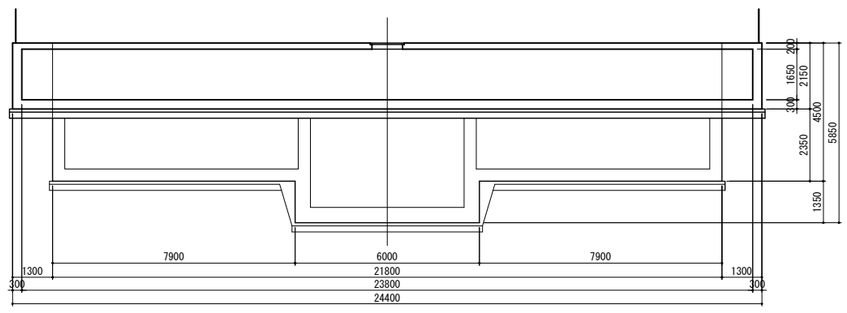

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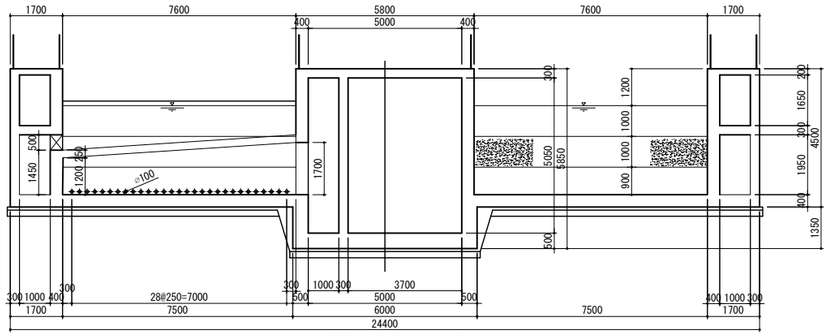
			PREPARED BY **NISHIDA Kosei**	DATE **2021.4.21**	SCALE 1:200



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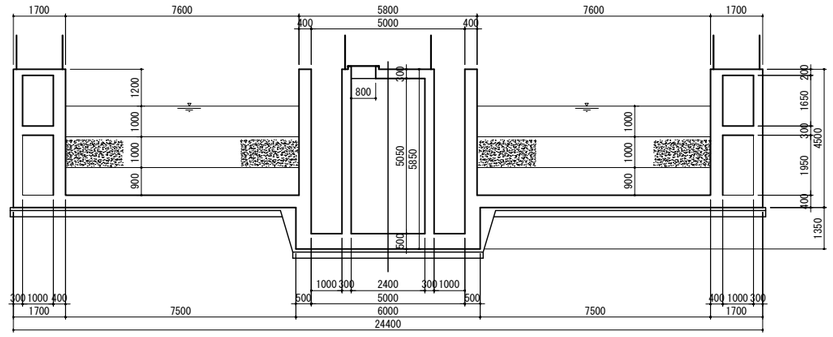

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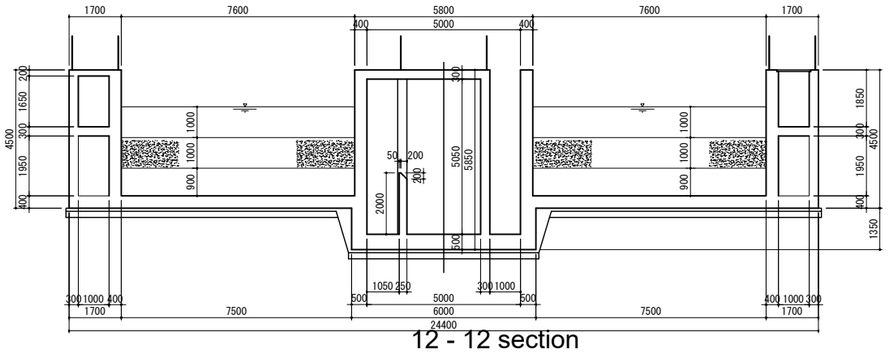

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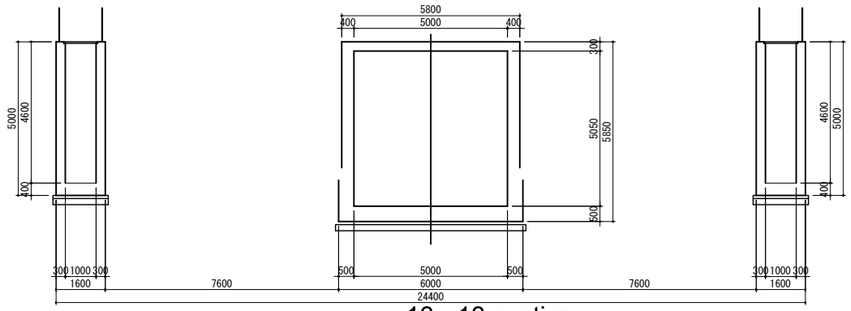

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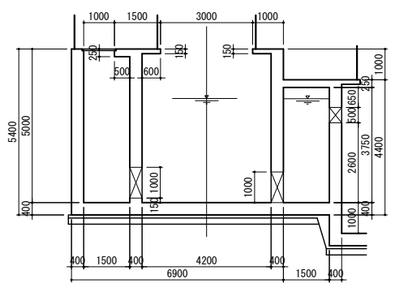

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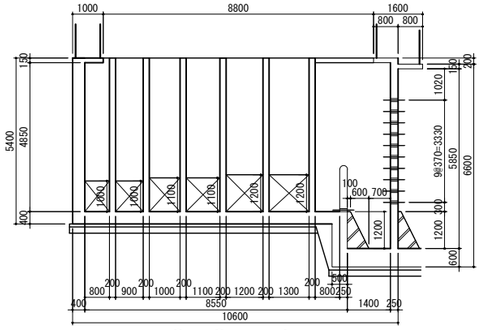

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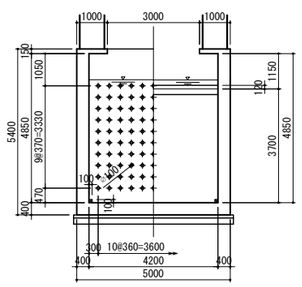

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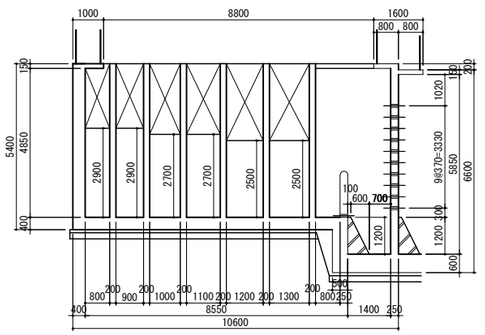

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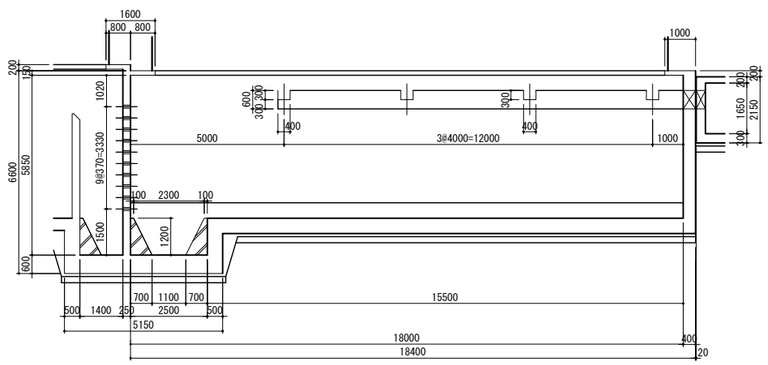
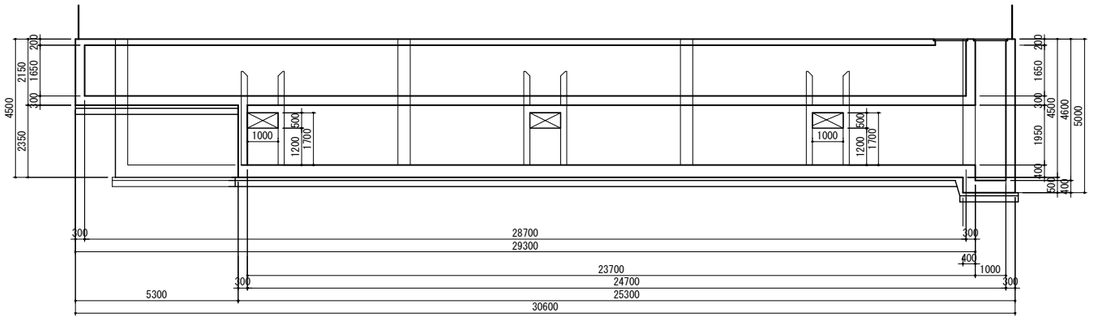


E - E section

PROJECT	DESCRIPTION		APPROVED BY	DATE	DRAWING No
KIGALI WATER SUPPLY MASTERPLAN: *FEASIBILITY STUDY FOR THE EXPANSION OF KARENGE WTP*	Water Treatment Facility Structure (3/4)	*Nihon Suido Consultants CO., LTD. and Yachiyo Engineering Co., Ltd. joint venture in cooperation with Water & Sanitation Corporation (WASAC)*	**MAMIYA Takemasa**	**2021.4.21**	W06
			PREPARED BY **NISHIDA Kosei**	DATE **2021.4.21**	SCALE 1:200

SECTIONAL PLAN



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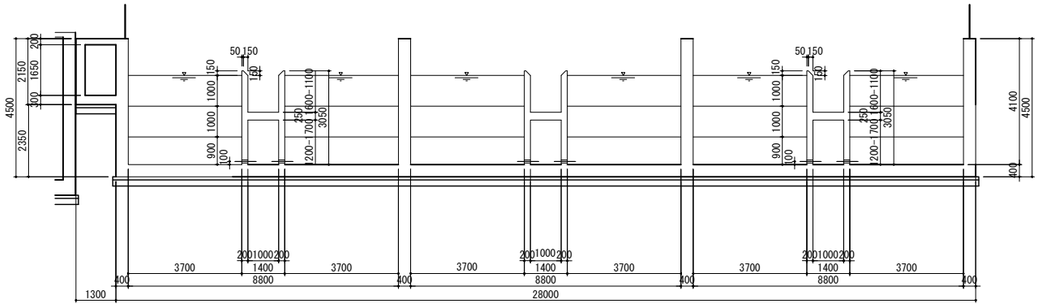
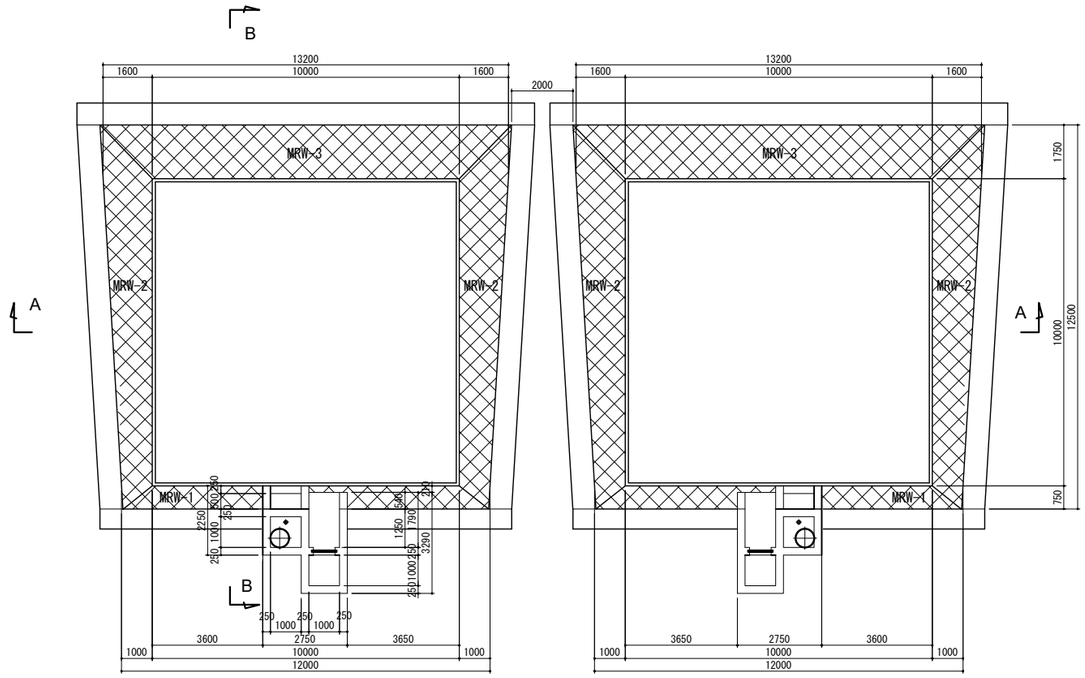


G - G section

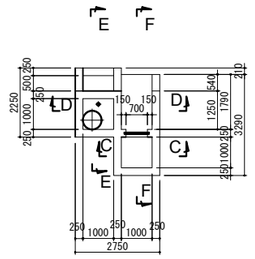
H - H section

I - I section

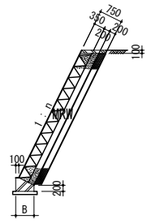
PROJECT	DESCRIPTION		APPROVED BY	DATE	DRAWING No
KIGALI WATER SUPPLY MASTERPLAN: *FEASIBILITY STUDY FOR THE EXPANSION OF KARENGE WTP*	Water Treatment Facility Structure (4/4)	*Nihon Suido Consultants CO., LTD. and Yachiyo Engineering Co., Ltd. joint venture in cooperation with Water & Sanitation Corporation (WASAC)*	**MAMIYA Takemasa**	**2021.4.21**	W07
			PREPARED BY **NISHIDA Kosei**	DATE **2021.4.21**	SCALE 1:200



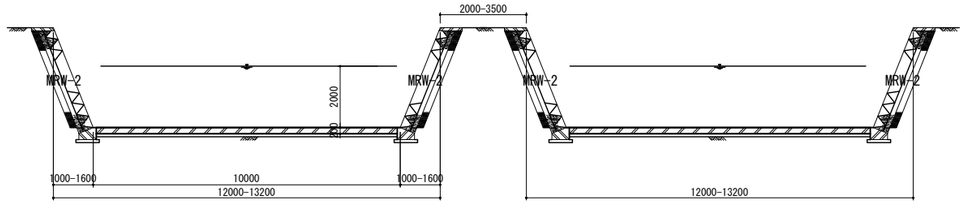
PLAN



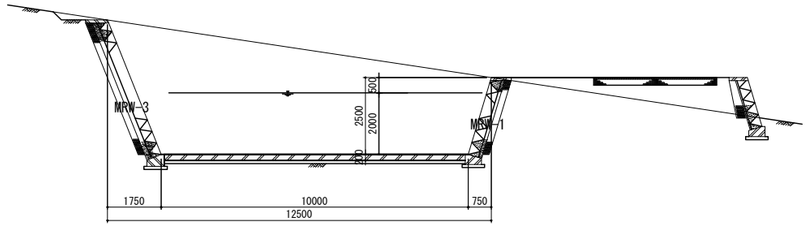
Inlet and Outlet Structure



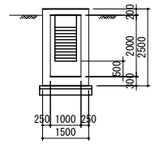
	1 : n	B (mm)
MRW-1	1:0.3	630
MRW-2	1:0.4	610
MRW-3	1:0.4	610



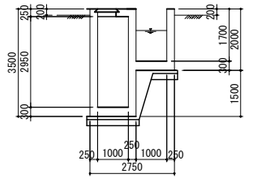
A - A section



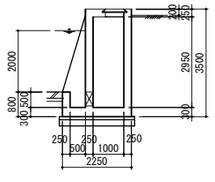
B - B section



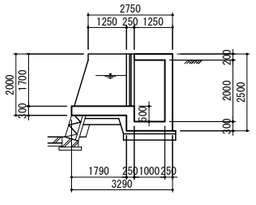
C - C section



D - D section

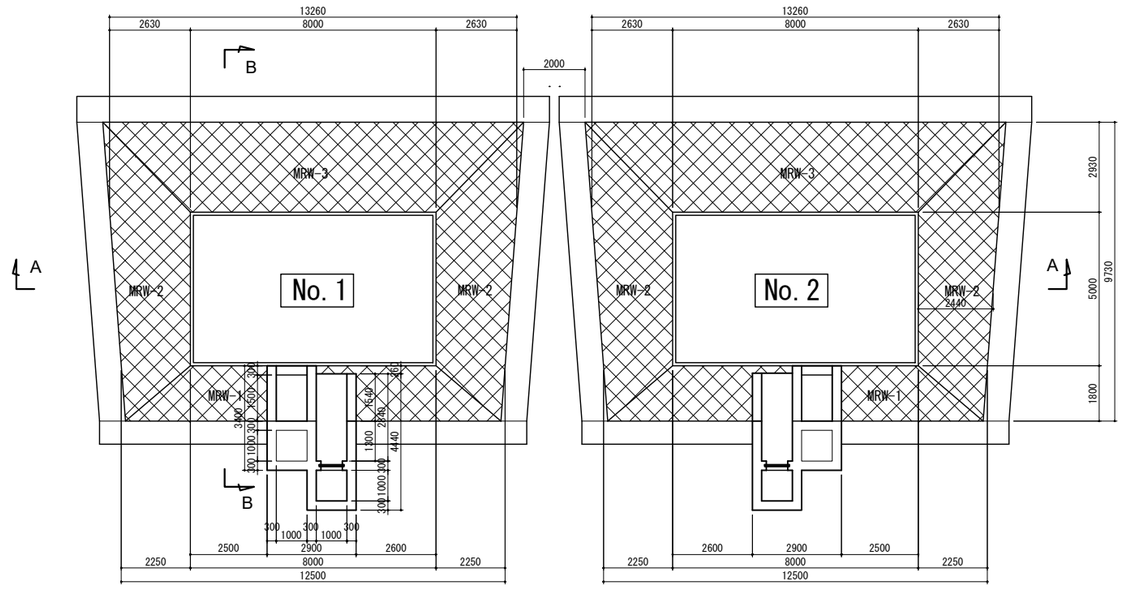


E - E section

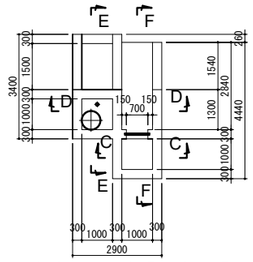


F - F section

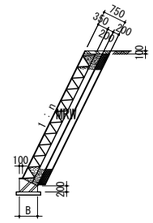
PROJECT	DESCRIPTION		APPROVED BY	DATE	DRAWING No
KIGALI WATER SUPPLY MASTERPLAN: *FEASIBILITY STUDY FOR THE EXPANSION OF KARENGE WTP*	Drainage Basin Structure	*Nihon Suido Consultants CO., LTD. and Yachiyo Engineering Co., Ltd. joint venture in cooperation with Water & Sanitation Corporation (WASAC)*	MAMIYA Takemasa	2021.4.21	W08
			PREPARED BY NISHIDA Kosei	DATE 2021.4.21	SCALE 1:200



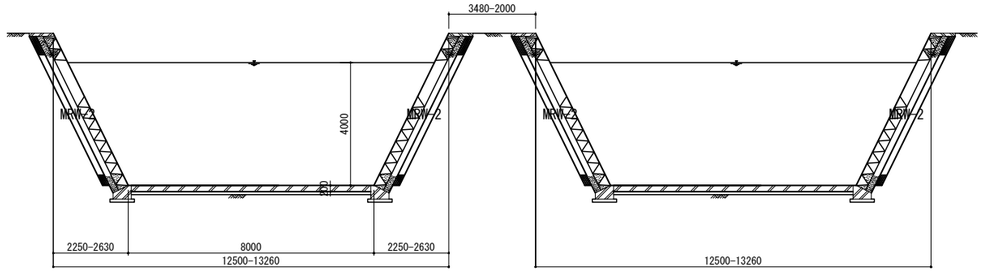
PLAN



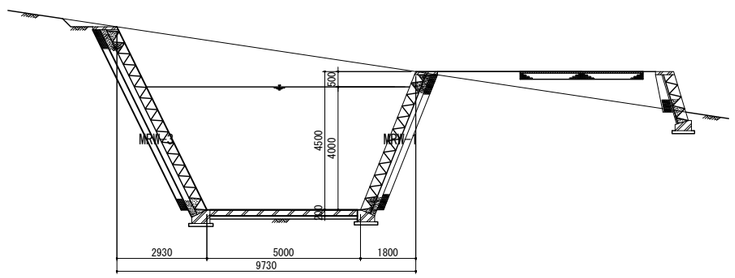
Inlet and Outlet Structure



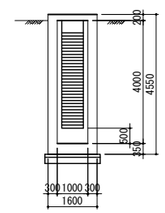
	1 : n	B (mm)
MRW-1	1:0.4	610
MRW-2	1:0.5	590
MRW-3	1:0.5	590



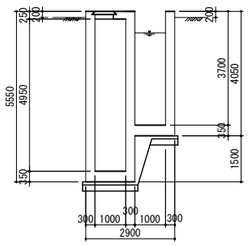
A - A section



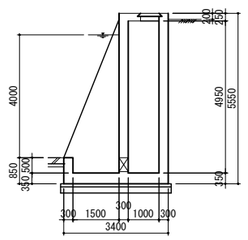
B - B section



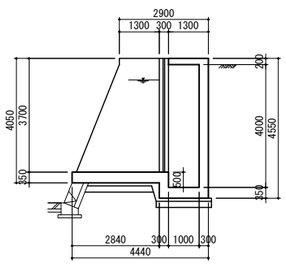
C - C section



D - D section

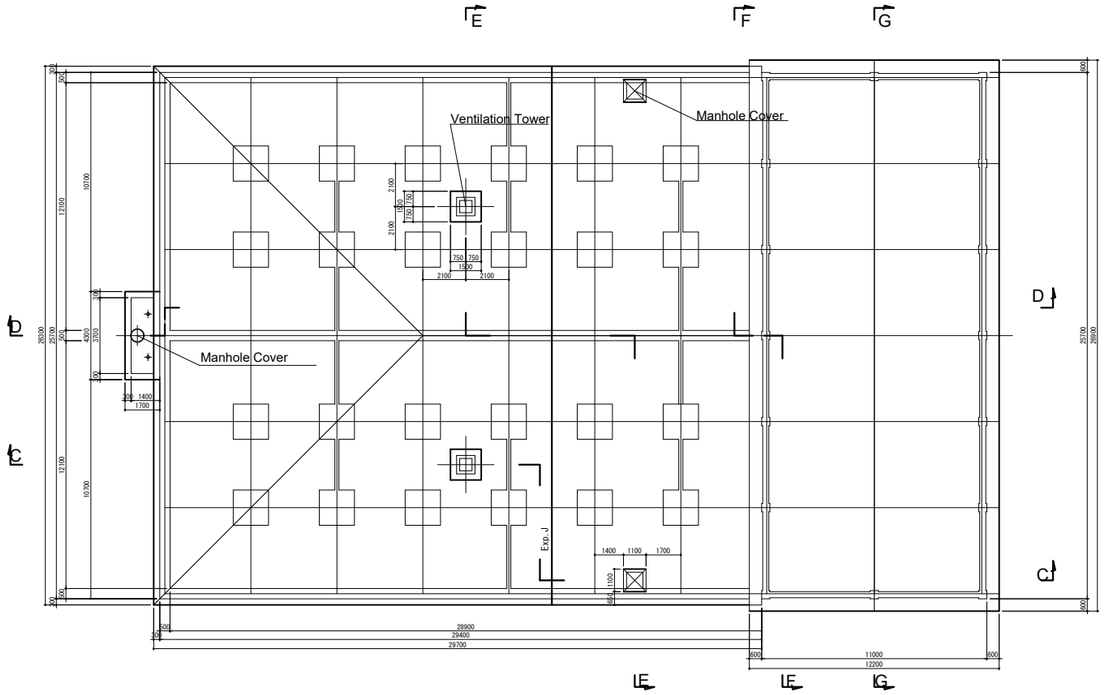


E - E section

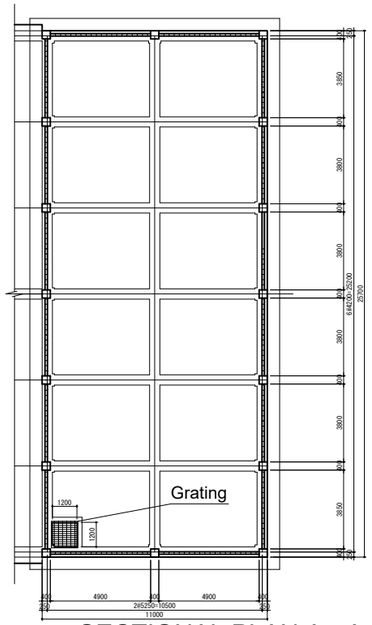


F - F section

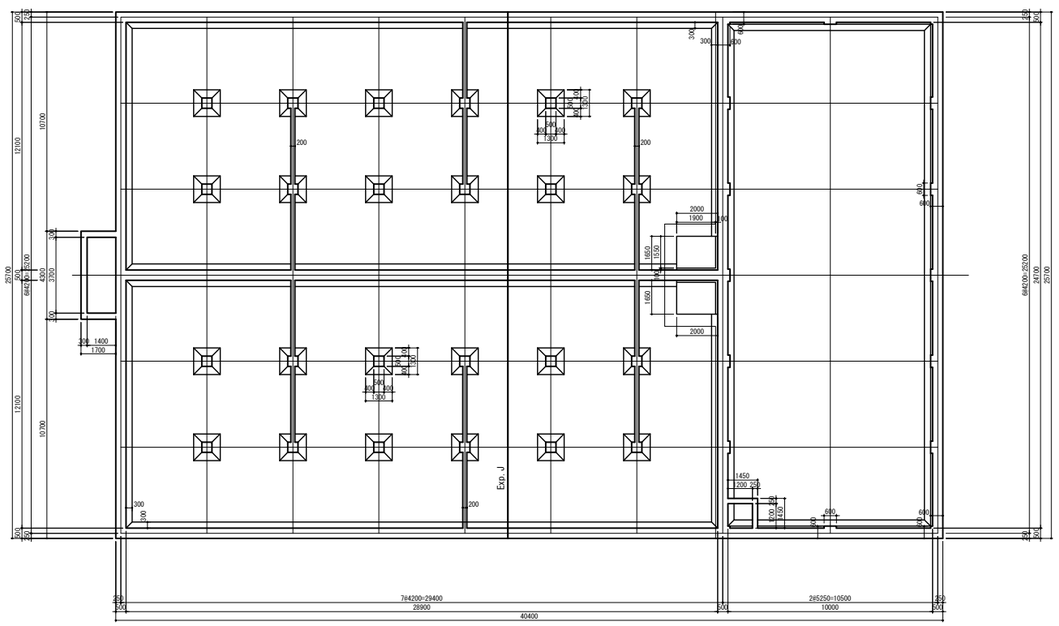
PROJECT *KIGALI WATER SUPPLY MASTERPLAN:* *FEASIBILITY STUDY FOR THE EXPANSION OF KARENGE WTP*	DESCRIPTION Sludge Storage Basin Structure	*Nihon Suido Consultants CO., LTD. and Yachiyo Engineering Co., Ltd. joint venture in cooperation with Water & Sanitation Corporation (WASAC)*	APPROVED BY MAMIYA Takemasa PREPARED BY NISHIDA Kosei	DATE 2021.4.21 DATE 2021.4.21	DRAWING No W09 SCALE 1:200



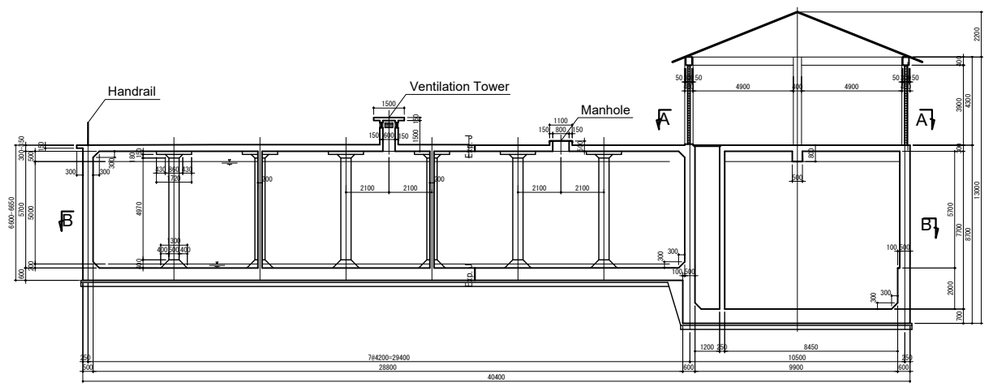
PLAN



SECTIONAL PLAN A - A

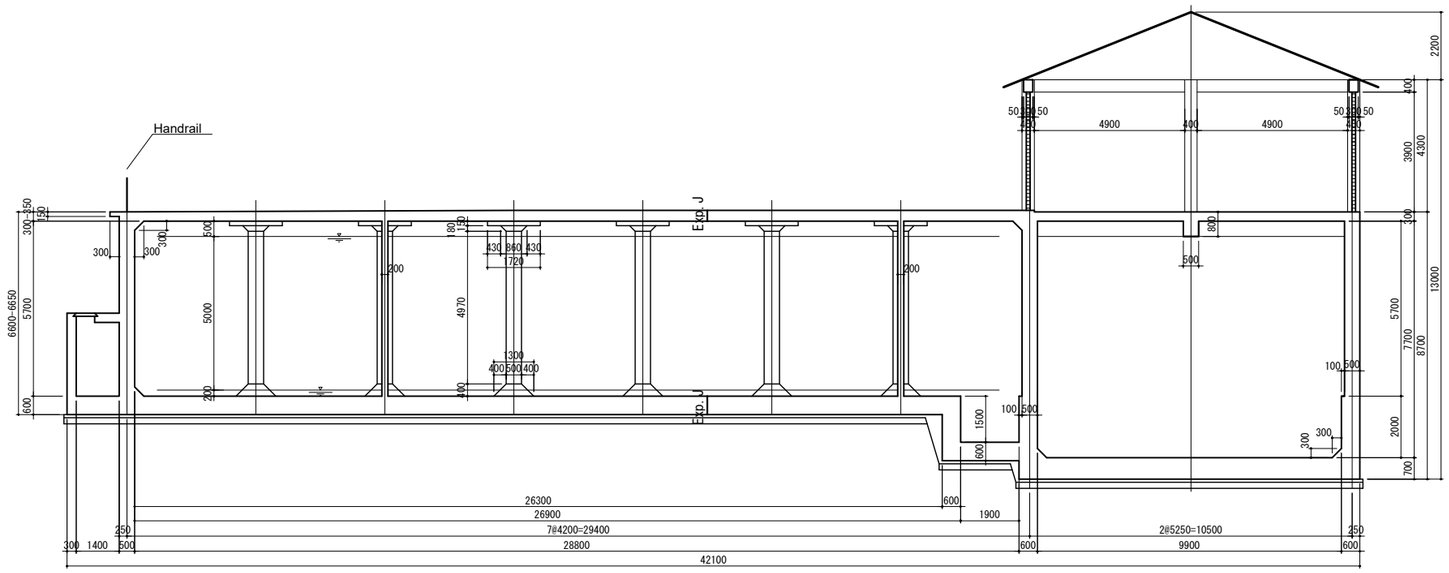


SECTIONAL PLAN B - B

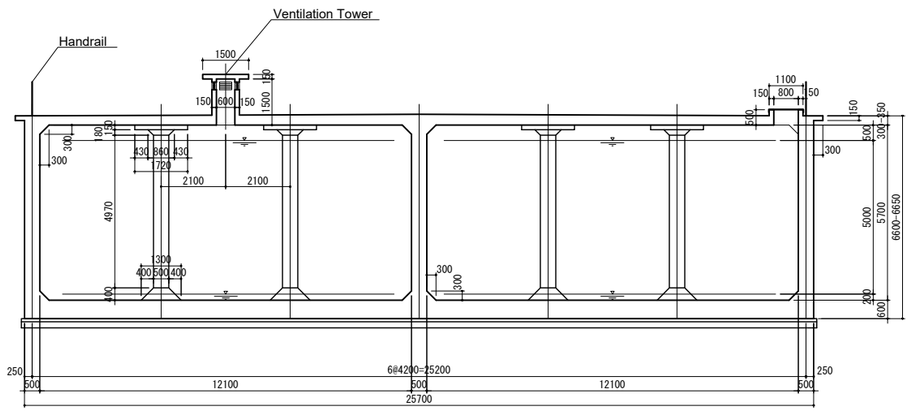


C - C section

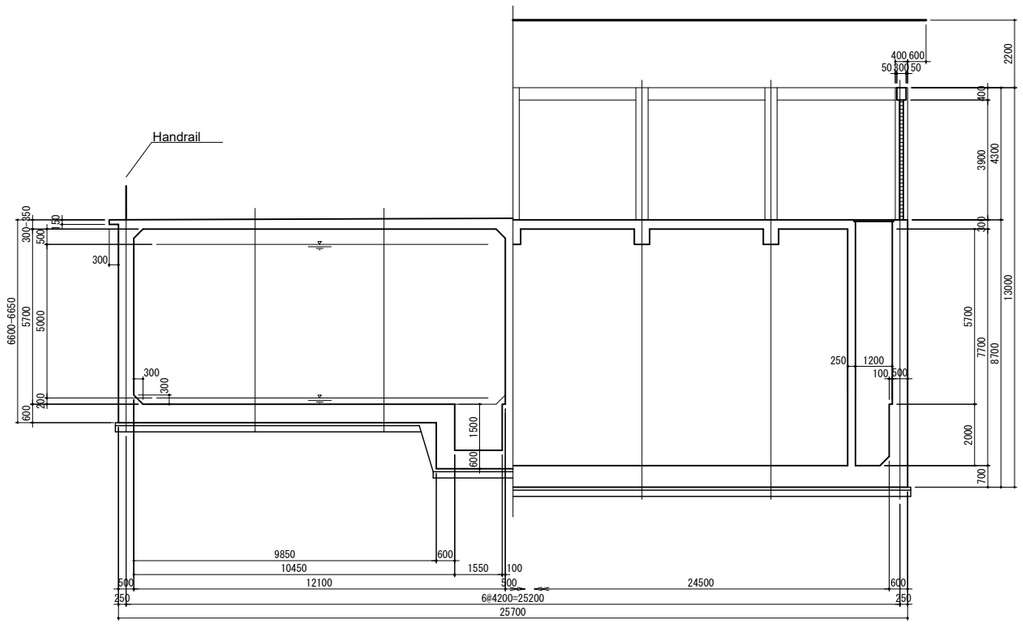
PROJECT	DESCRIPTION		APPROVED BY	DATE	DRAWING No
KIGALI WATER SUPPLY MASTERPLAN: *FEASIBILITY STUDY FOR THE EXPANSION OF KARENGE WTP*	Clear Water Reservoir Structure (1/2)	*Nihon Suido Consultants CO., LTD. and Yachiyo Engineering Co., Ltd. joint venture in cooperation with Water & Sanitation Corporation (WASAC)*	MAMIYA Takemasa	2021.4.21	W10
			PREPARED BY	DATE	SCALE
			NISHIDA Kosei	2021.4.21	1:300



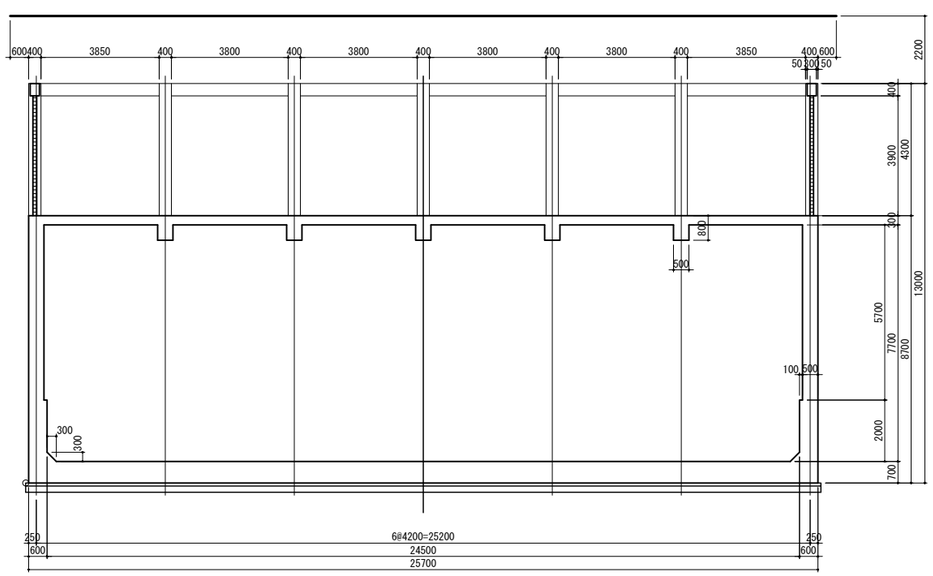
D - D section



E - E section

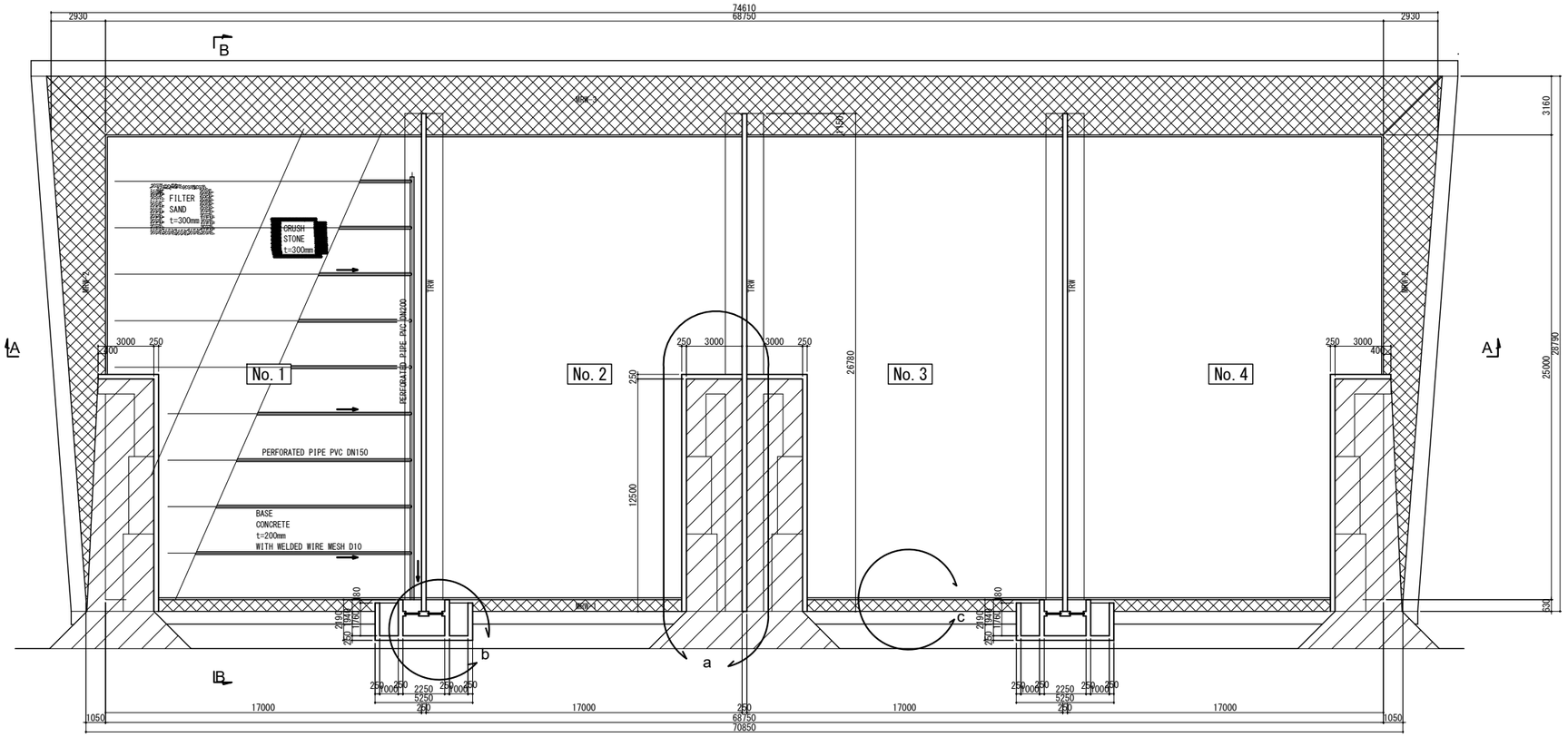


F - F section

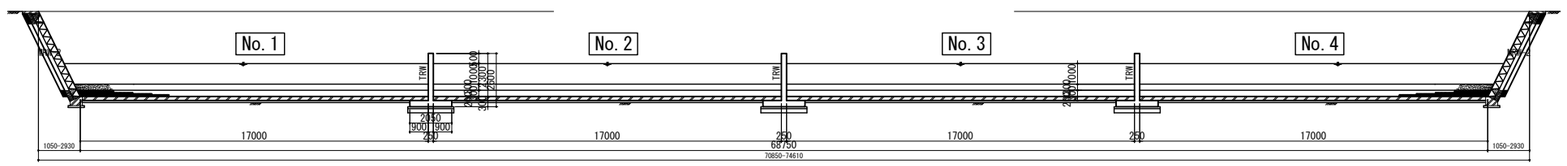


G - G section

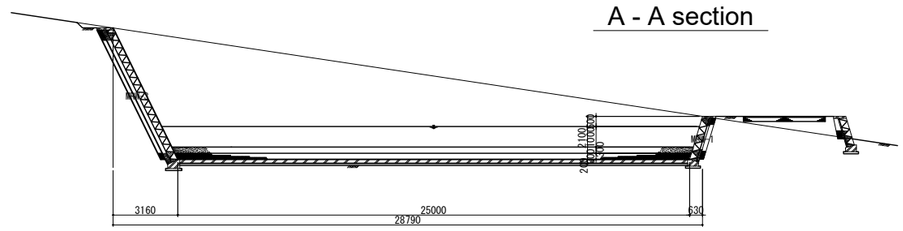
PROJECT *KIGALI WATER SUPPLY MASTERPLAN:* *FEASIBILITY STUDY FOR THE EXPANSION OF KARENGE WTP*	DESCRIPTION Clear Water Reservoir Structure (2/2)	*Nihon Suido Consultants CO., LTD. and Yachiyo Engineering Co., Ltd. joint venture in cooperation with Water & Sanitation Corporation (WASAC)*	APPROVED BY MAMIYA Takemasa	DATE 2021.4.21	DRAWING No W11
			PREPARED BY NISHIDA Kosei	DATE 2021.4.21	SCALE 1:200



Sectional Plan



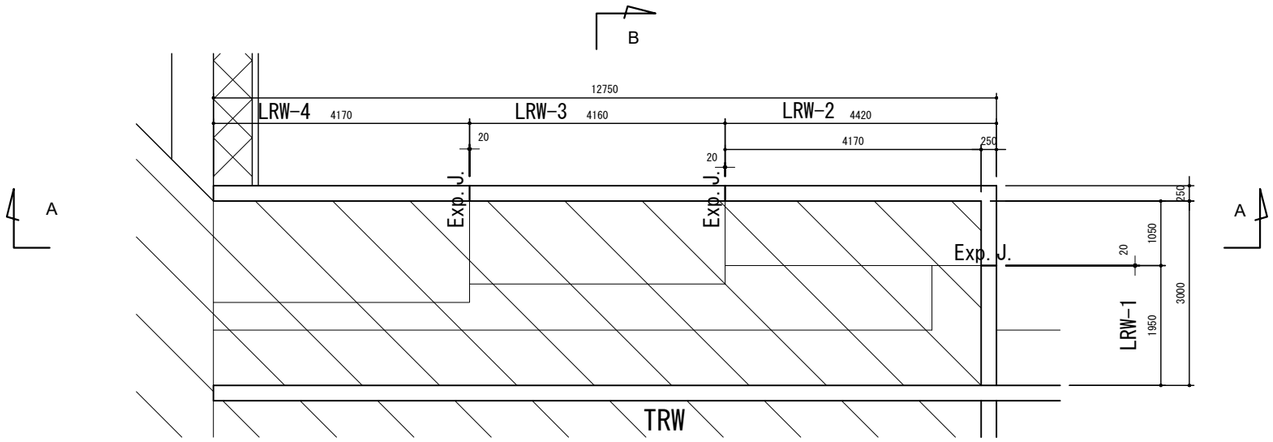
A - A section

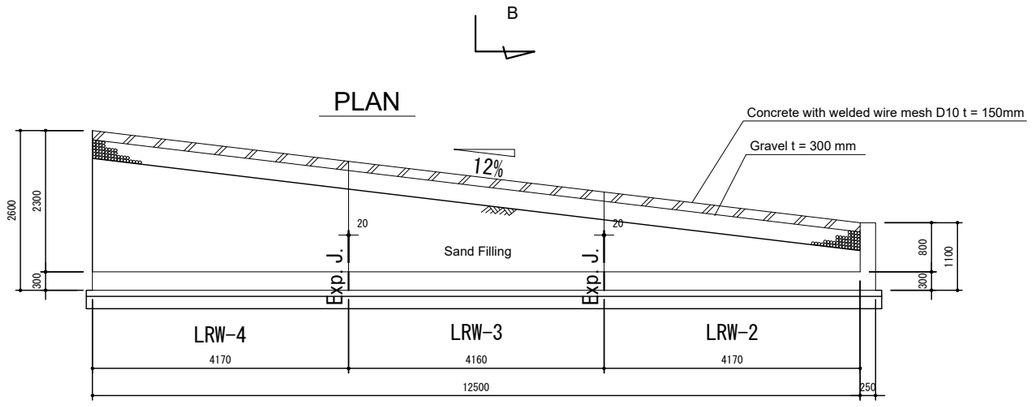


B - B section

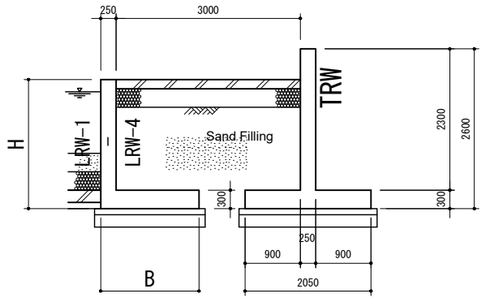
MRW : MASONRY RETAINING WALL
TRW : T-TYPE RETAINING WALL
LRW : L-TYPE RETAINING WALL

PROJECT	DESCRIPTION		APPROVED BY	DATE	DRAWING No
KIGALI WATER SUPPLY MASTERPLAN: *FEASIBILITY STUDY FOR THE EXPANSION OF KARENGE WTP*	Sludge Drying Bed Structure (1/2)	*Nihon Suido Consultants CO., LTD. and Yachiyo Engineering Co., Ltd. joint venture in cooperation with Water & Sanitation Corporation (WASAC)*	MAMIYA Takemasa	2021.4.21	W12
			PREPARED BY NISHIDA Kosei	DATE 2021.4.21	SCALE 1:300





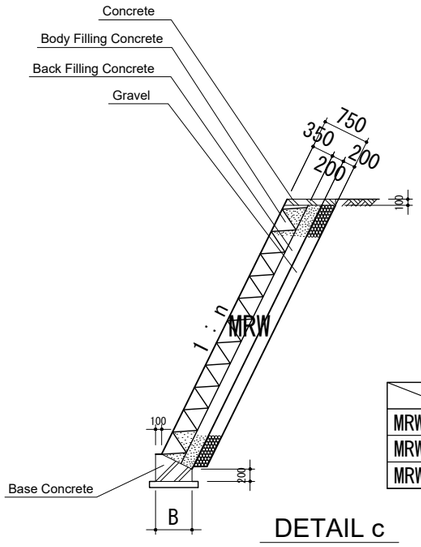
A - A section



B - B section

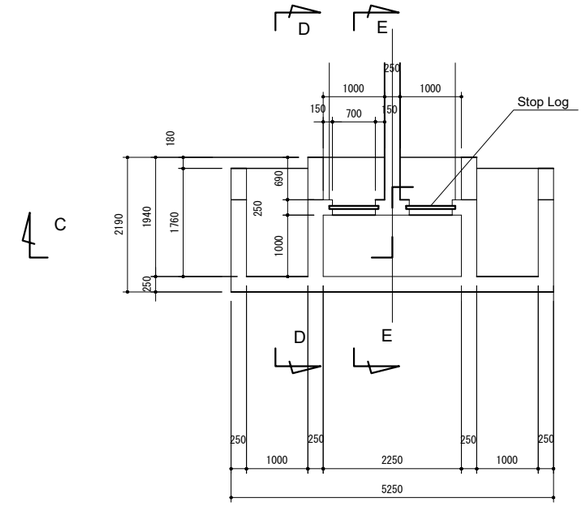
	H (mm)	B (mm)
LRW-1	1100	1050
LRW-2	1100-1600	1300
LRW-3	1600-2100	1600
LRW-4	2100-2600	1900

DETAIL a

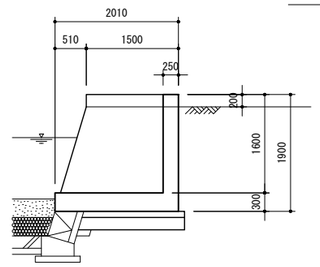


	1 : n	B (mm)
MRW-1	1:0.3	630
MRW-2	1:0.5	590
MRW-3	1:0.5	590

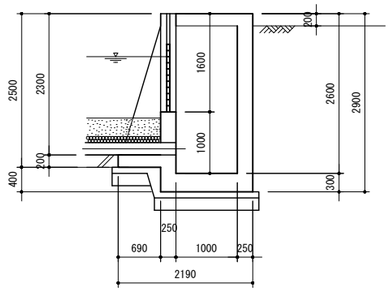
DETAIL c



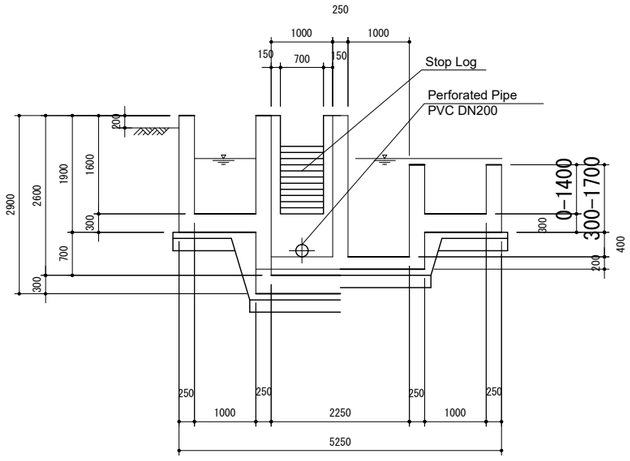
PLAN



D - D section



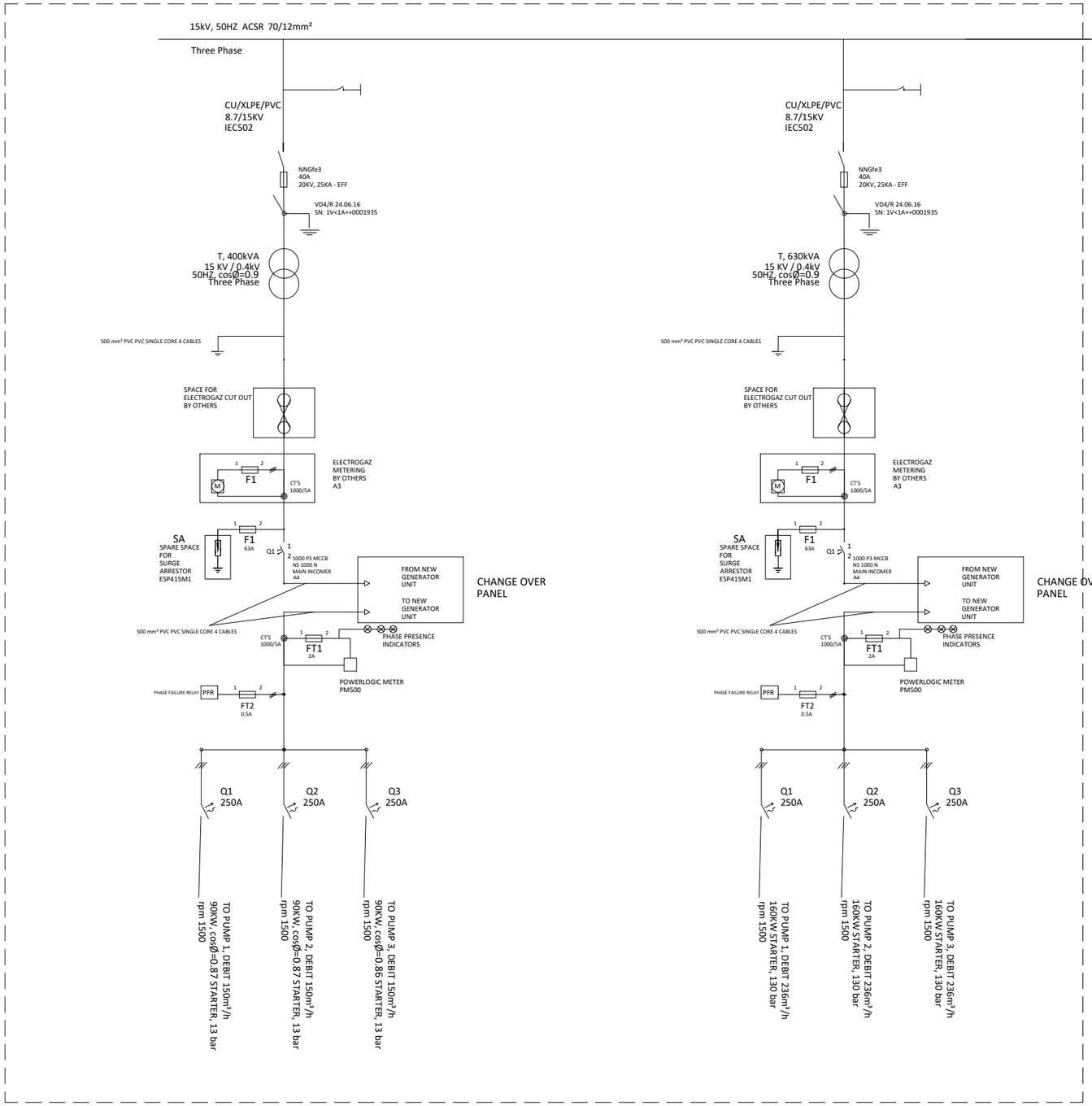
E - E section



C - C section

DETAIL b

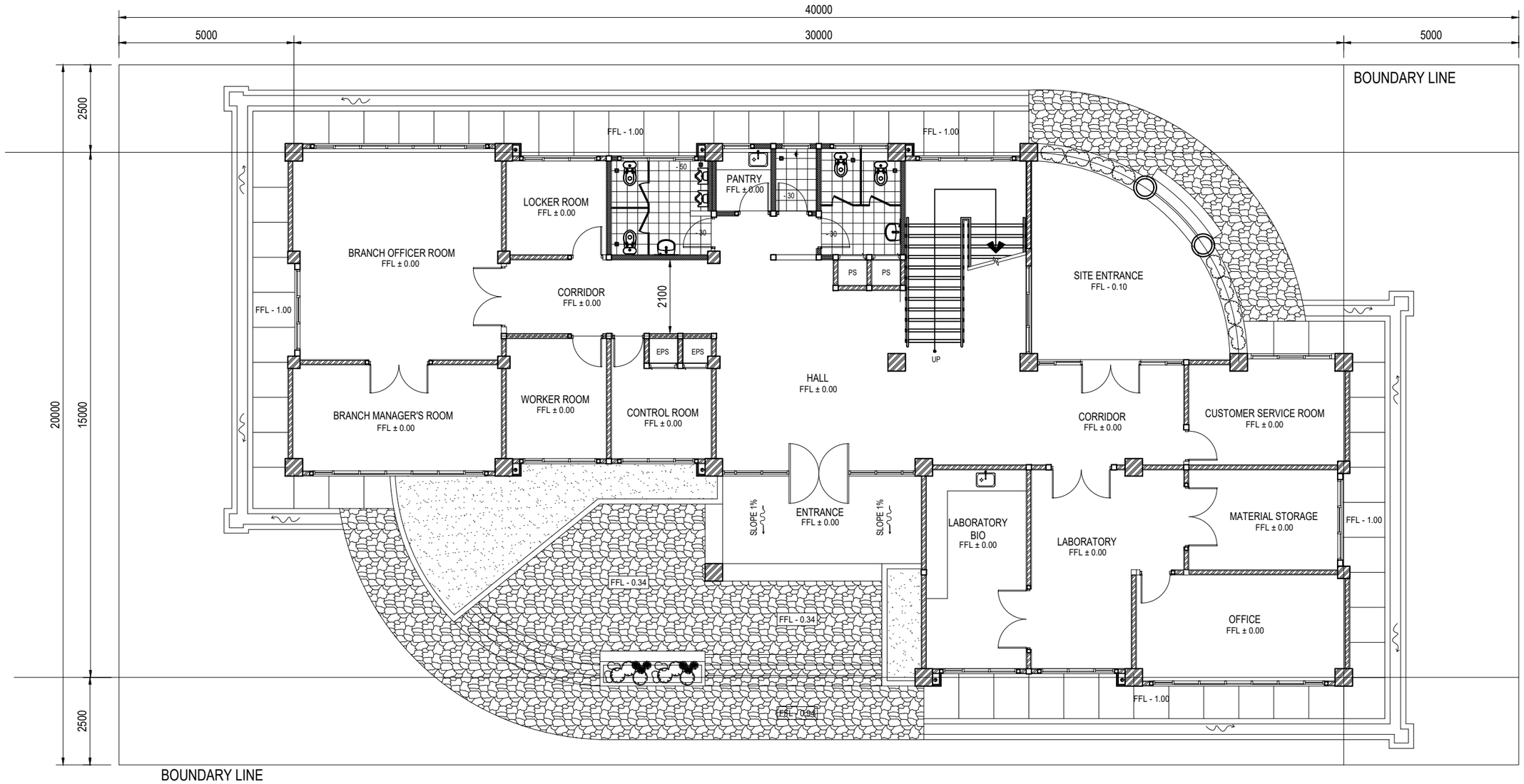
PROJECT	DESCRIPTION		APPROVED BY	DATE	DRAWING No
KIGALI WATER SUPPLY MASTERPLAN: *FEASIBILITY STUDY FOR THE EXPANSION OF KARENGE WTP*	Sludge Drying Bed Structure (2/2)	*Nihon Suido Consultants CO., LTD. and Yachiyo Engineering Co., Ltd. joint venture in cooperation with Water & Sanitation Corporation (WASAC)*	MAMIYA Takemasa	2021.4.21	W13
			PREPARED BY	DATE	SCALE
			NISHIDA Kosei	2021.4.21	1:100



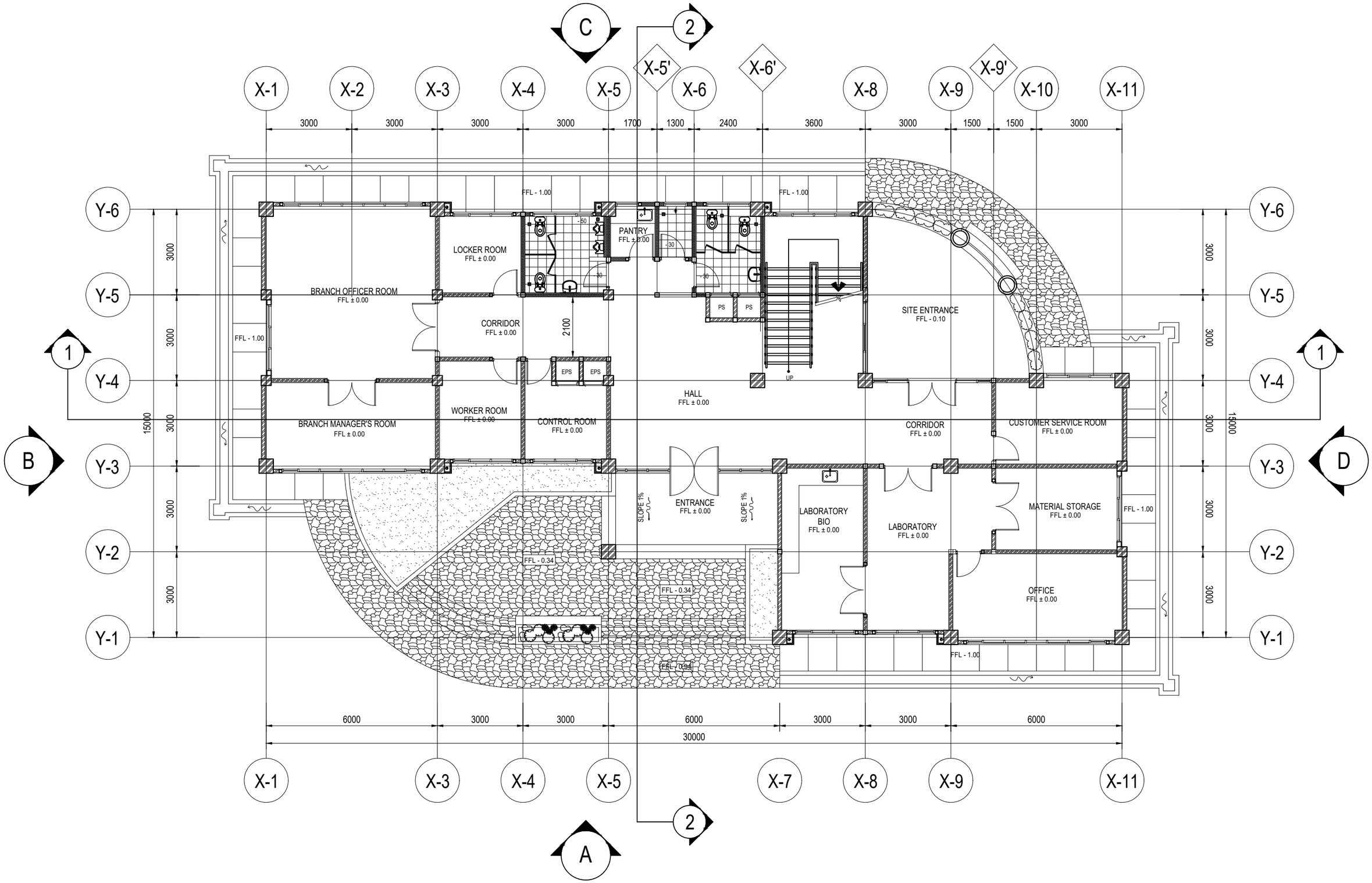
EXISTING

NEW

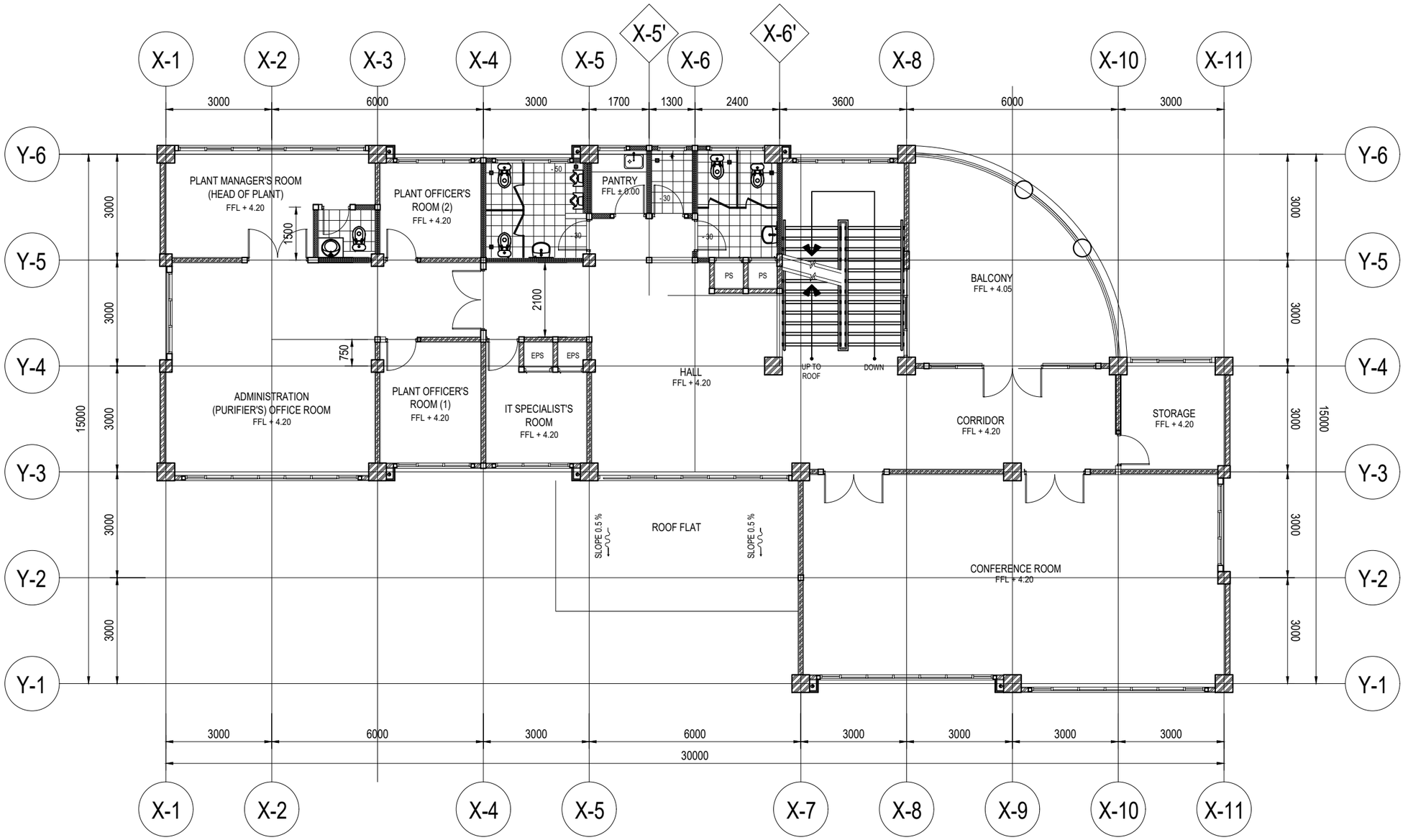
PROJECT *KIGALI WATER SUPPLY MASTERPLAN:* *FEASIBILITY STUDY FOR THE EXPANSION OF KARENGE WTP*	DESCRIPTION Single Line Diagram – Intake Pumping Station	*Nihon Suido Consultants CO., LTD. and Yachiyo Engineering Co., Ltd. joint venture in cooperation with Water & Sanitation Corporation (WASAC)*	APPROVED BY MAMIYA Takemasa	DATE 2021.4.21	DRAWING No W16
			PREPARED BY NISHIDA Kosei	DATE 2021.4.21	SCALE None



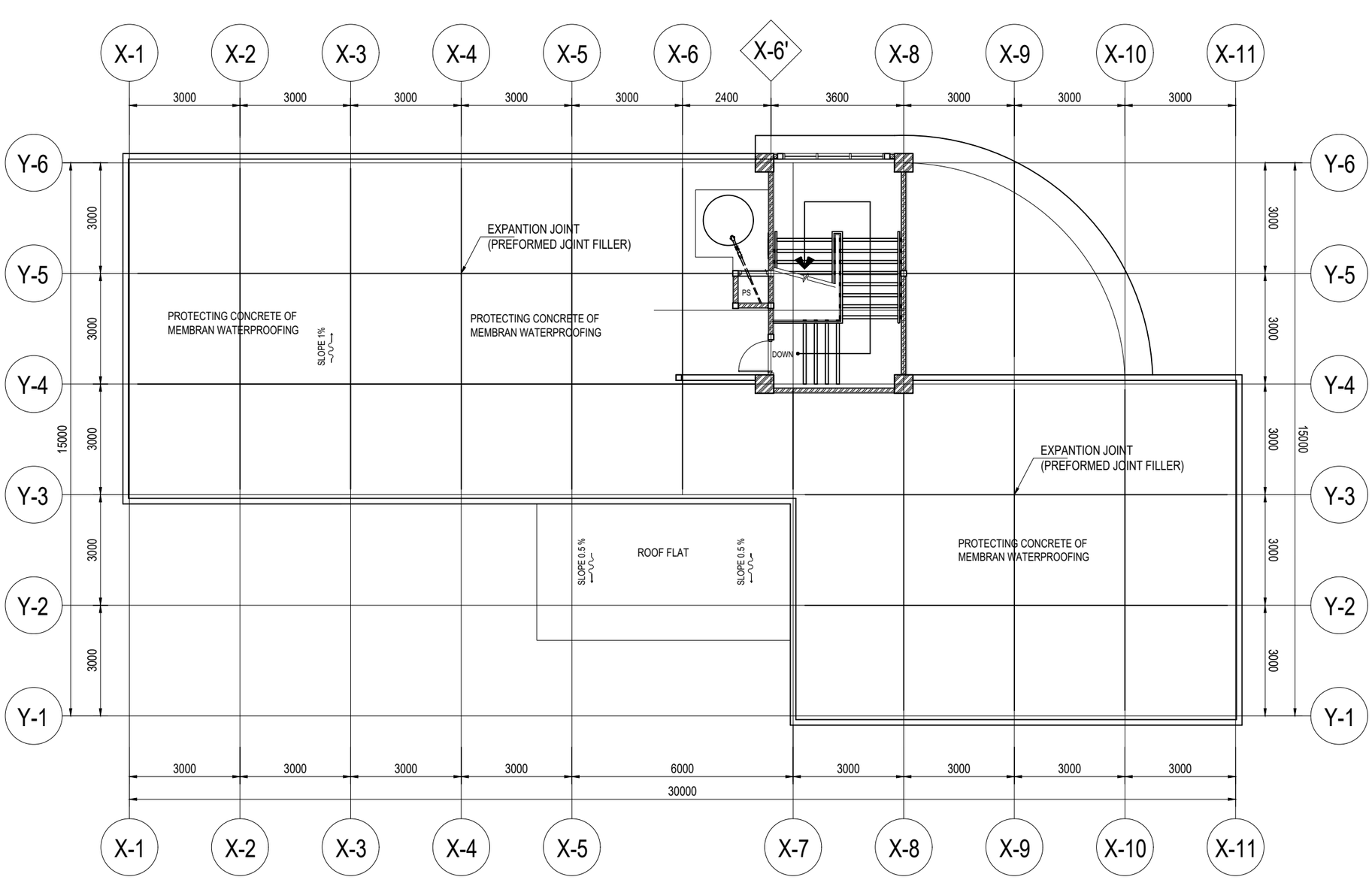
PROJECT	DESCRIPTION		APPROVED BY	DATE	DRAWING No
KIGALI WATER SUPPLY MASTERPLAN: *FEASIBILITY STUDY FOR THE EXPANSION OF KARENGE WTP*	Site Plan	*Nihon Suido Consultants CO., LTD. and Yachiyo Engineering Co., Ltd. joint venture in cooperation with Water & Sanitation Corporation (WASAC)*	**MAMIYA Takemasa**	**2020.12.31**	A01
			PREPARED BY **NISHIDA Kosei**	DATE **2020.12.31**	SCALE 1:125



PROJECT	DESCRIPTION		APPROVED BY	DATE	DRAWING No
KIGALI WATER SUPPLY MASTERPLAN: *FEASIBILITY STUDY FOR THE EXPANSION OF KARENGE WTP*	First Floor Plan	*Nihon Suido Consultants CO., LTD. and Yachiyo Engineering Co., Ltd. joint venture in cooperation with Water & Sanitation Corporation (WASAC)*	**MAMIYA Takemasa**	**2020.12.31**	A02
			PREPARED BY **NISHIDA Kosei**	DATE **2020.12.31**	SCALE 1:125



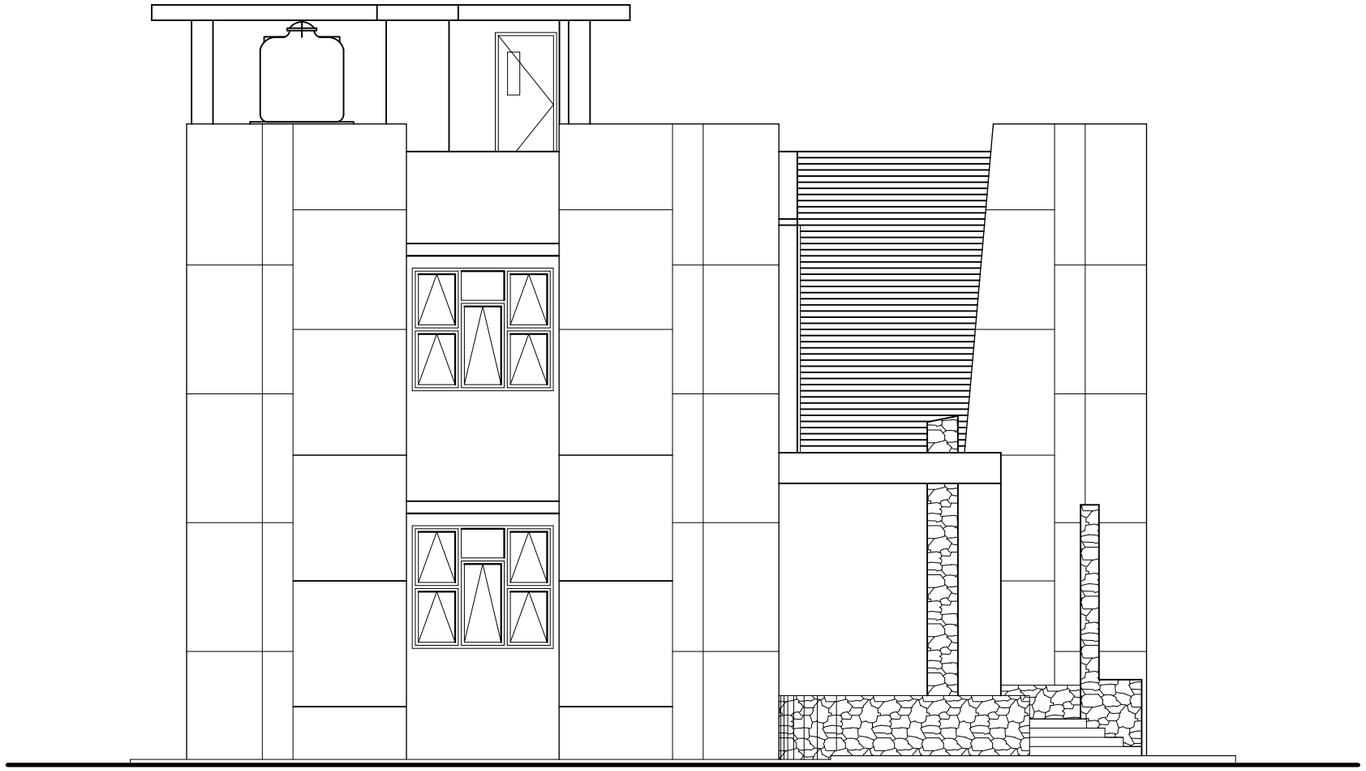
PROJECT	DESCRIPTION		APPROVED BY	DATE	DRAWING No
KIGALI WATER SUPPLY MASTERPLAN: *FEASIBILITY STUDY FOR THE EXPANSION OF KARENGE WTP*	Second Floor Plan	*Nihon Suido Consultants CO., LTD. and Yachiyo Engineering Co., Ltd. joint venture in cooperation with Water & Sanitation Corporation (WASAC)*	**MAMIYA Takemasa**	**2020.12.31**	A03
			PREPARED BY **NISHIDA Kosei**	DATE **2020.12.31**	SCALE 1:125



PROJECT	DESCRIPTION		APPROVED BY	DATE	DRAWING No
KIGALI WATER SUPPLY MASTERPLAN: *FEASIBILITY STUDY FOR THE EXPANSION OF KARENGE WTP*	Roof Floor Plan	*Nihon Suido Consultants CO., LTD. and Yachiyo Engineering Co., Ltd. joint venture in cooperation with Water & Sanitation Corporation (WASAC)*	**MAMIYA Takemasa**	**2020.12.31**	A04
			PREPARED BY **NISHIDA Kosei**	DATE **2020.12.31**	SCALE 1:125

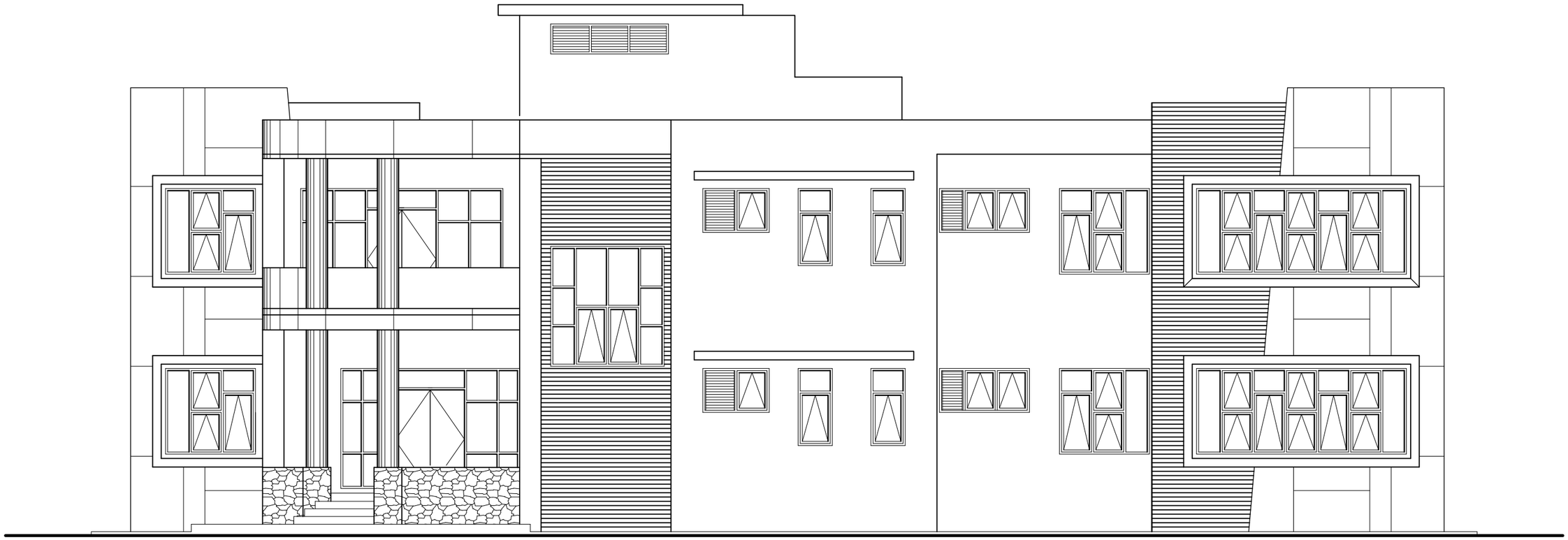
ELEVATION A

PROJECT	DESCRIPTION		APPROVED BY	DATE	DRAWING No
KIGALI WATER SUPPLY MASTERPLAN: *FEASIBILITY STUDY FOR THE EXPANSION OF KARENGE WTP*	Elevation A	*Nihon Suido Consultants CO., LTD. and Yachiyo Engineering Co., Ltd. joint venture in cooperation with Water & Sanitation Corporation (WASAC)*	**MAMIYA Takemasa**	**2020.12.31**	A05
			PREPARED BY **NISHIDA Kosei**	DATE **2020.12.31**	SCALE 1:100



ELEVATION B

PROJECT	DESCRIPTION		APPROVED BY	DATE	DRAWING No
KIGALI WATER SUPPLY MASTERPLAN: *FEASIBILITY STUDY FOR THE EXPANSION OF KARENGE WTP*	Elevation B	*Nihon Suido Consultants CO., LTD. and Yachiyo Engineering Co., Ltd. joint venture in cooperation with Water & Sanitation Corporation (WASAC)*	**MAMIYA Takemasa**	**2020.12.31**	A06
			PREPARED BY **NISHIDA Kosei**	DATE **2020.12.31**	SCALE 1:100



ELEVATION C

PROJECT	DESCRIPTION		APPROVED BY	DATE	DRAWING No
KIGALI WATER SUPPLY MASTERPLAN: *FEASIBILITY STUDY FOR THE EXPANSION OF KARENGE WTP*	Elevation C	*Nihon Suido Consultants CO., LTD. and Yachiyo Engineering Co., Ltd. joint venture in cooperation with Water & Sanitation Corporation (WASAC)*	**MAMIYA Takemasa**	**2020.12.31**	A07
			PREPARED BY **NISHIDA Kosei**	DATE **2020.12.31**	SCALE 1:100

ELEVATION D

PROJECT	DESCRIPTION		APPROVED BY	DATE	DRAWING No
KIGALI WATER SUPPLY MASTERPLAN: *FEASIBILITY STUDY FOR THE EXPANSION OF KARENGE WTP*	Elevation D	*Nihon Suido Consultants CO., LTD. and Yachiyo Engineering Co., Ltd. joint venture in cooperation with Water & Sanitation Corporation (WASAC)*	**MAMIYA Takemasa**	**2020.12.31**	A08
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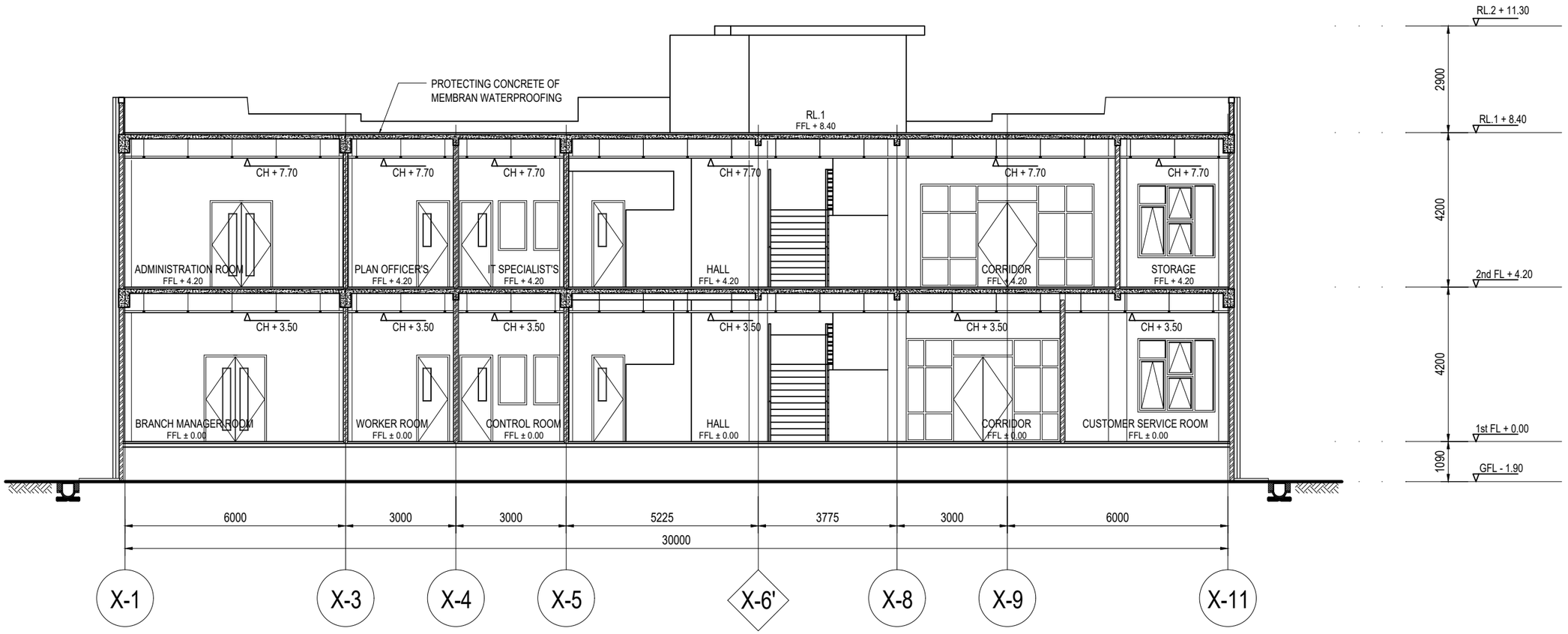
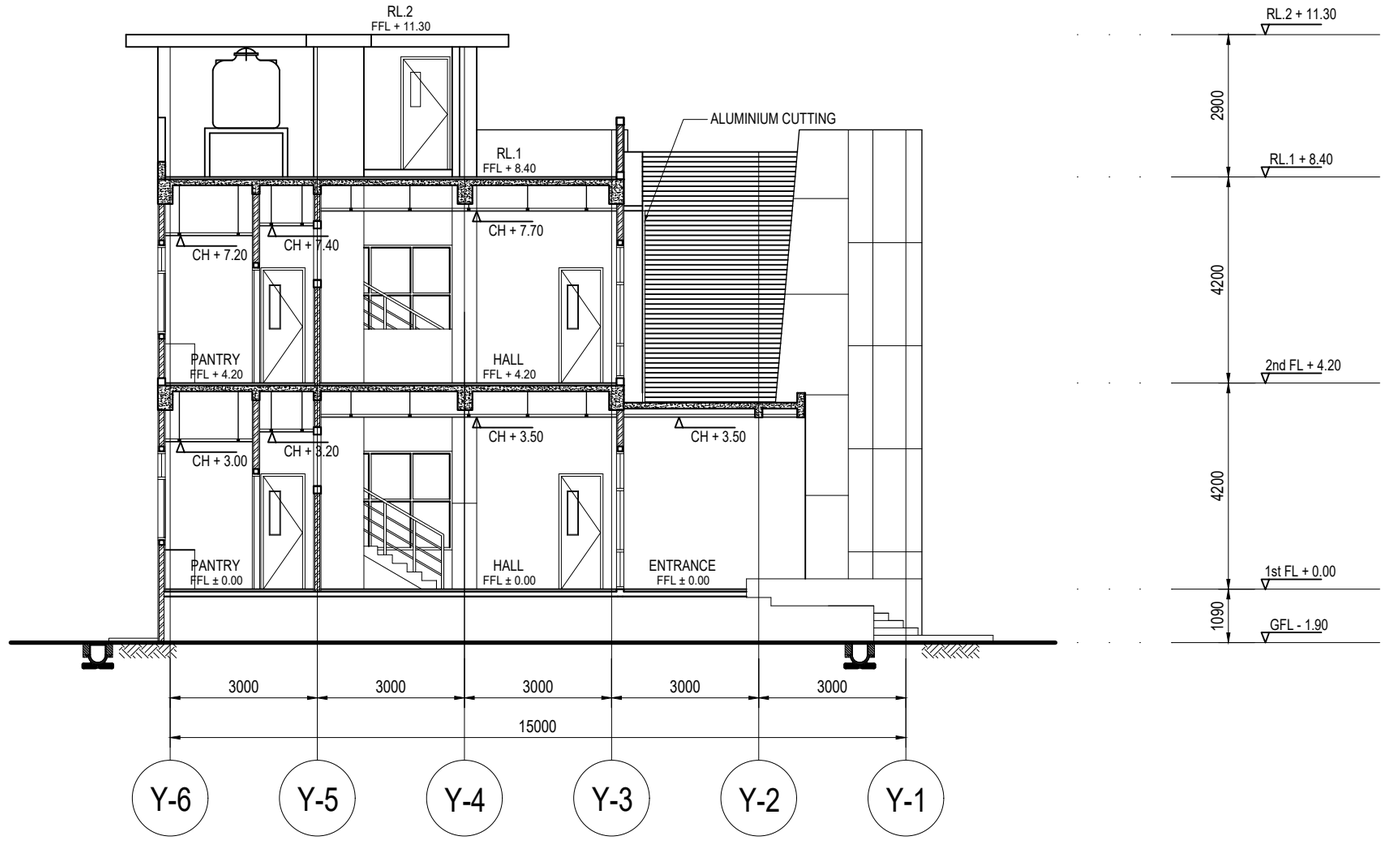


SECTION 1 - 1

PROJECT *KIGALI WATER SUPPLY MASTERPLAN:* *FEASIBILITY STUDY FOR THE EXPANSION OF KARENGE WTP*	DESCRIPTION Section 1−1	*Nihon Suido Consultants CO., LTD. and Yachiyo Engineering Co., Ltd. joint venture in cooperation with Water & Sanitation Corporation (WASAC)*	APPROVED BY **MAMIYA Takemasa**	DATE **2020.12.31**	DRAWING No A09
			PREPARED BY **NISHIDA Kosei**	DATE **2020.12.31**	SCALE 1:125



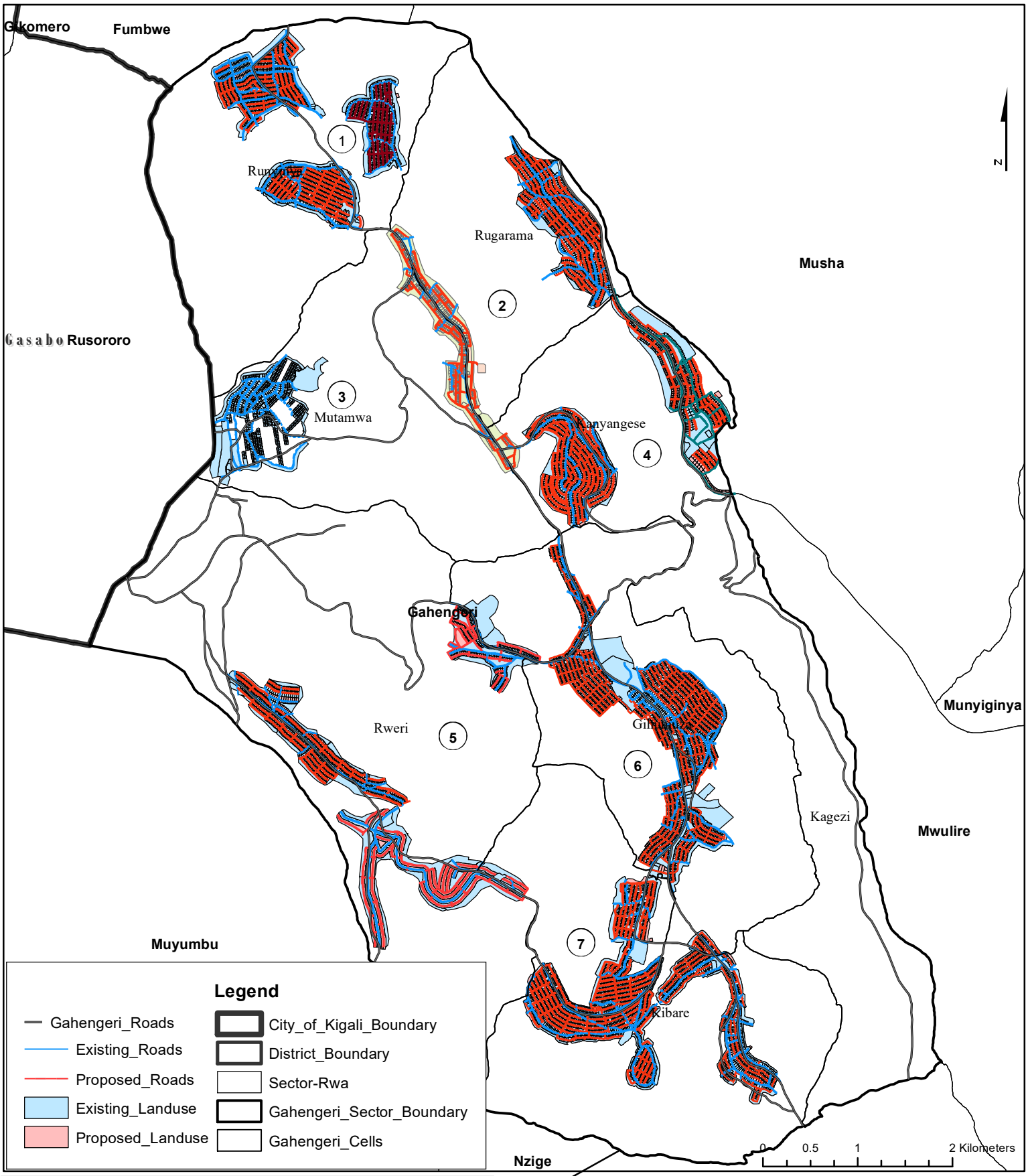
SECTION 2 - 2

PROJECT	DESCRIPTION		APPROVED BY	DATE	DRAWING No
KIGALI WATER SUPPLY MASTERPLAN: *FEASIBILITY STUDY FOR THE EXPANSION OF KARENGE WTP*	Section 2-2	*Nihon Suido Consultants CO., LTD. and Yachiyo Engineering Co., Ltd. joint venture in cooperation with Water & Sanitation Corporation (WASAC)*	**MAMIYA Takemasa**	**2020.12.31**	A10
			PREPARED BY **NISHIDA Kosei**	DATE **2020.12.31**	SCALE 1:125

APPENDIX B：Sector Masterplans for Gahengeri, Muyumbu Nyakaliro Sectors

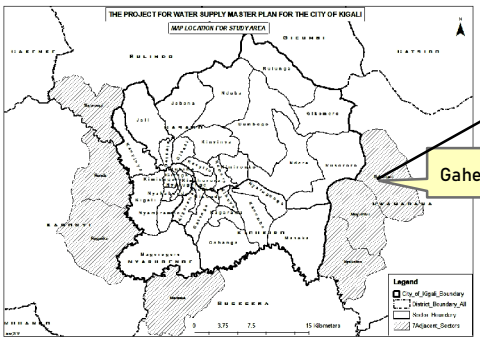
Appendix B Sector Masterplans for Gahenger i, Muyumbu Nyakaliro sectors

GAHENGERI SECTOR LAYOUT AND MASTER PLAN



Legend

- Gahengeri_Roads
- Existing_Roads
- Proposed_Roads
- Existing_Landuse
- Proposed_Landuse
- City_of_Kigali_Boundary
- District_Boundary
- Sector-Rwa
- Gahengeri_Sector_Boundary
- Gahengeri_Cells



① RUNYINYA

② RUGARAMA

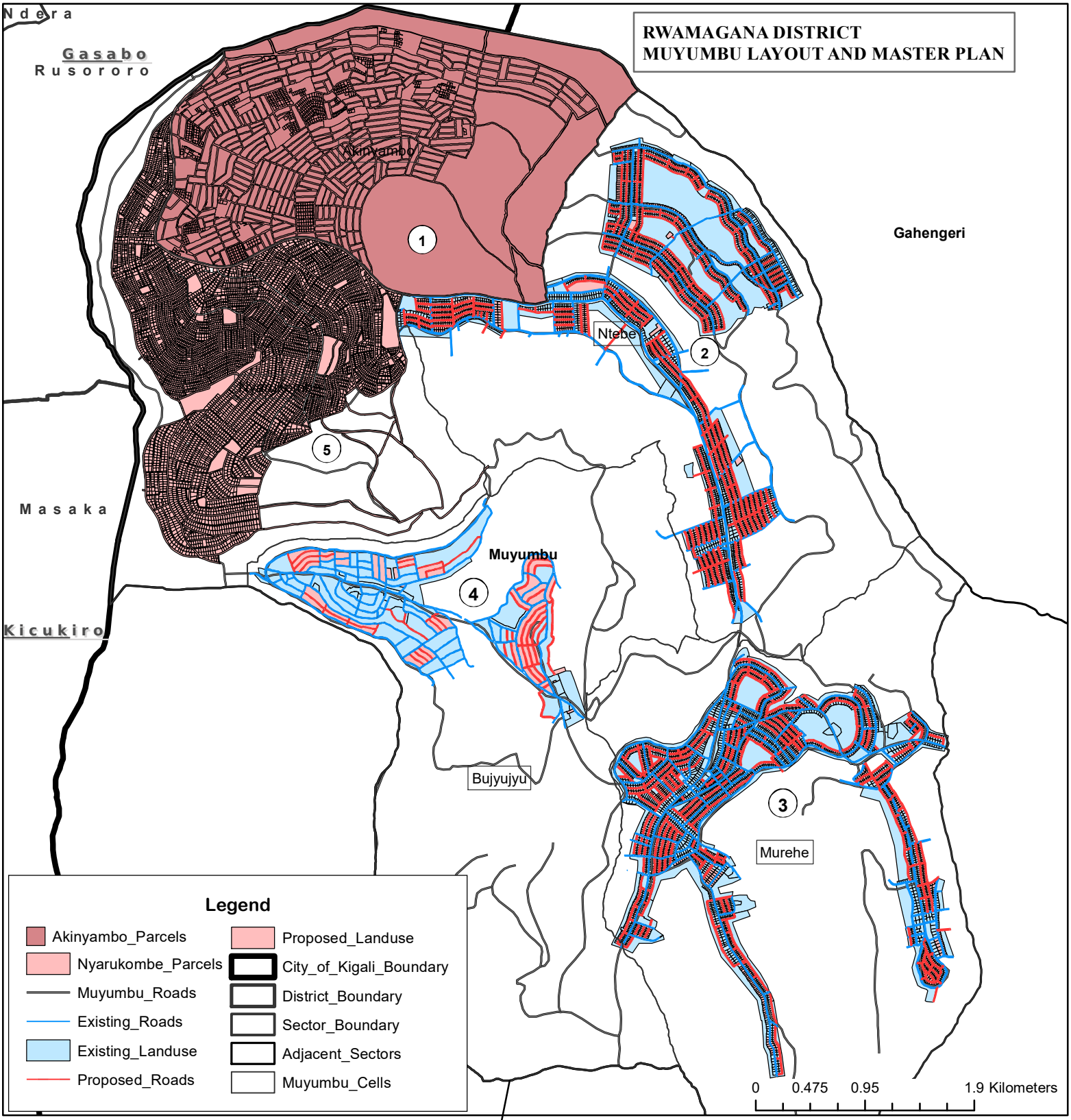
③ MUTAMWA

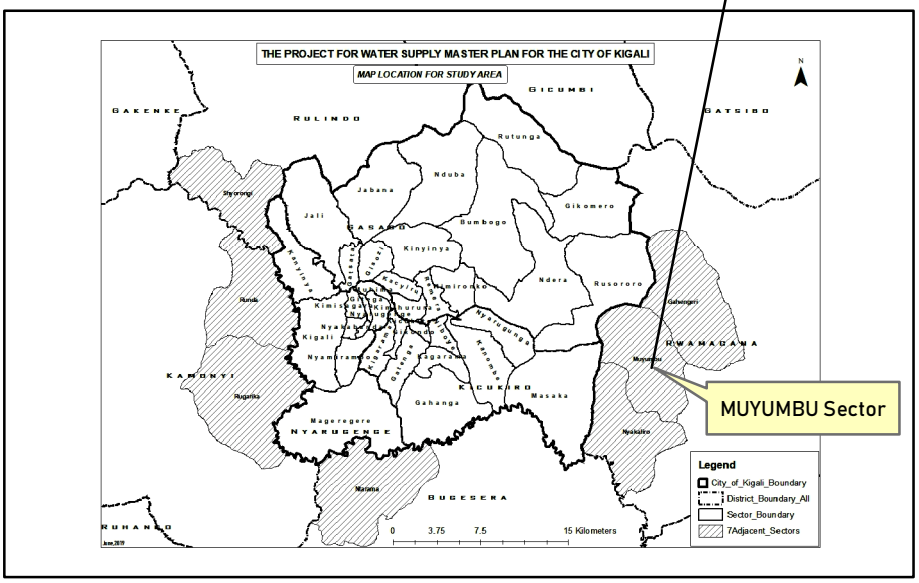
④ KANYANGESE

⑤ RWERI

⑥ GIHUMUZA

⑦ KIBARE





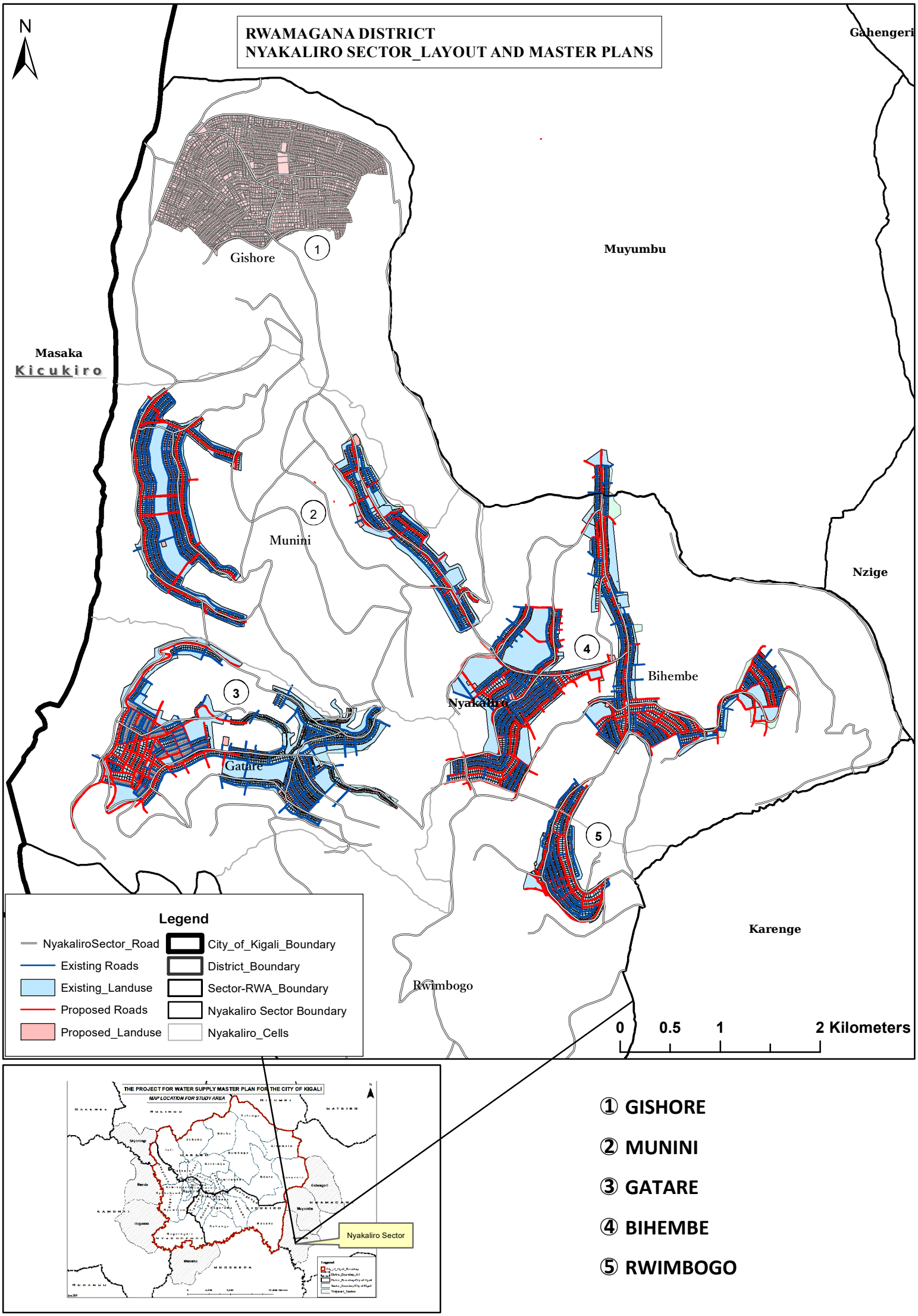
① AKINYAMBO

② NTEBE

③ MUREHE

④ BUJYUJYU

⑤ NYARUKOMBE


RWAMAGANA DISTRICT
NYAKALIRO SECTOR_LAYOUT AND MASTER PLANS
N
Gahengeri
Muyumbu
Gishore
1
Masaka
Kicukiro
2
Munini
Nzige
4
Bihembe
3
Nyakaliro
Gatare
5
Karenge
Rwimbogo
Legend
NyakaliroSector_Road
Existing Roads
Existing_Landuse
Proposed Roads
Proposed_Landuse
City_of_Kigali_Boundary
District_Boundary
Sector-RWA_Boundary
Nyakaliro Sector Boundary
Nyakaliro_Cells
0
0.5
1
2 Kilometers
THE PROJECT FOR WATER SUPPLY MASTER PLAN FOR THE CITY OF KIGALI
MAP LOCATION FOR STUDY AREA
Nyakaliro Sector
① GISHORE
② MUNINI
③ GATARE
④ BIHEMBE
⑤ RWIMBOGO

APPENDIX C：Documentation on Water Withdrawal Permissions

Appendix C- Documentation on water withdrawal permissions

O/N	WATER SOURCE	VOLUME/AREA	USE/AUTHORIZED ACTIVITY	LOCATION
1	Nyiramupaka river		Industrial (processing wooden electricity pole) and ancillary uses	Nyungwe buffer zone: Southern Provence, Nyamagabe District, Uwinkingi Sector, Rugogwe Cell
2	Rwibishanyi Stream	21.73 m3/day	Irrigation	Eastern Provence, Ngoma District, Rurenge&Remera Sectors, Jango Cell, Mubuga Village
	Groundwater/Boreholes	130 m3/day	Livestock watering	Eastern Provence, Bugesera District,
3	Sebeya river	114 m3/day	Industrial (tea processing) & residential	Western Provence, Rubavu District, Nyundo Sector
4	Kihene&Gisema rivers	276.48 m3/day	Aquaculture in fish ponds	Biringanya/Bunyogombe Marshland, Sourthern Provence, Ruhango District, Ruhango Sector,
5	Kivu Lake	120 ha 51 a 88 ca	Aquaculture using cages	Western Provence, Karongi District, Bwishyura Sector, Kiniha Village
6	Ngozi Stream	5 m3/day	Washing mineral ores	Northern Provence, Gakenke District, Ruli Sector, Jango Cell, Mubuga Village
7	Nyakiramba Stream	0.033 m3/s	Electricity generation	Sourther Provence, Muhanga District, Kibangu Sector, Jurwe Cell
8	Gitare Spring	56.7 m3/day	Water Bottling Business	Northern Provence, Rulindo District, Bushaki Sector, Giko Cell
9	Congori Stream	0.3 L/s	Washing mineral ores	Northern Provence, Gakenke District, Ruli Sector, Busoro Cell,
	Ngozi Stream	0.5 L/s	Washing mineral ores	Northern Provence, Gakenke District, Ruli Sector, Mubuga Cell
	Rutumba Stream	0.44 L/s	Washing mineral ores	Washing mineral ores
	Kimporobwe Stream	0.5 L/s	Washing mineral ores	Northern Provence, Gakenke District, Ruli Sector, Ruli Sector, Gikingo Cell
	Maryohe Stream	0.8 L/s	Washing mineral ores	Northern Provence, Gakenke District, Ruli Sector, Ruli Sector, Gikingo Cell
	Bubwe Stream	0.5 L/s	Washing mineral ores	Northern Provence, Gakenke District, Ruli Sector, Ruli Sector, Busoro Cell
10	Nyamabuye Stream	0.0081 L/s	Washing mineral ores	Northern Provence, Gakenke District, Rushashi
11	Confluence stream of outlet of Artificial pond (Nyagahene) stream and	1,391.04 m3/day	Irrigating the golf course	Kigali City, Gasabo District, Remera Sector, Nyarutarama Cell
12	Akanyaru River	8,640 m3/day	Industrial use, Electricity generation and other general use on power plant site	Sourthern Provence, Gisagara District, Mamba Sector, Nunga Cell
		10,800 m3/day		
		75 m3/day	Potable services and construction activities	Southern Provence, Gisagara District, Mamba Sector, Kabumbwe Cell, Buye Village
13	Lake Muhazi		Aquaculture using cages	Eastern Provence, Rwamagana District, Fumbwe Sector, Ituze Village
14	Lake Mugesera	17.5 m3/day	Irrigation	Eastern Provence, Rwamagana District, Rubona Sector, Byinza Cell
15	Lake Burera	0.014 m3/s	Mining	Northern Provence, Burera District, Kagogo Sector, Nyamabuye Cell, Gitare Village
16	Ruturirwa River	0.00046 m3/s	Mining	Western Provence, Ngororero District, Sovu Sector, Gashubi Cell
	Kazibira stream	0.0000864 m3/s	Mining	Western Provence, Rubavu District, Nyamyumba Sector, Busoro Cell
	Gashoka stream	0.0003224 m3/s	Mining	Western Provence, Rubavu District, Nyamyumba Sector, Busoro Cell
	Gakararanka river	0.0035 m3/s	Mining	Western Provence, Ngororero District, sovu and Bwira Sectors, Gashubi and Kinyinya Cells
17	Lake Muhazi	5 ha	Aquaculture using cages	Northern Provence, Gicumbi District, Bukure Sector, Kivumu cell, Karambo Village
18	Lake Muhazi	68 ha	Aquaculture using cages	Easter Provence, Rwamagana District, Musha Sector, Nyabisindu cell
19	Two wells on Akagera River	0.017 m3/s	Industrial	Easter Provence, Bugesera District, Ntarama Sector, Kanzenze cell, Kabaha Village
20	Rufigiza River	0.00108 m3/s	Aquaculture in fish ponds	Kigali City, Gasabo District, Kinyinya Sector, Kagugucell, Kagarama Village
21	Lake Mirayi	0.003 m3/s	Aquaculture in fish ponds	Easter Provence, Bugesera District, Gashora Sector, Gashora cell, Mwendo Village
	Lake Mirayi	4.5 ha	Aquaculture using cages	Easter Provence, Bugesera District, Gashora Sector, Gashora cell, Mwendo Village
22	Natural spring	10 m3/s	Mining	Easter Provence, Gatsibo District, Murambi Sector, Rwankuba cell
	Muhazi Lake	1000 m3/day	Mining	Easter Provence, Gatsibo District, Murambi Sector, Rwankuba cell
25	Borehole/Well (Aquifer from south bank of Nyabarongo River)	40,000 m3/day	Domestic water supply	Kanzenze cell, Ntarama sector, Bugesera District, Eastern Province
26	Kazibira stream	0.000183 m3/s	Mining	Western Provence, Rubavu District, Nyamyumba Sector, Kiraga Cell, Kigufi village
	Nyaruhonga stream	0.000183 m3/s	Mining	Western Provence, Rubavu District, Nyamyumba Sector, Kiraga Cell, Kigufi village
27	Bwangacumu stream	0.0028 m3/s	Mining	Sourthen Provence, Muhanga District, Nyarusange Sector, Musongati&Rusovu Cells,
28	1. Rwondo River		Electricity generation	1. Mushubi sector, Nyamagabe district, Sourthern Province
	2. Akanyaru River			2. Busanze sector, Nyaruguru district, Sourthern province
	3. Santinsyi River			3. Ngororero district, Western province
	4. Base River I & Base River			4. Gakenke district Northern province

29	Nyamuhindura stream	0.01 m3/s	Electricity generation	Sourthen Provence, Muhanga District, Kiyumba Sector, Rukeri Cell, Rusagara village
30	Mpenge river	737917 m3/s	Electricity generation	Northern Provence, Musanze District, Muhoza Sector, Cyabararika Cell, Gasanze&Buhuye villages
31	Ruhondo Lake	2.5 ha	Aquaculture using cages	Northern Provence, Musanze District, Gashaki Sector, Kigabiro Cell, Musekera village
32	Ruhondo Lake	24.2 ha	Aquaculture using cages	Northern Provence, Musanze District, Gashaki Sector, Kavumu&Kigabiro Cells, Kavumu, Burango, Butati, Shanga&Birwa villages
33	Ruhondo Lake	1.6 ha	Aquaculture using cages	Northern Provence, Musanze District, Gashaki Sector, Kigabiro Cell, Butati village
34	Ruhondo Lake	1.5 ha	Aquaculture using cages	Northern Provence, Musanze District, Gashaki Sector, Kigabiro Cell, Musekera village
35	Cyohoha Lake South	370.2 m3/day	Irrigation	Eastern Provence, Bugesera District, Kamabuye sector, Biharagu Cell, Rubugu Village
36	Geothermal exploration by drilling 5 temperature gradient wells		Electricity generation	Western Provence, Rusizi District, Mashyuza concession (CIMERWA)
	Geothermal exploration by drilling 2 temperature gradient wells		Electricity generation	Western Provence, Rusizi District, Gikundamvura sector
37	Rumira Lake	13 m3/d	Domestic	Eastern Provence, Bugesera District, Gashora sector, Kagomasi Cell
38	Gikarara I, II and III	372 m3/day	Domestic, Industrial	Western Provence, Nyamasheke District, Karambi Sector, Gasovu cell, Gasamba village/Nyungwe Forest
	Kigogo stream	132.2 m3/day		Western Provence, Nyamasheke District, Rangiro Sector, Gakenke cell, Rwasa village/Nyungwe Forest
39	Akagera River	1,200 m3/day		Eastern Provence, Kirehe District, Mahama sector, Munini Cell
40	Muhazi Lake	5 ha	Aquacultureusing cages	Eastern Province, Rwamagana District, Musha Sector, Budahanda cell
41	Kivu Lake	3 ha	Aquacultureusing cages	Western Provence, Nyamasheke District, Nyabitekeri Sector, Gasovu cell, Ntango cell, Nyamirundi village
42	Rubagabaga river	90% of available flow at any time	Electricity generation	Western Provence, Ngororero District, Shyira sector, Binana cell, Kaseke village,
43	Mukungwa river	90% of available flow at any time	Electricity generation	Northern Provence, Musanze District, Muko ans Rwaza sectors, Nturo cell cell, Buhuye and Kiryi
44	Kivu Lake	3 ha	Aquaculture using cages	Western Provence, Karongi District, Bwishyura Sector, Kibuye cell, Gatwaro&Ruganda villages
45	Rusebeya spring	0.0021 m3/s	Industrial (tea processing)	NorthernProvence, Gicumbi District, Cyumba Sector, Nyaruka cell,
	Butozo spring	0.00404 m3/s	Industrial (tea processing)	NorthernProvence, Gicumbi District, Kaniga Sector, Mulindi cell, Nyakabungo village
46	Muhazi Lake	6,000 m3/day	Irrigation (60 ha)	Eastern Provence, Rwamagana District, Munyiginya Sector, Nkomangwa cell,
47	Mwange stream	0.42 m3/s	Electricity generation	NorthernProvence, Gicumbi District, Kageyo Sector, Kabuga cell, Mulama village
48	Kivu Lake	4 ha	Aquacultureusing cages	Western Provence, Nyamasheke District, Kanjongo Sector, Kibogora cell, Maseka & Kabuya villages
49	Muhazi Lake	18.5 ha	Aquaculture using cages	Eastern Provence, Rwamagana District, Munyiginya Sector, Nyarubuye cell, Nkindi village
	Kivu Lake	9 ha	Aquaculture using cages	Western Provence, Rubavu District, Nyamyumba Sector, Kiraga cell, Kigufi and Nyaruhonga villages
50	Kivu Lake	5 ha	Aquaculture using cages	Western Provence, Karongi District, Bwishyura Sector, Rurembo cell
51	Kivu Lake	5 ha	Aquaculture using cages	Western Provence, Nyamasheke District, Macuba Sector, Rugali cell, Munimba
52	Lake Cyohoha Sourth	41074 m3	Irrigation	EasternProvince, Bugesera District, Kamabuye Sector
53	Kivu Lake	14 ha	Aquaculture using cages	Western Provence, Karongi District, Bwishyura Sector, Gasura cell
54	Groundwater/Drilled Boreholes	0.0011 m3/s	Water supply	Eastern Provence, Rwamagana District, Gishari Sector, Ruhunda cell
55	Muhazi Lake (Rwimiyange perimeter)	4 ha	Aquaculture using cages	Kigali City,Gasabo District, Gikomero Sector, Gasagara cell
56	Kivu Lake (Nyirarugota bay)	5 ha	Aquaculture using cages	Western Provence, Karongi District, Bwishyura Sector, Kibuye cell, Rurembo Village
57	Akagera River	94,000 m3/day	Irrigation (824 ha)	Eastern Provence, Kirehe District, Mpanga Sector, Ruhunda cell
	Rweru Lake	5,479.45 m3/day	Irrigation	Eastern Provence, Bugesera District, Rweru Sector, Nkanga cell, Nkanga Village
	Akagera River	24,657.53 m3/day	Irrigation	Eastern Provence, Bugesera District, Rweru Sector, Nkanga cell, Nkanga Village
58	Akagera River	236,842 m3/day	Irrigation (16,000 ha): Gabiro Commercial Farming Project	Eastern Provence, Nyagatare District, Karangazi Sector
59		20 m3/day	Company's activities	Kigali City, Nyarugenge District, Kanyinya Sector, Nyamweru
60	Nyankorogoma river	7,776 m3/day	Power production	Eastern Provence, Kirehe District, Mpanga Sector, Nasho Cell
61	Mudasomwa river	0,110 m3/s	Power production	Southern Provence, Nyaruguru District, Ruheru Sector, Remera and Uwumusebera Cells
62	Kivu Lake	7 ha	Fish Farming (Pharmakina bay)	Wester Provence, Rusizi District, Nanka and Gihundwe Sectors,
63		25.6 m3/day	Water supply	Eastern Provence, Kayonza District, Ruramira Sector,
65	Mwogo River	0.09 m3/s	Irrigation (50 ha)	Southern Provence, Nyamagabe District, Kamegeri Sector, Rusura Cell

66	Mutobo river	0.2 m3/s	Power production	Northern Provence, Musanze District, Gataraga Sector, Rubindi Cell
	Rwishywa river	0.2 m3/s	Power production	Wester Provence, Rutsiro District, Gihango Sector, Shyembe Cell
	Rubindi river	0.4 m3/s	Power production	Northern Provence, Musanze District, Gataraga Sector, Rubindi Cell
67	Gaseke river	1.08 m3/s	Power production	Northern Provence, Gakenke District, Busengo Sector, Birambo Cell
68	Mukungwa river	12 m3/s	Power production	Northern Provence, Gakenke and Musanze Districts, Rusasa, Nkotsi and Rugera Sectors, Birambo Cell
69	Lake Kidogo	465 m3/day	Construction processes of New Bugesera International Airport	Eastern Provence, Bugesera District, Rusasa, Nkotsi and Rugera Sectors, Birambo Cell
70	Former Karama RAB Research Center		Groundwater investigation	Eastern Provence, Bugesera District,
	Lake Kirimbi	1,392.5 m3/day	Irrigation/domestic water supply	Eastern Provence, Bugesera District, Gashora Sector, Mwendo Cell, Gaharwa Village
71	Kivu Lake (Mashyuza bay)	4 ha	Fish Farming	Wester Provence, Rubavu District, Nyamyumba Sector, Kiraga Cell, Rambo Village
72	Muhazi Lake	2000 m3/day	Irrigation (40 ha)	Eastern Provence, Rwamagana District, Gishari
73		20 m3/day	Package bottle water plant	Southern Provence, Kamonyi District, Runda Sector, Rubumba Cell,
	Spring	20 m3/day	Package bottle water plant	Southern Provence, Kamonyi District, Runda Sector, Rubumba Cell,
74	Bisinia valley dam	533 m3/day	Mining activities	Eastern Provence, Rwamagana District, Musha Sector, Kagarama Cell, Muhogoto Village
75	Muhazi Lake (Nkindi bay)	24 ha	Fish Farming	Eastern Provence, Rwamagana District, Munyiginya Sector, Nyarubuye Cell
76	Ruhondo Lake (Gana bay)	3 ha	Fish Farming	Northern Provence, Burera District, Kinoni Sector, Ntaruka Cell, Nyirabagenzi Village
77	Ruhondo Lake (Gana bay)	5 ha	Fish Farming	Northern Provence, Burera District, Kinoni Sector, Ntaruka Cell, Gikoro Village
78	Byimana spring (Kimisagara)	850 m3/day	Domestic water supply	Kigali City, Kicukiro District, Niboye Sector, Gatare Cell, Byimana Village
	Rwampara Spring	1,300 m3/day	Domestic water supply	Kigali City, Kicukiro District, Kagarama Sector, Nyarurama Cell, Kambuye Village
	Rwangamazimwe spring	250 m3/day	Domestic water supply	Southern Province, Huye District, Mbazi Sector, Gatobotobo Cell
	Rwabigeyo spring	500 m3/day	Domestic water supply	Easter Province, Gatsibo District, Mugera Sector,
	Ruhondo spring	800 m3/day	Domestic water supply	Western Province, Rusizi District, Nyakarenzo Sector
	Rugeramigozi dam	4,320 m3/day	Domestic water supply	Southern Province, Muhanga District, Nyamabuye Sector, Gahogo Cell, Kamazuru Village
	Rubengera spring	500 m3/day	Domestic water supply	Western Province, Karongi District, Rubengera Sector, Nyarugenge Cell
	Pfunda river	9,600 m3/day	Domestic water supply	Northern Province, Rubavu District, Rugerero Sector, Gisa Cell, Kiniga Village
	Tovu spring	650 m3/day	Domestic water supply	Eastern Province, Nyagatare District, Rukomo Sector, Nyakagarama Cell
	Byimana spring (Gihuma)	150 m3/day	Domestic water supply	Southern Province, Ruhango District, Byimana Sector, Nyakabuye Cell
	Byimana spring (Gasabo)	400 m3/day	Domestic water supply	Kigali City, Gasabo District, Murambi Sector
	Litiro spring	5,200 m3/day	Domestic water supply	Western Province, Nyamasheke District, Ruharambuga Sector
	Muhazi Lake	6,600 m3/day	Domestic water supply	Eastern Province, Rwamagana District, Gishari
	Yanze river	24,000 m3/day	Domestic water supply	Kigali City, Nyarugenge District, Kimisagara Sector
	Umuvumba river	2,400 m3/day	Domestic water supply	Eastern Province, Nyagatare District, Rukomo Sector, Nyakagarama Cell
	Kanyabusage spring	850 m3/day	Domestic water supply	Western Province, Karongi District, Bwishyura Sector, Nyarusazi Cell, Kanyabusage Village
	Ngoma River	5,500 m3/day	Domestic water supply	Eastern Province, Nyagatare District, Kiyombe Sector, Kabungo Cell
	Ibisi bya Huye spring	150 m3/day	Domestic water supply	Southern Province, Huye District, Ngoma Sector, Ngoma Cell
	Kadahokwa dam	8,500 m3/day	Domestic water supply	Southern Province, Huye District, Mbazi Sector, Mwurire Cell
	Gisuma river	1,400 m3/day	Domestic water supply	Southern Province, Nyamagabe District, Remera Sector, Gitwa Cell
	Kibonabose spring	500 m3/day	Domestic water supply	Western Province, Rusizi District, Nkungu Sector
	Jali spring	100 m3/day	Domestic water supply	Kigali City, Gasabo District, Jali Sector, Agatego Cell, Rwankuba Village
	Bishya dam	9,140 m3/day	Domestic water supply	Southern Province, Nyanza District, Mukingo Sector, Mpanga Cell
	Bunono stream	9,140 m3/day	Domestic water supply	Eastern Province, Kayonza District, Kabarondo
	Cyatokwe stream	750 m3/day	Domestic water supply	Eastern Province, Kayonza District, Rukari Sector, Rukara Cell
	Cyampirita spring	500 m3/day	Domestic water supply	Eastern Province, Gatsibo District, Rugarama Sector, Mutunguru Cell
	Cyunyu river	1,300 m3/day	Domestic water supply	Western Province, Rusizi District, Kamembe Sector, Mururu Cell
	Cyohoha Lake	5,600 m3/day	Domestic water supply	Eastern Province, Bugesera District, Nyarugenge Sector, Murambi Cell, Kanome Village
	10 Drilled Wells at Nkombo	720 m3/day	Domestic water supply	Western Province, Rusizi District, Nkombo Sector, Rwenje Cell, Rutarakiro Village
	Gihengeri stream	3,500 m3/day	Domestic water supply	Northern Province, Gicumbi District, Bwisige Sector, Gitega Cell

	Gihogwe spring	400 m3/day	Domestic water supply	Kigali City, Nyarugenge District, Jali Sector, Cyuga Cell, Rugina Village
	Kinyinya spring	1,100 m3/day	Domestic water supply	Kigali City, Gasabo District, Bumbogo Sector, Nyabikinke Cell
	Kazabazana spring	450 m3/day	Domestic water supply	Eastern Province, Kayonza District, Mukarange Sector, Cyeru Cell
	Kanwiriri spring	170 m3/day	Domestic water supply	Eastern Province, Gatsibo District, Gatoki Sector, Nyamirama Cell
	Nyabarongo river	145,000 m3/day	Domestic water supply	Kigali City, Nyarugenge District, Kinyinya Sector, Ruyenzi Cell
	Mutobo and Rubindi springs	120,000 m3/day	Domestic water supply	Northern Province, Musanze District, Gataraga Sector, Rubindi Cell, Kabaya Village
	Miyove spring	150 m3/day	Domestic water supply	Northern Province, Gicumbi District, Byumba Sector, Nyamabuye Cell
	Mugesera Lake	48,000 m3/day	Domestic water supply	Eastern Province, Rwamagana District, Byimana Cell, Bwiza Village
	Mburabuturo spring	900 m3/day	Domestic water supply	Kigali City, Nyarugenge District, Nyarugenge Sector, Nyarugenge Cell, Rugunga Village
	Mbare spring	80 m3/day	Domestic water supply	Southern Province, Muhanga District, Shyogwe Sector, Kinini Cell
	Kizanye spring	700 m3/day	Domestic water supply	Kigali City, Nyarugenge District, Gitega Sector, Mpazi Cell, KatabaroVillage
	Yaramba spring	480 m3/day	Domestic water supply	Norhern Province, Gicumbi District, Byumba Sector, Nyamabuye Cell
	Rwakibirizi spring	450 m3/day	Domestic water supply	Eastern Province, Bugesera District, Kanazi Cell, Rugando Village
	Rwasamira spring	120 m3/day	Domestic water supply	Southern Province, Muhanga District, Nyamabuye Sector, Gahogo Cell, Rugando
	Rwasaburo stream	1,300 m3/day	Domestic water supply	Eastern Province, Ngoma District, Kibungo Sector
	Rwasama spring	400 m3/day	Domestic water supply	Eastern Province, Gatsibo District, Muhura Sector, Mamfu Cell
	Nyamasharaza and Kidobogo streams	1,920 m3/day	Domestic water supply	Southern Province, Huye District, Mbazi Sector
	Nyamabuye spring	1,200 m3/day	Domestic water supply	Norhern Province, Gicumbi District, Byumba Sector, Nyamabuye Cell
	Nyamuhinda stream	250 m3/day	Domestic water supply	Eastern Province, Ngoma District, Kazo Sector
	Sebeya river	15,000 m3/day	Domestic water supply	Western Province, Rubavu District, Rugerero Sector, Gisa Cell, Gihira Village
79	Ruhondo Lake	5 ha	Fish Farming	Northern Province, Burera District, Kinoni Sector, Nkumba Cell
80	Kaberu spring	80 m3/day	Manufacturing of dairy products	Northern Province, Nyabihu District, Mukamira Sector, Kanyovu Cell
81	Agatobwe river	1.35 m3/s	Electricity generation	Southern Province, Nyaruguru District, Ngoma Sector, Kiyonza Cell
82	Muhazi Lake	184.9 m3/day	Irrigation	Eastern Province, Rwamagana District, Munyiginya Sector, Nyarubuye Cell, Buyanja Village
83	Muhazi Lake	0.14 m3/day	Irrigation	Eastern Province, Kayonza District, Rukara Sector, Kawangire Cell, Butimba I Village
84	Giciye river	0.9 m3/s	Electricity generation	Western Province, Nyabihu District, Rurembo Sector,
85	Rwabikwano dam	13.7 m3/d	Irrigation	Eastern Province, Bugesera District, Mareba Sector, Rugarama Cell, Karurama Village
86	Kivu Lake	5 ha	Fish farming	Western Province, Karongi District, Mubuga Sector, KagabiroCell,
87	Nyirihirwe river	0.68 m3/s	Electricity generation	Western Province, Nyamasheke District, Cyato Sector
	Nyirihirwe river	0.56 m3/s	Electricity generation	Western Province, Nyamasheke District, Cyato Sector
88	Ngiramazi spring	5 m3/d	Mining	Northern Province, Gakenke District, Ruli Sector, Busoro Cell, Rugaragara Village
89	Gitsiro spring	0.56 m3/s	Coffee washing	Northern Province, Rulindo District, Ruli Sector
	Nyamwenda stream	13.7 m3/d	Coffee washing	Western Province, Rubavu District, Nyamyumba
	Kabilizi stream	8.2 m3/d	Coffee washing	Western Province, Rutsiro District, Kavumu Sector
	Nyakagezi stream	13.7 m3/d	Coffee washing	Western Province, Rutsiro District, Kigeyo Sector
	Gisuma stream	13.7 m3/d	Coffee washing	Western Province, Rutsiro District, Boneza Sector
	Cyacika stream	8.2 m3/d	Coffee washing	Northern Province, Gakenke District, Muyongwe
90	Mazimeru river	0.275 m3/s	Electricity generation	Sourthenr Province, Nyaruguru District, Muganza
91	Base dam	937.800 m3/d	Irrigation	Sourthenr Province, Bweremana and Mukingo Sectors, Ruhango and Nyanza Districts
92	Rugeramigozi I dam	622,699 m3/6months: 3,459.43 m3/d	Irrigation	Sourthenr Province, Muhanga District, Shyogwe and Nyamabuye Sectors
93	Cyili dam	1,617,008 m3/6months: 8,983.37 m3/d	Irrigation	Sourthenr Province, Gisagara District, Musha Sector
94	Rugeramigozi II dam	393,876 m3/6months: 2,188.2 m3/d	Irrigation	Sourthenr Province, Muhanga District, Shyogwe Sector
95	Akagera River	250 m3/d	Irrigation	Eastern Province, Ngoma District, Rukumberi Sector, Gituza Cell, Mfune Village
	Cyohoha South Lake	251 m3/d	Irrigation	Eastern Province, Bugesera District, Nyarugenge Sector, Murambi Cell, Rugandara Village
	Nasho Lake	500 m3/d	Irrigation	Eastern Province, Kayonza District, Ndego Sector,
96	Kivu Lake	213,910.08m3/d	Industrial	Western Province, Rubavu District, Nyamyumba Sector, Busoro Cell, Kabushongo Village
97	Rukopfu stream	20 m3/d	Industrial	Western Province, Karongi District, Rugabano Sector, Gitega Cell, Misagara Village
98	Nyarubogo dam	8702.1 m3/d	Irrigation	Southern Province, Nyanza District, Rugabano Sector, Gitega Cell, Misagara Village
99	Kiruhura dam	1823.5 m3/d	Irrigation	Eastern Province, Bugesera District, Kibirizi Sector, Mutuku Cell, Kanyinya Village

100	Kivu Lake	4 ha	Fish farming	Western Province, Nyamsheke District, Nyabitekeri Sector, Mariba Cell
101	Groundwater	70 m3/d	Hotel activities	Western Province, Rubavu District, Gisenyi Sector
102	Sebeya river	3 m3/s	Hydropower	Western Province, Rubavu District, Rugerero Sector
	Cyimbiri river	0.2 m3/s	Hydropower	Western Province, Rubavu District, Rurembo Sector
	Nkora river	0.7 m3/s	Hydropower	Western Province, Rutsiro District, Rurembo Sector
103	Gashashi river	0.35 m3/s	Hydropower	Western Province, Rutsiro District, Kivumu Sector
104	Rwangingo dam	4,776,576 m3/6months	Irrigation	Eastern Province, Gatsibo District, Gatsibo and Gitoki Sectors
105	Kabindi stream	300 m3/d	Mining and quarrying	Southern Province, Kamonyi District, Kayenzi Sector, Kirwa Cell, Gasamba Village
106	Kivu Lake	213,910.08m3/d	Industrial	Western Province, Rubavu District, Nyamyumba Sector, Busoro Cell, Kabushongo Village
107	Rukarara river	5.3m3/s, 457,920m3/day	Hydropower	Southern Province, Nyamagabe District, Kibumbwe Sector
	Sebeya river	2.5m3/s, 216,000m3/day	Hydropower	Western Province, Rubavu Gisenyi Sector, Rubavu District
	Rukarara river	2.65m3/s, 228,960m3/day	Hydropower	Southern Province, Nyamagabe District, Uwinkindi
	Mukungwa river	6.8m3/s, 587,520m3/day	Hydropower	Northern Province, Musanze District, Nkotsi Sector
108	Kanyonyomba dam	3,104,118m3/6months	Irrigation	Eastern Province, Gatsibo District, Kiziguro and Remera Sectors
	Kanyonyomba dam		Fish Farming	Eastern Province, Gatsibo District, Kiziguro and Remera Sectors
	Munago dam	140,670m3/6months	Irrigation	Eastern Province, Gatsibo District, Murambi Sector
	Munago dam		Fish Farming	Eastern Province, Gatsibo District, Murambi Sector
109	Ntende dam	1,474,220m3/6months	Irrigation	Eastern Province, Gatsibo District, Kiziguro and Rugarama Sectors
	Ntende dam		Fish Farming	Eastern Province, Gatsibo District, Kiziguro and Rugarama Sectors
	Kiriba dam	11 ha	Fish Farming	Eastern Province, Gatsibo District, Rugarama Sector
	Kiriba dam	8,333.3 m3/day	Irrigation	Eastern Province, Gatsibo District, Rugarama Sector
110	Kivu Lake(Nkombo bay1)	1.2 ha	Fish Farming	Western Province,Rusizi District, Nkombo Sector, Gihaya & Bigoga Cells
	Kivu Lake(Gihaya bay)	1.3 ha	Fish Farming	Western Province,Rusizi District, Gihundwe Sector, Gihaya Cell
	Kivu Lake(Nkombo bay2)	0.5 ha	Fish Farming	Western Province,Rusizi District, Nkombo Sector, Bigoga & Gihaya Cells
	Kivu Lake(Ireba North bay)	1.1 ha	Fish Farming	Western Province,Rusizi District, Gihundwe Sector, Bigoga & Gihaya Cells
	Kivu Lake(Ireba South bay)	1.2 ha	Fish Farming	Western Province,Rusizi District, Nkombo Sector, Bigoga & Gihaya Cells
111	Gashyuha_Muganza Springs	1,500m3/day	Water supply	Western Province,Rusizi District, Gitambi Sector
112	KABEZA Water Pond	1,692m3/day	Mining	Western Province,Ngororero District, Gatumba Sector
113	Kivu Lake	5 ha	Fish Farming	Western Province,Rutsiro District,Kigeyo Sector,Buhindure cell
114	Ruboroga river	29,881.48m3/6months	Irrigation	Southern Province, Kamonyi District, Nyamiyaga and Rugalika Sectors
115	Bukaba river	15,552m3/day	Hydropower	Southern Province, Muhanga District, Rongi Sector
116	Nyabahanga river	51,840m3/day	Hydropower	Western Province,Karongi District, Bwishyura Sector
117	Gacaca dam	2,500,000m3/6months	Irrigation	Eastern Province, Kayonza District, Murundi Sector
118	Bushoga dam	117,225m3/6months	Irrigation	Eastern Province, Nyagatare District, Nyagatare
119	Warufu river	3,835,602m3/6months	Irrigation	Eastern Province, Nyagatare District, Rukomo Sector
120	Warufu river	16,411,500m3/6months	Irrigation	Eastern Province, Nyagatare District, Rukomo Sector
121	Bahimba Stream	200m3/day	Mining	Southern Province, Kamonyi District, Kayenzi Sector
122	RUVUBU dam	478,278m3/6months	Irrigation	Eastern Province, Nyarugenge Sector,Bugesera
123	RWINKWAVU dam	5,873,280m3/6months	Irrigation	Eastern Province, Kayonza District, Rwinkwavu
124	KINONI1 dam	1,219,140m3/6months	Irrigation	Eastern Province, Kirehe District, Kigarama Sector
125	SAGATARE dam	431,388M3/6months	Irrigation	Eastern Province, Kirehe District, Kirehe &Musaza Sectors
125	KAYONZA4 dam	3,422,970m3/6months	Irrigation	Eastern Province, Kayonza District, Kabare Sector
127	CYAMBWE LAKE	6,998.4m3/day	Irrigation	Eastern Province, Kirehe District, Nasho Sector
128	Kivu LAKE	25 ha	Fish Farming	Western Province,Karongi District, Bwishyura Sector, Gasura Cell
129	GATINDINGOMA DAM	2,269,476m3/6months	Irrigation	Southern Province, Huye District, Rwaniro Sector
130	CYUNUZI DAM	1,491,102m3/6months	Irrigation	Eastern Province, Kirehe District, Mushikiri Sector
131	NSHILI RIVER	95,040m3/day	Hydropower	Southern Province, Nyaruguru District, Busanze
132	AGASASA DAM	1,031,580m3/6months	Irrigation	Southern Province, Nyanza District, Ntyazo Sector
133	MUHAZI LAKE	2 ha	Fish Farming	Eastern Province, Rwamagana District, Musha Sector
134	CYARUBARE DAM	375,120m3/6months	Irrigation	Southern Province, Huye District, Ruhashya Sector
135	MUHORORO DAM	937,800m3/6months	Irrigation	Southern Province, Huye District, Ruhashya Sector
136	RUGENDE DAM	3,282,300m3/6months	Irrigation	Eastern Province, Rwamagana District, Muyumbu
137	Gakuta and Kiriba Springs	20 m3/day	Industry	Western Province,Karongi District, Rugabano Sector
138	Nyabombe Stream	35.7 m3/day	Irrigation	Eastern Province, Kayonza District, Gahini Sector
139	Nyanza Springs	25 m3/day	Industry	Western Province,Nyamasheke District, Bushekeri
140	Lake Kivu	30 Ha	Boat testing	Western Province,Karongi District, Bwishyura Sector, Gasura Cell
150	Ryarunagana and Nyamuhira s	198.7m3/day	Public Water supply	Western Province,Nyamasheke District, Karengera Sector, Gasayo cell
151	Lake Kivu	4 Ha	Fish Farming	Murwa bay, Murwa Village, Ninzi cell, Kagano Sector, Nyamasheke District of Western Province
152	Cyohoha and Rukeri streams	9,269 m3/day	Irrigation	Kinihira sector, Rulindo district, Northern province
153	Nyabarongo river	2,851,921 m3/day	Hydropower	Mushishiro sector, Muhanga district, Southern

APPENDIX D : Hydraulic Calculation of Water Treatment Plant

Appendix D

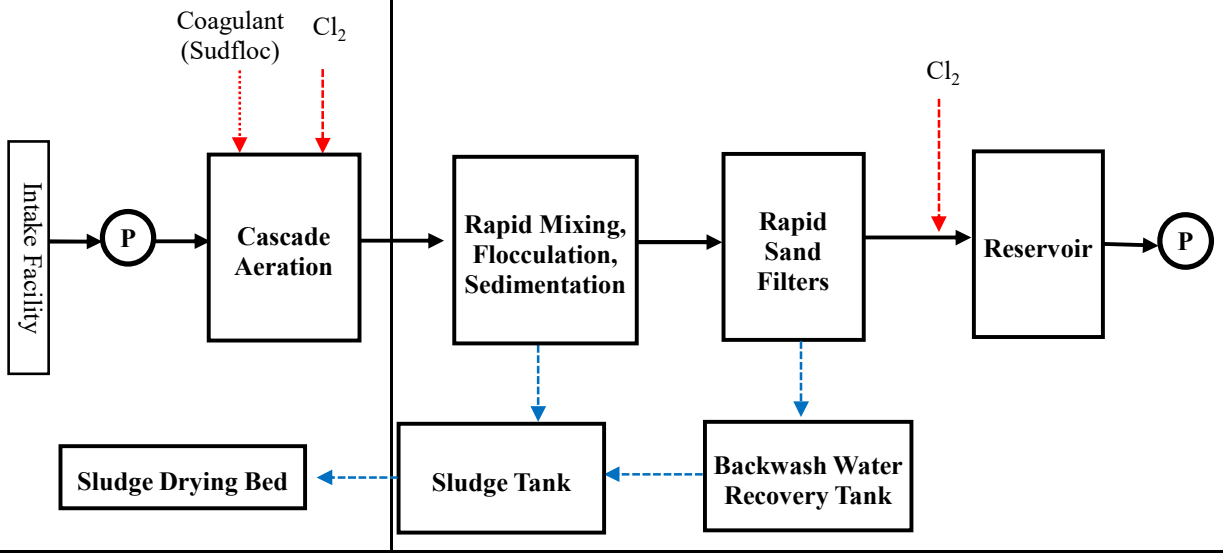
Hydraulic Calculation of Water Treatment Plant

Karenge WTP F/S

Ver.1 20210313

Nihon Suido Consultants Co., Ltd.

Item	Calculation
1. Design Parameters	
1-1 Outline of Water Treatment Plant Water Treatment Process	Receiving Well → Aeration → Flocculation/Sedimentation Basin → Rapid Sand Filters → Clear Water Reservoir → Distribution P/S
1-2 Design Production Capacity	38,000 m^3/d
WTP Capacity	40,000 m^3/d
1-3 Raw Water Quality	
(1) pH	8.0
(2) Turbidity	20 NTU (5-40 NTU)
(3) Fe	1.0 mg/l
(4) Mn	0.5 mg/l
(5) Ammonia	0.3 mg/l
(6) Alkalinity	80 mg/l
1-4 Treated Water Quality	
(1) Turbidity	< 1.0 NTU 5 NTU, Rwanda Drinking Water Quality Standards
(2) Fe	< 0.3 mg/l 0.3 mg/L , Rwanda Drinking Water Quality Standards
(3) Mn	< 0.1 mg/l 0.1 mg/L , Rwanda Drinking Water Quality Standards
(4) Ammonia	< 0.5 mg/l 0.5 mg/L , Rwanda Drinking Water Quality Standards
1-5 Return Wastewater (with Raw Water)	1,900 m^3/day
2. Design Process	



Chemicals and its purpose and application point are summarized below.

Chemical	Purpose	Application Point
Aeration	Odor and ammonia removal, iron and manganese oxidation	Cascade Aeration Basin
Sudfloc	Coagulant	Cascade Aeration Basin
Chlorine		
Pre-chlorination	Kill most disease causing microorganisms Help control taste and odor causing substances (NH_3) Oxidize iron and manganese	Cascade Aeration Basin
Post-chlorination	Disinfection	Clear Water Reservoir

Item			Calculation		
1.	**Design Condition**				
1.1	**Design Flow rate**	=	40,000 m^3/d = 1,667 m^3/h = 0.463 m^3/s		
1.2	**Design water quality**				
	Average turbidity of raw water	=	20	NTU	(5-40 NTU)
	Turbidity of treated water	<	1	NTU	
2.	**Chemicals dose**				
	Maximum dose of Sudfloc	=	35	mg/L	(Nzove WTP: 15 mg/L, Kimisagara WTP: 5.8 mg/L (average))
	Maximum Dose of $Ca(ClO)_2$ for Pre-chlorination	=	5.8	mg/L	(Dose at existing Karenge WTP)
	Maximum Dose of $Ca(ClO)_2$ for Post-chlorination	=	5.8	mg/L	(Dose at existing Karenge WTP)
	Maximum Dosage of Sudfloc	=	49	L/hr	(Specific gravity of Sudfloc=1.2)
	Max. Dosage of $Ca(ClO)_2$ for Pre-chlorination	=	744	L/hr	
3.	**Sludge Treatment System**				
	Design Turbidity (Average)	=	20	NTU	
	Treated Water Turbidity	=	1	NTU	
	Dose of Coagulant	=	20	mg/L	(Dose at existing Karenge WTP)
	Turbidity - SS Conversion Rate	=	1		
	Total Dry Sludge Amount	=	1,125	kg/d	
	Sludge loading of sludge drying bed	=	40	kg/m^2	
	Average dry time	=	60	days	
	Area of sludge drying bed	=	1,700	m^2	
4.	**Dissolved Air Flotation (DAF) System**		(Only as reference for estimating the area in case DAF being used)		
	Recycle rate	=	10	%	
	Capacity of DAF Pump	=	167 m^3/h = 2.8 m^3/min		(2 sets, one for stand-by)
	Total flow rate of DAF	=	1,833	m^3/h	
	No. of DAF basin	=	2		
	Design flow of each DAF basin	=	917	m^3/h	
	Surface loading rate	=	15	m/hr	
	Effective depth of basin	=	3	m	
	Surface area of each basin	=	61	m^2/basin	
	Width of single basin	=	6.0	m	
	Length of single basin	=	10.2 m → 10.5	m	
	Actual area of single basin	=	63	m^2	(<90-110m^2)
	Contact zone detention time	=	120.0	s	
	Contact zone volume per basin	=	30.6	m^3	
	Contact zone Area per basin	=	10.2	m^2	
	Contact zone width per basin	=	1.7	m	
	Total length of DAF basin	=	12.2	m	
	Dimension of DAF system		6.0 ^{W}x 10.5 ^{L}x 3.0 ^{H}x 2 Basins		
	Retention time	=	12	min	

Hydraulic Calculation of Water Treatment Plant

KARENGE WATER TREATMENT PLANT

1) WATER TREATMENT PLANT

Planed Daily Maximum Treated Water

Treated Water		**36,000**	m³/d
UFW 5% + Plant Consumption 5%		**3,600**	m³/d
Inlet Water	**Round-up at 1,000**	**40,000**	**m³/d**
		1,667	**m3/hour**
		27.78	m³/min
		0.463	m³/s
Planed Ground Level		**0.000**	**m**

(1) Receiving Well

a) Receiving Water Level + **5.000 (all season)**

b) Head Loss of Perforated Baffle Wall

$h=1/\alpha^2*V^2/(2*g)$

where,

α; Coefficient of Orifice 0.6

V; Inlet Velocity through Orifice

V=Q/A

Q= 0.463 m³/s

$A=\pi/4*d^2*N$

d: hole diameter 0.15 m

N:nunber of hole 110 pieces

A= 1.944 m2

g; Acceleration of Gravity 9.81 m/sec²

V= 0.238 m/s

∴ h= 0.008 m

Water Level after Perforated Baffle Wall

WL= 5 - 0.008

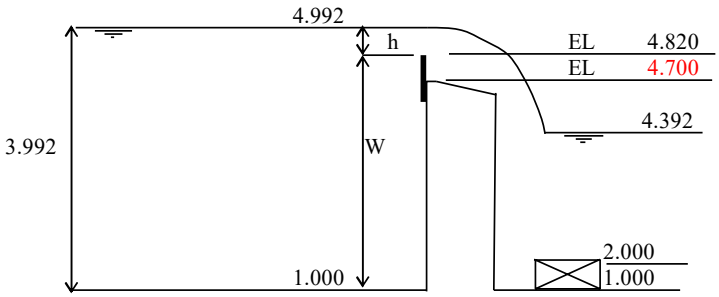
= **4.992 m**

c) Overflow Pipes

Clearance for Overflow pipe	0.600	m
Top level of overflow pipe	5.592	m
Diameter of Over flow pipes	500	mm
Overflowing depth	0.25	m
Overflow level	5.842	m
Clearance below top slab	0.100	m (minimum)

d) Head Loss of Weir

for mixing of coagulant h= **0.600 m**



Broad Crested rectangular Weir

Ishihara & Ida's Formula $Q=C*B*h^{3/2}$

$C=1.785+(0.00295/h+0.237*h/W)*(1+\varepsilon)$

where,

Water Level before Weir		4.992	
Width of Weir	B=	4.2	m
Top of Weir		4.820	
Height of Weir			
W= 4.82 - 1=		3.820	m
overflow depth at Weir			
h= 4.992 - 4.82=		0.172	m
Coefficient of Correction ε ε=0.55*(W-1) (W>1m)		1.551	
C=		1.856	
∴ Q=		0.556 m3/s >	0.463 m³/s
Depth from top of Weir to Water level after Weir		0.428	m (total head is 0.6m)

Water Level after Weir

WL= 4.992 - 0.172 - 0.428 = **4.392 m**

(2) Mixing Tank

Utilizing the Energy of Broad Crested Weir

*velocity : above 1.5m/s (Japanese Design Criteria for Waterworks Facilities)

*Water Fall Distance : 0.45 to 0.60m (general guide)

*G-value 200-500sec^{-1} (〃)

*Mixing duration time: 1 to 5min (Japanese Design Criteria for Waterworks Facilities)

a) Calculation of G-Value for Coagulation

$G=(\rho*g*h/(\mu*t))^{1/2}$

where,

G ;	Velocity Gradient (sec^{-1})		
ρ ;	Density of Water at 25℃	997.1	kg/m^3
g ;	Acceleration of Gravity	9.81	m/sec^2
h ;	Head Loss	0.60	m
μ ;	Dynamic Viscosity at 25℃	0.000898	kg/m・sec
t ;	Detention Time	2.05	min
		(123	sec)
∴ G=		231	/sec

b) Head Loss of Submerged Flow

Submerged Flow $h_3=f_3*V_3^2/(2*g)$

f_3:	Coefficient of head loss		(average)
f_3=		3.5	(Japanese Design Criteria)
g;	Acceleration of Gravity	9.81	m/sec^2
Width		2.0	m
Height of Opening		1	m
V_3=		0.232	m/s
h_3=		0.01	m

Water Level after Opening

WL= 4.392 - 0.01 = **4.382 m**

c) Head Loss of Coagulation Tank Inlet Gate

Number of Inlet Gate		**4**	
Inlet Flow rate per gate		**0.116**	m^3/s
Submerged Flow	$h_3=f_3*V_3^2/(2*g)$		
f_3:	Coefficient of head loss		(average)
f_3=		3.5	(Japanese Design Criteria)
g;	Acceleration of Gravity	9.81	m/sec^2
Width		0.5	m
Height of Opening		0.5	m
V_3=		0.463	m/s
h_3=		0.038	m

Water Level after Opening

WL= - 0.038 = **4.344 m**

(3) Flocculation Basin

a) Formula for Head Loss

- Winding Flow $h_1=f_1*V_1^2/(2*g)$ f_1: Coefficient of head loss $f_1=$ 4.0
- Friction $h_2=L/(C^2R)*V_2^2$ $C^2=1/n^2*R^{1/3}$
  $=n^2*L/R^{4/3}*V_2^2$
  C: coefficient of Chezy
  n: roughness coefficient of Manning 0.013
  R: hydraulic mean depth
  L: channel length
- Submerged Flow $h_3=f_3*V_3^2/(2*g)$ f_3: Coefficient of head loss $f_3=$ 3.5 (average) (Japanese Design Criteria for Waterworks Facilities)
- Overflow $h_4=f_4*V_4^2/(2*g)$ f_4: Coefficient of head loss $f_4=$ 1.0 (velocity head) (〃)

b) Inlet Flow per Unit

Inlet Water 40,000 ㎥/d
No. Trains 2 ea
20,000 m3/d= 0.231 m3/s

c) Inlet Water Level **4.344 m**

d) Top of Base Slab 1 m average: 0+(0.05+0.2)/2

e-g) Width

	unit	**Width**	submerge	overflow	
Row 1	m	0.80	1.000	0.800	m
Row 2	m	0.90	1.000	0.800	m
Row 3	m	1.00	1.100	0.900	m
Row 4	m	1.10	1.100	0.900	m
Row 5	m	1.20	1.200	1.000	m
Row 6	m	1.30	1.200	1.000	m

	Wier No.	Wier Hight	Top of con.	H of plate
Row 1	a	3.529	2.929	0.6
	b	3.507	2.907	
Row 2	c	3.486	2.886	
	d	3.468	2.868	
Row 3	e	3.295	2.695	
	f	3.283	2.683	
Row 4	g	3.272	2.672	
	h	3.262	2.662	
Row 5	i	3.125	2.525	
	j	3.119	2.519	
Row 6	k	3.112	2.512	
	ℓ	3.107	2.507	

h) G-Value

Generally allowable Range
G= 10-75 /sec (Japanese Design Criteria for Waterworks Facilities)
GT= 23,000-210,000

$G=(\rho*g*h/(\mu*t))^{1/2}$

where, G; Velocity Gradient (sec^{-1})
ρ ; Density of Water at 25℃ 997.1 kg/m^3
g ; Acceleration of Gravity 9.81 m/sec^2
h ; Head Loss m
μ ; Viscosity at 25℃ 0.000898 kg/m・sec
t ; Detention Time sec

i) Velocity 0.15 to 0.3 m/s (Japanese Design Criteria for Waterworks Facilities)

j) Detention Time 20 to 40 minutes = (〃)
1200 to 2400 sec

k) Hydraulic Calculation

① Hydraulic Calculation of Up and Down Flow Baffled Channel Flocculator 1/2

Row	Place	Inlet W.L.	upstream or downstream friction						Bending		submerged / overflow				Total Head	Volume of Row	Detention Time	Velocity Gradient	GT Value
			width 1	width 2	R	V	L	h_2	V	h_1	width 1	depth	V	h_3,h_4					
		(m)	(m)	(m)	(m)	(m/sec)	(m)	(m)	(m/sec)	(m)	(m)	(m)	(m/sec)	(m)	Loss	(m^3)	(sec)	(sec^{-1})	
1	1-1	4.3440	0.800	1.600	0.267	0.180	3.344	0.0001							0.0001				
	submerged	4.3439	0.800								0.800	1.000	0.289	0.0149	0.0149				
	1-2	4.3290	0.800	1.600	0.267	0.180	3.329	0.0001							0.0001				
	overflow	4.3289	0.800								0.800	0.800	0.361	0.0066	0.0066				
	1-3	4.3223	0.800	1.600	0.267	0.180	3.322	0.0001							0.0001				
	submerged	4.3222	0.800								0.800	1.000	0.289	0.0149	0.0149				
	1-4	4.3073	0.800	1.600	0.267	0.180	3.307	0.0001							0.0001				
	overflow	4.3072	0.800								0.800	0.800	0.361	0.0066	0.0066				
	1-5	4.3006	0.800	1.600	0.267	0.180	3.301	0.0001							0.0001				
	submerged	4.3005	0.800								0.800	1.000	0.289	0.0149	0.0149				
	Subtotal-1st Row														0.0584	21.262	92	83.2	7,654
2	2-1	4.2856	0.900	1.600	0.288	0.160	3.286	0.0001							0.0001				
	overflow	4.2855	0.900								0.900	0.800	0.321	0.0053	0.0053				
	2-2	4.2802	0.900	1.600	0.288	0.160	3.280	0.0001							0.0001				
	submerged	4.2801	0.900								0.900	1.000	0.257	0.0118	0.0118				
	2-3	4.2683	0.900	1.600	0.288	0.160	3.268	0.0001							0.0001				
	overflow	4.2682	0.900								0.900	0.800	0.321	0.0053	0.0053				
	2-4	4.2629	0.900	1.600	0.288	0.160	3.263	0.0001							0.0001				
	submerged	4.2628	0.900								0.900	1.000	0.257	0.0118	0.0118				
	2-5	4.2510	0.900	1.600	0.288	0.160	3.251	0.0001							0.0001				
	refraction	4.2509	0.300						0.237	0.0484					0.0484				
	Subtotal-2nd Row														0.0831	23.531	101.9	94.2	9,599
3	3-1	4.2025	1.000	1.600	0.308	0.144	3.203	0.0001							0.0001				
	submerged	4.2024	1.000								1.000	1.100	0.210	0.0079	0.0079				
	3-2	4.1945	1.000	1.600	0.308	0.144	3.195	0.0001							0.0001				
	overflow	4.1944	1.000								1.000	0.900	0.257	0.0034	0.0034				
	3-3	4.1910	1.000	1.600	0.308	0.144	3.191	0.0001							0.0001				
	submerged	4.1909	1.000								1.000	1.100	0.210	0.0079	0.0079				
	3-4	4.1830	1.000	1.600	0.308	0.144	3.183	0.0001							0.0001				
	overflow	4.1829	1.000								1.000	0.900	0.257	0.0034	0.0034				
	3-5	4.1795	1.000	1.600	0.308	0.144	3.180	0.0001							0.0001				
	submerged	4.1794	1.000								1.000	1.100	0.210	0.0079	0.0079				
	Subtotal-3rd Row														0.0310	25.528	110.5	60.6	6,696

Hydraulic Calculation of Up and Down Flow Baffled Channel Flocculator 2/2

Row	Place	Inlet W.L.	upstream or downstream friction						Bending		submerged / overflow				Total Head	Volume of Row	Detention Time	Velocity Gradient	GT Value
			width 1	width 2	R	V	L	h_2	V	h_1	width 1	depth	V	h_3,h_4					
		(m)	(m)	(m)	(m)	(m/sec)	(m)	(m)	(m/sec)	(m)	(m)	(m)	(m/sec)	(m)	Loss	(m^3)	(sec)	(sec^{-1})	
4	4-1	4.1715	1.100	1.600	0.326	0.131	3.172		0.052	0.0006					0.0006				
	overflow	4.1709	1.100								1.100	0.900	0.233	0.0028	0.0028				
	4-2	4.1681	1.100	1.600	0.326	0.131	3.168												
	submerged	4.1681	1.100								1.100	1.100	0.191	0.0065	0.0065				
	4-3	4.1616	1.100	1.600	0.326	0.131	3.162												
	overflow	4.1616	1.100								1.100	0.900	0.233	0.0028	0.0028				
	4-4	4.1588	1.100	1.600	0.326	0.131	3.159												
	submerged	4.1588	1.100								1.100	1.100	0.191	0.0065	0.0065				
	4-5	4.1523	1.100	1.600	0.326	0.131	3.152												
	refraction	4.1523	0.500						0.111	0.0227					0.0227				
	Subtotal-4th Row														0.0419	27.825	120.5	70.4	8,483
5	5-1	4.1296	1.200	1.600	0.343	0.120	3.130												
	submerged	4.1296	1.200								1.200	1.200	0.160	0.0046	0.0046				
	5-2	4.1250	1.200	1.600	0.343	0.120	3.125												
	overflow	4.1250	1.200								1.200	1.000	0.193	0.0019	0.0019				
	5-3	4.1231	1.200	1.600	0.343	0.120	3.123												
	submerged	4.1231	1.200								1.200	1.200	0.160	0.0046	0.0046				
	5-4	4.1185	1.200	1.600	0.343	0.120	3.119												
	overflow	4.1185	1.200								1.200	1.000	0.193	0.0019	0.0019				
	5-5	4.1166	1.200	1.600	0.343	0.120	3.117												
	submerged	4.1166	1.200								1.200	1.200	0.160	0.0046	0.0046				
	Subtotal-5th Row														0.0176	29.982	129.8	45.6	5,919
6	6-1	4.1120	1.300	1.600	0.359	0.111	3.112												
	overflow	4.1120	1.300								1.300	1.000	0.178	0.0016	0.0016				
	6-2	4.1104	1.300	1.600	0.359	0.111	3.110												
	submerged	4.1104	1.300								1.300	1.200	0.148	0.0039	0.0039				
	6-3	4.1065	1.300	1.600	0.359	0.111	3.107												
	overflow	4.1065	1.300								1.300	1.000	0.178	0.0016	0.0016				
	6-4	4.1049	1.300	1.600	0.359	0.111	3.105												
	submerged	4.1049	1.300								1.300	1.200	0.148	0.0039	0.0039				
	6-5	4.1010	1.300	1.600	0.359	0.111	3.101												
	refraction	4.1010	0.800						0.070	0.0143					0.0143				
	Subtotal-5th Row														0.0253	32.308	139.9	54.7	7,653
Total															0.2573	160.436	694.6	63.5	44,107

Water Level after Flocculation **4.087 m**

l) Loss by perforated wall

Pore diameter	100	mm	
Number of holes	300	ea	
Water Level before Wall	4.087	m	
Width	8.6	m	(W)
Bottom Level of Wall	1.000	m	
Height	3.087	m	(H)
Rectification hole	6%		(a)
Effective Area			
W*H*a=	1.59	㎡	(A)
Number of Holes			
φ100 VP	200	ea	
Water flow area	2.356	m2	
Flow Velocity	0.001	m/s	
Water Loss			

$h=1/\alpha^2*V^2/(2*g)$

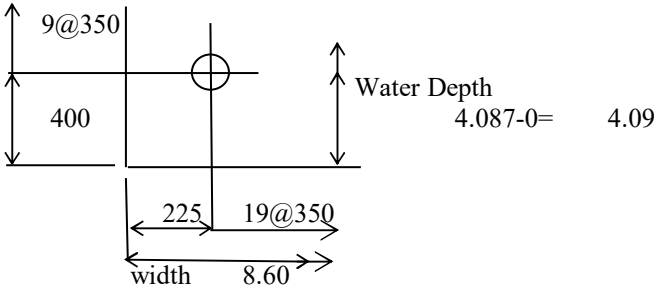
where, α= Coefficient of Orifice

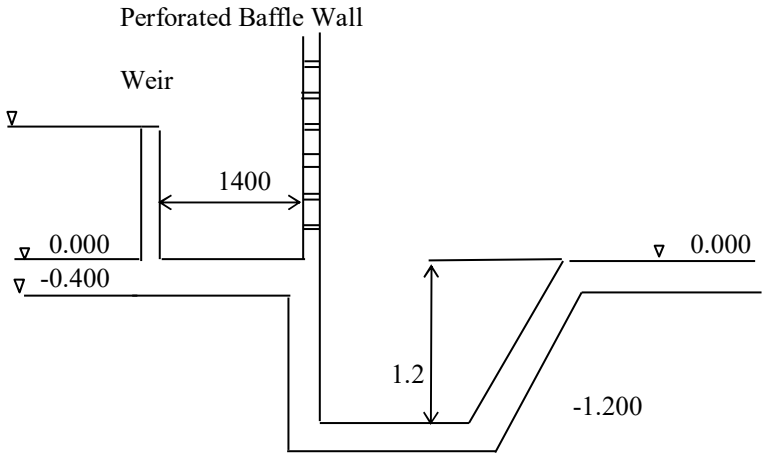
= 0.6

∴ h= 0 m

Rectification wall after the water level

WL= 4.087 - 0 = **4.087 m**





(4) Sedimentation Basin

Number of Basin 2
Number of Compartment 2

	All	Per Basin	Per Compartment
Treated Water	**36,000** m^3/d	18,000 m^3/d	9,000 m^3/d
UFW 10%	**3,600** m^3/d	1,800 m^3/d	900 m^3/d
Flow Quantity	**40,000** m^3/d	20,000 m^3/d	10,000 m^3/d
	27.78 m^3/m	13.89 m^3/m	6.95 m^3/m
	0.463 m^3/s	0.232 m^3/s	0.116 m^3/s

a) Inlet Water Level + **4.087 m**

b)Head Loss of Intermediate Perforated Baffle Wall (H_p)

Diameter of Orifice 100 mm
Number of Orifice 165 pieces
Area of Orifices 1.296 m2
Velocity at Orifice 0.179 m/s

$h=1/\alpha^2*V^2/(2*g)$ $\alpha=$ 0.6
$\therefore h=$ 0.005 m

Water Level after Perforated Baffle Wall

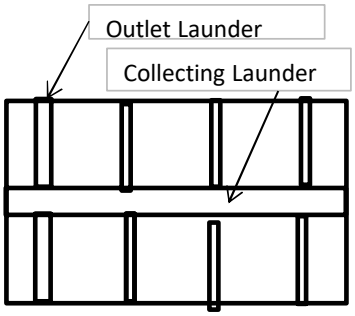
4.087 - 0.005
= **4.082 m**

c) Calculation of Outlet Launder (Transverse Type: Galvanized Steel)

Collecting Launder	B =	0.4	m	
	L =	4	m	
	H =	0.3	m	
Length Required	LW = 10,000 /350 =	28.6	m	(Design Criteria: <350 m3/d/m)
Numbers of Lines of Collection Launder per Basin	N =	8		
Thus, Weir Loading is		313	m3/d/m	OK

Camp's Formula
* in case of non-free-fall flow at terminal of Launder (① Section)

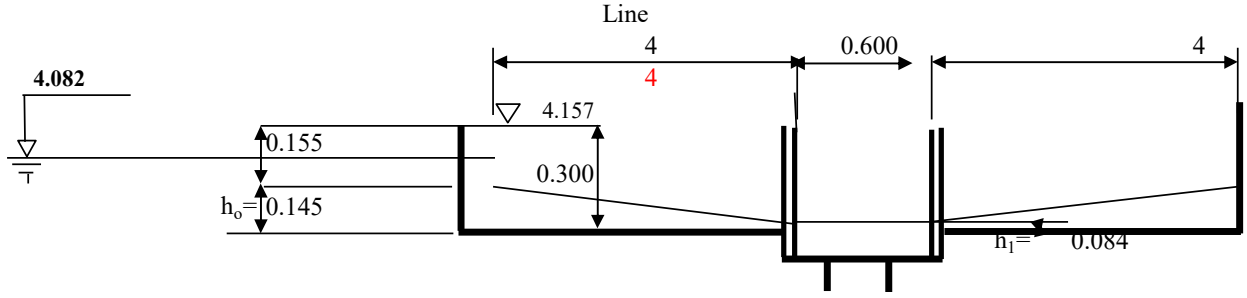
$$h_0 = (2*h_c^3/h_1+(h_c-i*L/3)^2)^{1/2}-(2/3)*i*L$$
$$= (2*h_c^3/h_1+h_c^2)^{1/2} \quad \because \text{ i=Slope of Launder } = 0$$



where,

h_0 ; Water Depth of Upstream of Launder (m)	
h_c; Critical Water Depth of Downstream of Launder (m)	
$h_c = (\alpha*Q^2/(g*B^2))^{1/3} =$	0.084
α ; Coefficient =	1.1
Q ; Flow Capacity of Launder (m^3/sec/line) =	0.029
g ; Acceleration of Gravity (m/sec2)	9.81
B ; Width of Launder (m) =	0.4
h_l; Water Depth of Downstream of Launder (m) =	0.084
L; Length of Launder (m) =	4

h_0= 0.145 m



d) Calculation of Head Loss on Orifice (H_0)

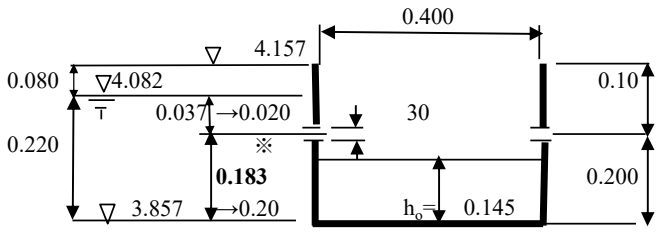
$H_0 = 1/\alpha^2 * V^2/(2*g)$

where,

α: Coefficient of Orifice			0.6
V: Verocity of Orifice (m/s)			
g: Accerated Gravity (m/sec^2)			9.81
V=q/A			
q: Flow Capacity of Orifice (m^3/s)	q=Q/N	q=	0.00036 m^3/s
Q: Flow Capacity of Launder (m^3/s・line)			0.0289 m^3/s
N: Number of Orifice (piece/line)	N=2*L/S		80 piece
L: Length of Launder (m/Line)		L=	4 m
S: Interval from each other (m)		S=	0.1 m
A: Area of Orifice (m^2)			
$A=\pi/4*D^2$	A=	0.000707 m^2	
D: Diameter of Orifice (m)		D=	0.03 m

V= 0.509 m/s

H_0= 0.037 m



H0= → 0.075 m

e) Calculation of Collecting Launder

Camp's Formula

* in case of free-fall flow at terminal of Launder

$h_0 = (2*h_c^2+(h_c-i*L/3)^2)^{1/2}-(2/3)*i*L$

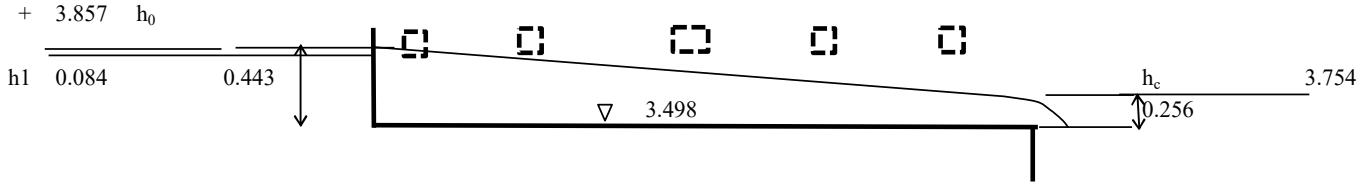
where, h_0 ; Water Depth of Upstream of Launder (m)

hc ;Critical Water Depth of Launder (m)

h_c='(α*Q2/(g*B2))1/3=	0.256	m
α ;Coefficient =	1.1	
Q ;Flow Capacity of Launder (m^3/sec/line) =	0.232	m3/sec/line
g; Acceleration of Gravity (m/sec2)	9.81	m/sec2
B; Width of Launder (m) =	0.6	m
L; Length of Launder (m) ＝	16	m
I; Base Gradient =	0	

h_0= 0.443 m

(in case of same flow capacity"Q" from up to down)



Upstream flow quantity is less than flow capacity"Q".

then,required quantity can be flowed by this trough.

Water Level after Collecting Launder

+ **3.754 m**

(5) Filter Basin

a) Inlet Water Level + **3.754 m**

b) Head Loss of Filter Inlet

Weir Height (Equal Split Inlet)

H= 0.20 m

Itaya & Tejima's Formula

$Q=C*b*h^{3/2}$

$C=1.785+0.00295/h+0.237*h/W-0.428*\sqrt{((B-b)*h/(B-W))}+0.034*\sqrt{(B/W)}$

where,

Water Level before Weir	+	**3.754**	**m**
Width of Weir	b=	3.35	m
Width of Chanel	B=	3.35	m
Top of Weir		3.600	
Height of Weir	W= 3.6 - 3.5		3.500 : Top of filter base concrete
	=	0.100	m
overflow depth at Weir	h= 3.754 - 3.6		
	=	**0.154**	m
from the above C=		2.366	
∴ Q=		0.479 m3/s >	0.116 m3/s **OK**
Depth from top of Weir to Water level after Weir		0.050	m
	+	**3.550**	**m**

Hight for water level control 0.15 m

→ **3.400 m**

c) Total Head Loss of Filter

H_f= 1.85 m See detailed calculation

Water Level at Filtered Chamber after Filter Regulator

3.55-1.85= + **1.550 m**

d)Head Loss of Filter Outlet to Filtered Water Measurement and Chlorine Chamber

$H_0=(f_i+f_v+f_o)*V^2/(2*g)$

where,

fi: Coefficient for Inlet	0.50	
fv: Coefficient for Butterfly Valve	0.25	(opening angle 85 degrees)
fo: Coefficient for Outlet	1.00	
V: Velocity through Pipe (m/s)		
g: Acceleration of Gravity (m/sec2)	9.81	

V=Q/A

Q:Flow Capacity (m^3/s・unit)

Q=40000/8= 0.058 m^3/s

A: Area of Pipe (m^2)

$A=\pi/4*D^2$= 0.126 m^2

D= 0.4 **m**

V= 0.459 m/s

H_0= 0.02 m

+ **1.531 m**

(6) Filtered Water Measurement and Chlorine Mixing Chamber

a) Inlet Water Level = + **1.531 m**

b) Head Loss of Inlet Gate

$h=1/\alpha^2*V^2/(2*g)$

where,

α: Coefficient 0.6

V: Verocity through Gate (m/s)

g: Acceleration of Gravity (m/sec2) 9.81 m/sec^2

V=Q/A

Q: Flow Capacity Q= 0.463 m^3/s

A: Area of Gate A=2*1.5= 3 m^2

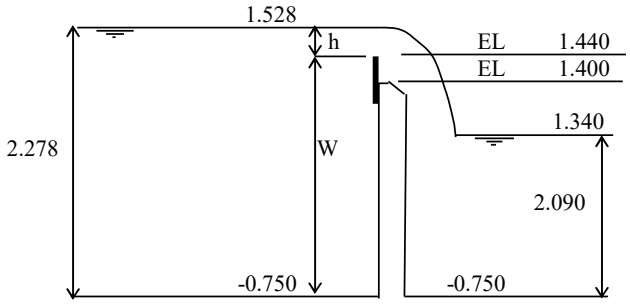
V= 0.154 m/s

H_0= 0.003 m

Water Level after Inlet Gate

1.531-0.003= + **1.528 m**

c) Loss of Weir



Broad Crested rectangular Weir

Ishihara & Ida's Formula

$Q=C*B*h^{3/2}$

$C=1.785+(0.00295/h+0.237*h/W)*(1+\varepsilon)$

where,

Water Level before Weir 1.528

Width of Weir B= 10.8 m

Top of Weir 1.440

Height of Weir W= 1.44 - -0.749999999999999

= 2.190 m

overflow depth at Weir h= 1.528 - 1.44

= 0.088 m

Coefficient of Correction ε

when W>1m ε=0.55*(W-1)

= 0.655

from the above C= 1.856

∴ Q= 0.523 m3/s ≧ 0.463 m3/s OK

Depth from top of Weir to Water level after Weir 0.100 m

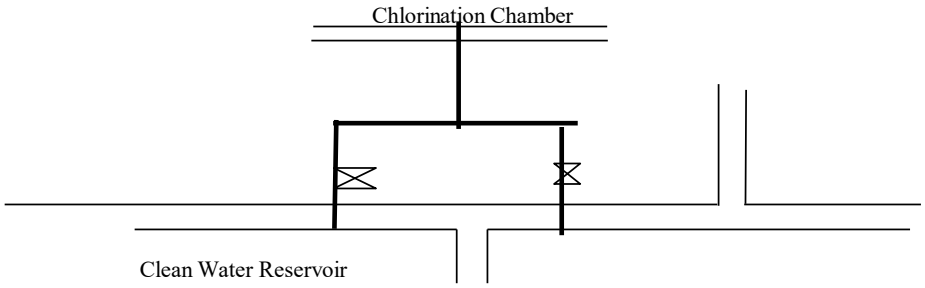
Water Level after Weir WL= 1.528 - 0.088 - 0.1

= **1.340 m**

(7) Filtered Water Pipe to Clear Water Reservoir

a) Inlet Water Level + **1.340 m**

b) Head Loss of Pipe to Clean Water Reservoir



Number			Dia.	Flow m3/d	Velocity m/s	Coeffi-cient	Loss m	remarks
	Inlet		φ800	40,000	0.921	0.5	0.022	
	Tee		φ800	40,000	0.921	0.40	0.017	
	Bend 90 degree		φ600	20,000	0.819	0.20	0.007	Given one reservoir is cleaning
	Butterfly V		φ600	20,000	0.819	0.25	0.009	Given one reservoir is cleaning
	Outlet		φ600	20,000	0.819	1.00	0.034	Given one reservoir is cleaning
	Friction	L50.00m	φ600	20,000			0.053	
	Friction	L10.00m	φ600	20,000			0.011	Given one reservoir is cleaning
total							0.153	
	Reaching Water Level at Clean Water Reservoir							
				1.187 m	>	**1.000**	OK	

※Calculation for Friction Loss is as follows by Hazen-Williams Formula

$H=10.666*C^{-1.85}*D^{-4.87}*Q^{1.85}*L$

H: Head Loss of Friction (m)

C: 130

D: Diameter (m)

Q: Flow Quantity (m3/s)

L: Length (m)

①Coefficient of Inlet

f= 0.5 (edge)

②Bend

f= fb_1*fb_2

90° K

ρ= radius of curvature

D= φ300

fb_1= 0.2 (when ρ/D=500/400=1.25)

fb_2= 1.0 (when bending angle is 90°)

③Head Loss at Branch 0.4

④Butterfly Valve

f= fv

fv:Coefficient for Butterfly Valve

fv= 0.25 (opening angle 85degrees)

⑤Outlet

f= 1.0

Calculation on Demensions of Water Treatment Plant

Karenge WATER TREATMENT PLANT

Calculation on Demensions of Water Treatment Plant

Karenge WATER TREATMENT PLANT

Planed Daily Maximum Treated Water

Treated Water	36,000	㎥/d
UFW 10%	3,600	㎥/d
Raw Water	40,000	㎥/d
	27.78	㎥/min
	0.463	㎥/s
	463	l/s
Present GL	0.00	m
Planed GL (FGL)	0.00	m

(1) Receiving Well

Detention Time exceed 1.5 min

Water Depth 3.0 to 5.0 m

(Japanese Design Criteria for Waterworks Facilities)

a)Demension

Width m	Length m	Height m	Water Depth m	Top EL. of Base m	Top EL. of Slab m	Water Level m
4.200	5.000	6.000	4.000	1.000	6.000	5.000

b)Detention Time

Volume Capacity 4.2*5*4= 84.00 ㎥

Detention Time 84/27.78= 3.02 min OK

※将来拡張40,000 m3/日を含む

c)Facilities

①Baffle Wall type of structure Reinforced Concrete

t=250

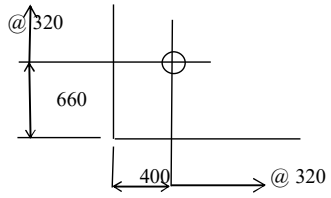
②Perforated Baffle Wall

Flowing Water Section *6% 4.2*4*0.06 = 1.01 ㎡

Hole Diameter φ100 VP

Number of Holes 1.01/(π/4*0.1^2)= 129 Pieces

→ 110 Pieces



Trial dis. form ori. 320 mm

Number of ori. 110 Pieces

Total ori. area 0.86 m^2

	Number of ori.		nber of ori.	T.D.B.O	Side	Verify
H	4200	12.13	10	2880	660	4200
V	4000	11.50	11	3200	400	4000

③Pipes

Overflow Pipe Diameter φ500 DIP

inlet quantity can be exhausted when overflow depth is 0.3m at dry season

Drain Pipe Diameter φ100 DIP

250

(2) Mixing Tank

Utilizing the Energy of Broad Crested Weir

*velocity :above 1.5m/s (Japanese Design Criteria for Waterworks Facilities)

*Water Fall Distance : 0.45 to 0.60m (general guide)

*G-value 200-500sec^{-1} (〃)

*Mixing duration time: 1 to 5min (Japanese Design Criteria for Waterworks Facilities)

a)Demension

Width	Length	Height	Water Depth	Top EL. of Base	Top EL. of Slab	Water Level
m	m	m	m	m	m	m
4.200	4.000	6.000	3.392	1.000	6.000	4.392

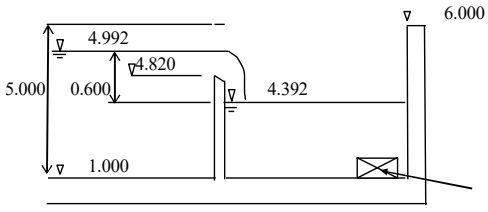
G-Value 231 /sec (refer to Hydraulic Calculation)

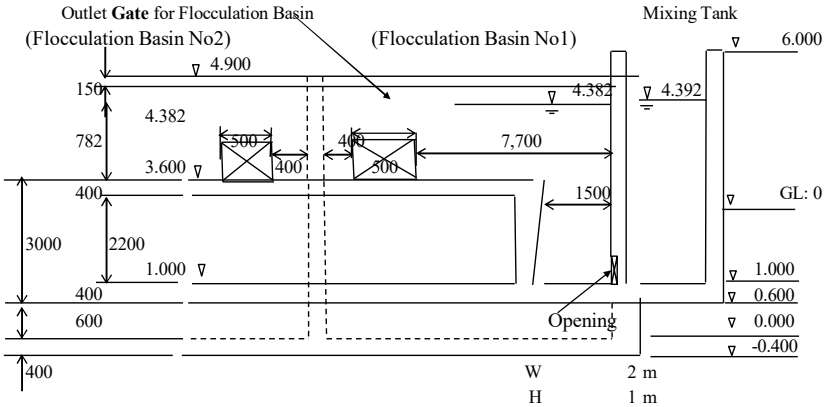
Water Fall Distance 0.6 m

b)Detension Time

Volume Capacity 4.2*4*3.392= 56.99 ㎥

Detension Time 56.99/27.78= 2.05 min





(3) Flocculation Basin

Velocity 0.15 to 0.3 m/s (Japanese Design Criteria for Waterworks Facilities)

Detention Time 20 to 40 minutes (〃)

= 1200 to 2400 sec

a)Demension

Row	Width m	Length m	Height m	H (m)	EL_1 (m)	EL_2 (m)	EL_3 (m)	WL (m)
1	0.80	8.600	4.700	3.344	0.000	1	4.700	4.344
2	0.90	8.600	4.700	3.286	0.000	1.000	4.700	4.286
3	1.00	8.600	4.700	3.203	0.000	1.000	4.700	4.203
4	1.10	8.600	4.700	3.172	0.000	1.000	4.700	4.172
5	1.20	8.600	4.700	3.130	0.000	1.000	4.700	4.130
6	1.30	8.600	4.700	3.112	0.000	1.000	4.700	4.112
計	6.30	11.000		3.228				

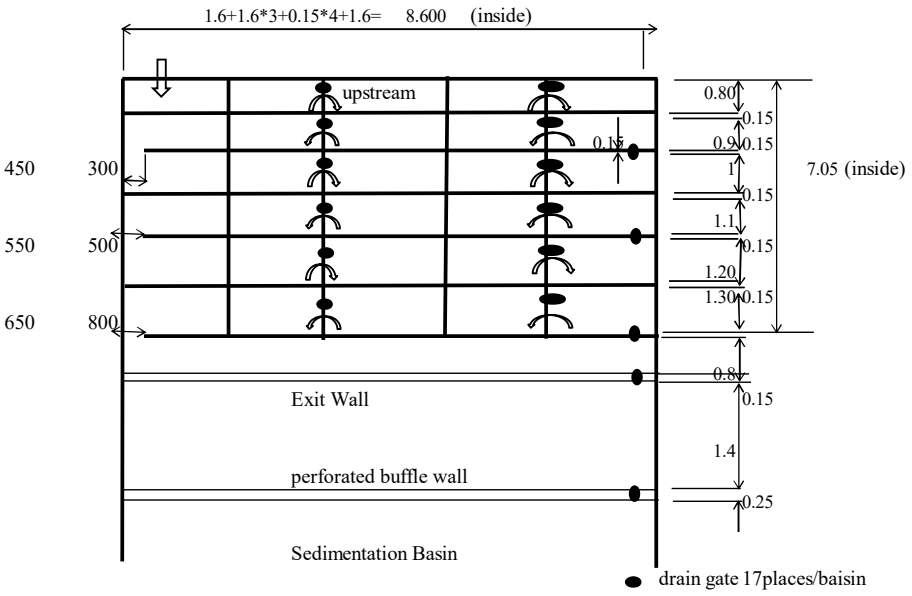
H: effective water depth (average)

EL_1: top of base concrete

EL_2: top of bottom slope concrete (average)

EL_3: top of wall

WL: water level of inlet each row



b)Detention Time

Capacity	6.3*1.6*5*3.228=	162.69 m³
Detention Time	162.69/(27.78/4)=	23.43 min
	[exept Outlet zone of Flocculation Basin]	
(162.69+(0.8+1.4)*8.6*(4.112-0))/(27.78/4)=		34.63 min
	[including Outlet zone of Flocculation Basin]	

c)Accesaries

Removable Weir Plate	12 places/basin
Drain Gate for Hole of 300B*200H	15 places/basin

Flowing Water Section *6%/Train	2.13 m²
Ori. Area/Section	1.065 m²
Number of ori./Train	271 Pieces
Number of ori./Section	135.5 Pieces
Trial dis. form ori.	340 mm
Number of ori./Section	165 Pieces
Ori. Area/Section	1.30 m²

	Number of ori.		No. of ori.	T.D.B.O	Side	Verify
H	5400	14.88	15	4760	320	5400
V	4000	10.76	11	3400	300	4000
V	3.228					

(4) Sedimentation Basin

Japanese Design Criteria for Waterworks Facilities

average Flow Velocity	≦	0.4 m/min	0.395 m/min
Width by Length		1:3-8	
effective Water Depth		3-4 m	
Depth for Sludge	≧	0.3 m	
Level free board	≧	0.3 m	
Weir Loading	≦	350 $m^3/d \cdot m$	

a)Type of Structure * Reinforced Concrete

b)Type of Sedimentation Method Horizontal Flow with Inclined Tube Settler

c) Dimension

Number basin	Width m	Length m	Height m	H (m)	EL_1 (m)	EL_2 (m)	EL_3 (m)	WL (m)
2	8.60	18.000	4.100	3.837	0.000	0.000	4.100	4.087

H: effective water depth (average)(except sludge)

EL_1: top of base concrete (upstream) (sludge height:0.5m)

EL_2: top of base concrete (downstream)

EL_3: top of wall

WL: inlet water level

d)Capacity of Sedimentation Basin

C_t= 8.6*18*3.837= 593.97 m^3/unit

Total Treatment Capacity			**40,000**	m3/day	a
a. Type			Inclining tube settler		
b. Number of train			**4**		b
c. Treatment capacity a/b			**10,000**	m3/day	c
			420	m3/hr	c2
d. Number of compartments			**2**	nos.	d
e. Surface loading			**0.60**	m3/hr/m2	e
f. Surface area per compartment			**350**	m2	f
g. Module of incling tu	size (width x length x height)		1.0	m	g1
	inclining angle (to horizontal)		60	deg.	g2
	effective area	tan(90-g2)*g1	0.577	m2/m	g3
	size of tube		**50**	mm	g4
	Efficiency Coefficient		0.6		
	Effective area per module (1.0 x 1.0m)		6.93	m2	g5
	Apparent Surface Loading (<7.5)		4.16	m3/hr/m2	
	Minumum surface area of modules		51	m2	g6
	Upflow Rate		0.069	m/min	
h. Dimensions					
height:	water depth above module		0.8	m	h1
	height of module		1.0	m	h2
	height of support of module		0.4	m	h3
	clealance between module (incl. support) and		1.7	m	h4
	free board		0.4	m	h5
	total height		4.3	m	h6
width:	access velocity into module		0.50	m/min	h7
	Inflow		3.5	m3/min	h8
	width		4.2	m	h9
	effective width		4.0	m	h10
length:	stilling zone		5.0	m	h11
	length of module		13	m	h12
	length		18.0	m	h15

10

(

e)Detention Time of Sedimentation Basin

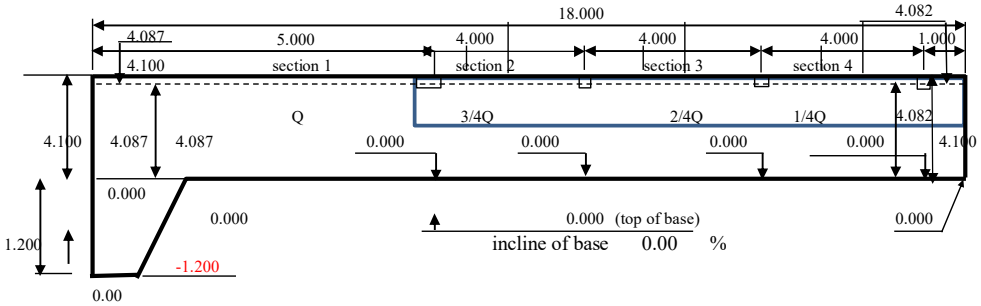
① Apparent Detention Time

T_{ta}= 593.97m3/unit/(27.78/4㎥/min)= 85.52 min = 1.4 h

② Substantial Detention Time

Capacity of Each Section of Sedimentation Basin as shown bellow:

sec. 1	4.2*((4.087-0)+(4.087-0))/2*5=	175.74 m^3/unit
sec. 2	4.2*((4.087-0)+(4.087-0))/2*4=	140.59 m^3/unit
sec. 3	4.2*((4.087-0)+(4.087-0))/2*4=	140.59 m^3/unit
sec. 4	4.2*((4.087-0)+(4.087-0))/2*4=	140.59 m^3/unit



Therefore, substantial detention time;

sec. 1	175.74m3/unit/(27.78/4*4/4)=	25.3 mim
sec. 2	140.59m3/unit/(27.78/4*3/4)=	26.99 mim
sec. 3	140.59m3/unit/(27.78/4*2/4)=	40.49 mim
sec. 4	140.59m3/unit/(27.78/4*1/4)=	80.97 mim
	total	173.75 mim
	=	2.9 h

f)Average Flow Velocity

V= Q/A

V: Average Flow Velocity

Q: flow quantity/basin

A: Average Section Area/basin

A= 8.6*1/2(4.087+4.082)= 35.13 ㎡/basin

V= 27.78/4㎥/min/35.13㎡/basin = 0.20 m/min OK

; at normal operation

V= 27.78/3㎥/min/35.13㎡/basin = 0.26 m/min OK

: in case of sedimentation washing/cleaning

h)Ratio of Length by Width

Ratio of Length/Width = 18/4.2= 1/4.29

i)Froude Number (Fr)

Fr= V_{av}^2／g×R

where, V_{av}; Average flow velocity (m/sec)

V_{av}= 0.463/4㎥/s/35.13㎡/basin= 0.00329 m/sec

g; Accelated Gravity (m/sec^2)= 9.81 m/sec^2

R: Hydroulic Radius(m)= A/P = 2.09 m

A = 8.6*1/2*(4.087+4.082)= 35.13 m^2

P = 8.6+1/2*(4.087+4.082)*2= 16.77 m

Fr= V_{av}^2／g×R = 5.3E-07

j)Reynolds Number (Re)

Re= V_{av}×R／ν

Where, V_{av}; Average flow velocity (m/sec)= 0.00329 m/sec

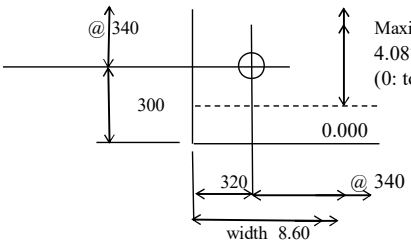
R: Hydroulic Radius (m)= A/P = 2.09 m

ν; Kinematic Viscosity at 25℃ (m^2/s) = 8.98E-07

Re= V_{av}×R／ν = 7.66E+03

k)Intermediate Perforated Baffle Wall

φ100 VP 165 pieces



Flowing Water Section *6%/Train	2.11	m^2
Ori. Area/Section	1.055	m^2
Number of ori./Train	269	Pieces
Number of ori./Section	134.5	Pieces

Trial dis. form ori.	340	mm
Number of ori./Section	165	Pieces
Ori. Area/Section	1.30	m^2

	Number of ori.		No. of ori.	T.D.B.O	Side	Verify
H	5400	14.88	15	4760	320	5400
V	4000	10.76	11	3400	300	4000
V	4087					

Opening Section Area of Intermediate Perforated Baffle Wall (m^2) :

$A_o = \pi/4*0.1*0.1*165$ = 1.296 m^2

Flow Section at Sedimentation

$A_s = 8.6*4.087$ = 35.148 m^2

$A_o/A_s = 1.296/35.148$ = 3.69 % ≒ 6.0 %

l)Valve for Discharging Water under operation W.L

Discharging time : about 2.2 hours

ϕ 250 * 1 place/basin

m)Sludge Drain Valve

Drain out to Sedimentation Basin by means of inclination Basement

ϕ 200 * 2 places/basin

n)Sludge Pit For Drain Pump

B0.6m*L3.0m*H5.1m

(5) Filter Basin

Japanese Design Criteria for Waterworks Facilities

rate of filtration	120 to 150	$m^3/m^2 \cdot d$
thickness of sand	0.6 to 0.7	m
effective size range for filter san	0.45 to 0.70	mm
uniformity coefficient	not exceed 1.7	
back washing flow rate	0.6 to 0.9	$m^3/m^2 \cdot min$
time of backwashing	4 to 6	min

a) Type of Structure

Reinforced Concrete

b) Type of Filtered Method

Coarse Sand High-Rate Filters

c) Dimension

Number of Filter		6		40,000	m3/day
Width of Sedimentation Basin		17.6	m	120	m/day
Width of Filter Basin		6.0	m width	333	m2
Water Level on Filter Basin	+	3.40	m	56	m2/filter
Water Depth on Sand		1.00	m		
Top of Sand	+	2.40	m		
Sand Layer Depth		1.00	m		
Bottom of Sand	+	1.40	m		
Underdrain Structure		0.90	m		

Number basin	Width m	Length m	Height m	H (m)	EL_1 (m)	EL_2 (m)	EL_3 (m)	WL (m)
6	7.400	7.600	3.600	1.000	0.300	0.500	4.100	3.754

1.0

H: water depth over the surface of sand
EL_1: top of base concrete (drain conduit)
EL_2: top of base concrete (filter basin)
EL_3: top of wall
WL: water level of inlet

d) Filter Area of the Basin

B 7.4m * L 7.6m = 56.24 m^2/basin

e) Filtration Rate

V = 40000/6/56.24=" 118.5 m/d : at normal operation

V_w = 40000/5/56.24= 142.2 m/d : in case of filter washing/cleaning

f) Depth of Sand and Water Depth above Sand

Depth of Sand (Ds): 1.000 m

Water Depth above Sand(H_{wd}) : 1.000 m

g) Specification of Sand

Effective Size 1.00 mm

Coefficient of Uniformity less than 1.40

h) Underdrain Devices

i) Drain Gutter

top elevation of base	upstream	14.530
	downstream	14.440
bottum elevation of base		14.190
top elevation of wall		15.340

j) Method of Washing for Filter

Rate of Air Blower;	1.00 $m^3/min/m^2$
Rate of Back Wash Water with Air;	0.35 $m^3/min/m^2$
Time of backwashing	10 min

k) Back Wash Pump

refer to other calculation for pumping

l) Air Blower

refer to other calculation for pumping

m) Inlet Valve

Mortor Drived Gate ϕ 400

Inlet Velocity

= 0.463/6/(π/4*0.4^2)= 0.61 m/sec : at normal operation

= 0.463/5/(π/4*0.4^2)= 0.74 m/sec : in case of filter washing/cleaning

n) Filtered Pipe/Filtered Flow Control Valve

Filtered Pipe SP ϕ 300 to 250

Flow Velocity

= 0.463/6/(π/4*0.3^2)= 1.09 m/sec :at normal operation

= 0.463/5/(π/4*0.3^2)= 1.31 m/sec :in case of filter washing/cleaning

Filtered Flow Control Valve

Type : Valveset Diameter: 300 to 350

Operator: Pneumatic Drive Capacity: 6,667 m^3/d :at normal operation

o) Back Wash Pipe SP ϕ 600 Need Check

Flow Velocity

= 0.35*56.24/60/(π/4*0.6^2)= 1.16 m/sec

p)Air Wash Pipe SP ϕ 300

Flow Velocity

= 1/60*56.24(π/4*0.3^2)= 13.26 m/sec

q) Outlet Weir

B0.7m*H0.4m

r) Opening Dimension of Wash Water Drain

0.5m*0.3m*1place/basin

s) Drain Pipe

Drain Pipe ϕ 250

(6) Filterd Water Measurement and Chloline Mixing Chamber

a)Type of Structure

Reinforced Concrete

b)Type of Method

Utilizing the Water Depth of Weir for Flow Measurement
Utilizing the Energy of Broad Crested Rectangular Weir for Mixing

c)Demension

Number basin	Width m	Length m	H_1 m	H_2 (m)	EL_1 (m)	EL_2 (m)	EL_3 (m)	WL (m)
1	2.40	10.200	2.278	2.090	-0.750	1.440	17.850	1.528

Measuremer
7.0

H_1: water depth before Weir
H_2: water depth after Weir
EL_1: top of base concrete
EL_2: top of weir
EL_3: top of slab
WL: water level of inlet
Length: 7.0m for measurement chamber , 3.2m for chlorine mixing

d)Capacity of Chamber

Filtered Water Flow Measurement Chamber:

V_f= 2.4m * 7m * 2.278= 38.27 m^3

Chloline Mixing Chamber

V_c= 2.4m * 3.2 * 2.09= 16.05 m^3

e)Detention Time of Chamber

* Filtered Water Flow Measurement Chamber:

T_f= 38.27/27.78= 1.38 min

* Chloline Mixing Chamber

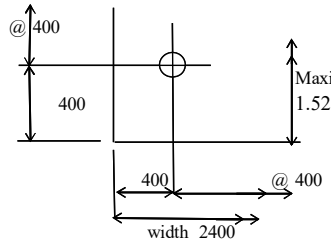
T_c= 16.05/27.78= 0.58 min

f)Inlet Gate

B1.0m * H1.0m * 1place
Flow Velocity= 0.463/(1*1)= 0.46 m/sec

g)Perforated Baffle Wall

φ150 VP 0 ea



Flowing Water Section *6% 0.33 m^2
Number of ori. 19.00 Pieces

Trial dis. form ori. 400 mm
Number of ori. 20 Pieces
Total ori. area 0.35 m^2

	Number of ori.	nber of ori.	T.D.B.O	Side	Verify
H	2400	5.00	5	1600	400	2400
V	2000	4.00	4	1200	400	2000

Opening Section Area of Perforated Baffle Wall (m^2) :

A_o= π /4*0.1^2*42 = 0.330 m^2

Flow Section

A_s= 2.4*2.278 = 5.467 m^2

A_o/A_s= 0.33/5.467 = 6.0 %

i)Weir

Broad Crested rectangular Weir

Width 2.4 m
Weir Hight 2.19 m

(7) Connecting Pipe between Chloline Mixing Chamber and Clear Water Reservoir

Diameter		0.8	m to	0.6	m
Flow Velocity	0.463/(π/4*0.8^2)=			0.92	m/sec (φ600)
	(0.463/2)/(π/4*0.6^2)=			0.82	m/sec (φ400)

(8) Clear Water Reservoir

a)Inlet Valve Chamber

Area= 1.8m*7.8m

b)Demension

Number basin	Width m	Length m	H_1 m	H_2 (m)	EL_1 (m)	EL_2 (m)	HWL (m)	LWL (m)
2	12.60	27.000	5.000	0.900	-4.400	1.800	1.000	-4.000

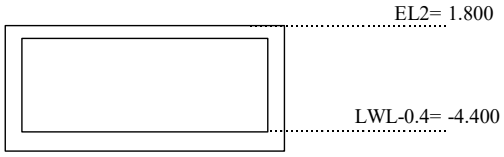
Wall thickness: 0.50 m

Base concrete thickness: 0.50 m

Depth of LWL: 0.40 m

Free board: 0.50 m

Top slab thickness: 0.30 m



H_1: effective water depth

H_2: depth of outlet pit

EL_1: top of base concrete

EL_2: top of top slab

outside Width: 26.700 m

Length: 28.000 m

Hight: 6.70 m

c)Effective Capacity

W12.6m * L27m * H5m * 2basins= 3,402 m^3

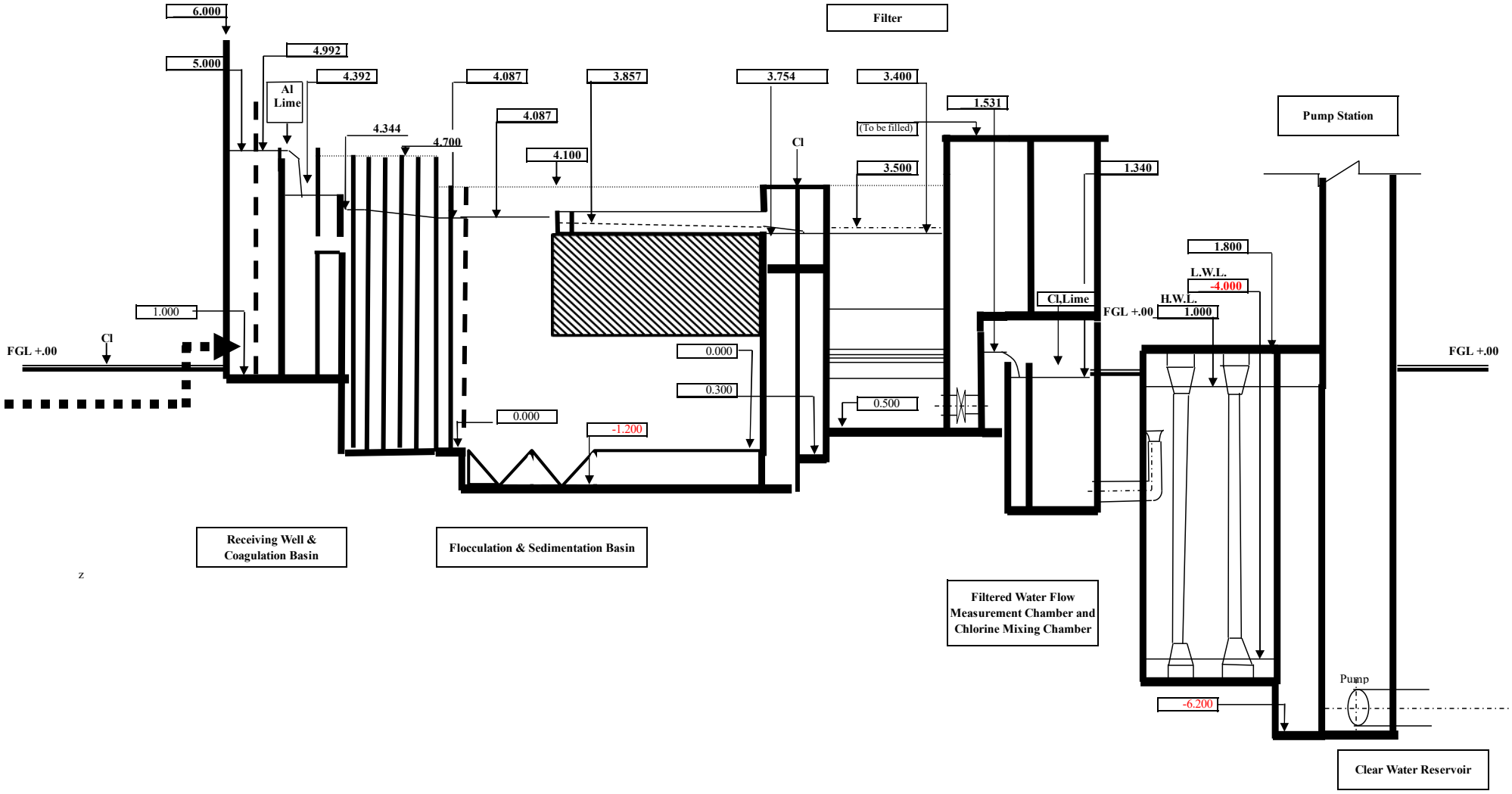
d) Detention Time

3402/(36000/24)= 2.3 h

(9) Transmission Pump and Distribution Pump

refer to other calculation for pumping

HYDRAULIC FLOW DIAGRAM



APPENDIX E：EIA Report for Karenge WTP

Appendix E

Japan International Cooperation Agency

FINAL REPORT

ENVIRONMENTAL IMPACT ASSESSMENT (EIA) FOR THE PROJECT OF REHABILITATION AND EXPANSION OF KARENGE WTP AND TRANSMISSION & DISTRIBUTION FACILITIES IN RWAMAGANA DISTRICT

Prepared for
Water and Sanitation Corporation (WASAC Ltd)
www.wasac.rw

Prepared by:
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September, 2021

ENGINEERING-ENVIRONMENT-CLIMATE CHANGE- SOCIO-ECONOMIC STUDIES

DISCLOSURE OF CONSULTANT

I hereby undertake that all requirements included in terms of reference provided by the client and approved by Rwanda Development Board (RDB) are complied with. I also undertake that the facts given in this EIA report are factually correct to the best of our knowledge.

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Kigali-Rwanda

EXECUTIVE SUMMARY

Project background

The government of Rwanda through Water and Sanitation Corporation (WASAC Ltd) and with the support from Government of Japan through, Japan International Cooperation Agency (JICA) is preparing a Water Supply Master Plan for City of Kigali (hereafter referred as Master Plan). The objective of this Master Plan is to enhance stability of water supply and to catch up growth of water demand in the City of Kigali and neighbouring sectors.

As part of the Master Plan, WASAC through NIHON SUIDO CONSULTANTS CO., LTD. and YACHIYO ENGINEERING CO., LTD JV is conducting Feasibility studies for selected projects including **Rehabilitation and Expansion of Karenge WTP and Transmission & Distribution Facilities in Rwamagana District,** to supply both Rwamagana district and City of Kigali. In accordance with the provisions the **Law N°48/2018 of 13/08/2018 on environment** determining the modalities of protection, conservation and promotion of environment in Rwanda; (ii) Ministerial Order **N°001/2018 of 25/04/2018** determining the list of works, activities and projects subject to an environmental impact assessment and, (iii) JICA guidelines for Environmental and social Consideration, the present project falls under category one requiring full EIA.

Objectives of the EIA

The overall objective is to develop an Environmental Impact Assessment (EIA) for the "Rehabilitation and Expansion of Karenge WTP and Transmission & Distribution Facilities in Rwamagana District" in order to ensure sustainability of proposed infrastructure, avoid, minimize and compensate negative impacts and to enhance positive impacts. Further, the EIA shall ensure that the project is implemented in an environmentally and socially sustainable manner and in full compliance with Rwanda's regulations as well as and JICA guidelines for environmental and social considerations.

Approach and methodology

To achieve the above objectives the consultant team followed procedures stipulated in General Guidelines and Procedures for Environment and Impact Assessment. The methodology used involves a number of stages from scoping phase that includes preliminary assessment to understand and establish boundaries of the study; the desk review of available literature, field visits to establish baseline data, analysis of all available data (secondary and primary data), prediction of positive and negative impacts, analysis of alternatives as well as the proposal of mitigation measures leading to an Environmental and Social Management Plan and Monitoring plan. Approach and methodology used include: (a) Literature review and primary data collection, (b)Field Survey and measurements and**, (c)** stakeholder consultation and engagement .

Project location and description

Karenge Water Treatment Plant is located in Southern Province of Rwanda, Rwamagana District, Karenge Sector, Byimana Cell, Rukori village. The Plant was constructed was constructed in 1978 and expanded in 1985 and 2000. Currently, the plant produces 16,000 m^3/d, which is much larger than the designed water treatment amount of 13,000 m^3/d with a distribution system extended to approximatively on 69,5km . The main source of water for the plant is Lake Mugesera. The plant supplies treated water in different areas of Rwamagana District and City of Kigali (Gasabo and Kicukiro District).

The key activities to be undertaken under rehabilitation and extension include: (a) **Rehabilitation of intake facility(r**ehabilitation of Raw Water Transmission pipes (ND300), relocation of the pump house and upgrading the capacity of pumps and motors), (b) Expansion of Karenge WTP and forwarding infrastructures(expansion of WTP capacity from 15,000m3/d to 18,000 m3/d (Filtration Basins, Clear Water Reservoirs)in phase one and expansion of Intake and WTP for 30,000 m3/d (Intake pumps, Treatment facilities, Clearwater reservoirs and pumps in Phase two) and, (c) Construction of new Transmission Pipelines (ND700, L= 33 km) and Rehabilitation and construction of treated water reservoirs.

Environmental and social impact prediction

The project is expected to have both positive and negative impacts on ecosystems and local communities. Positive impacts expected from the proposed project include: availability of treated water in both Kigali and Rwamagana, improvement of sanitation conditions, sustainable and wise use of natural resources (Mugesera Lake), temporary and permanent jobs creation and employment, income generation to the local population, transfer of knowledge from skilled to non-skilled people who may interact with the project activities , availability of potable and drinking water in the project areas of interventions , increasing of social welfare, etc.

Expected adverse impacts range from physical environment, biological environmental and social environment. These include potential pollution of water in Mugesera lake, air and noise pollution during construction works, possible soil erosion from excavation works of pipes trenches and other water storages facilities, modification of water table flows, generation of sludge from the treatment plant and other waste, loss of biodiversity at water distribution lines and at water reservoirs and encroachment of buffer zone etc. Social impacts of the project implementation will also include loss of land at WTP and new reservoir , Physical resettlement (one household for phase one and 5 households in phase 2) at the water treatment area, loss of land, trees and crops at WTP, water intake, water reservoirs(81households) and acquisition of easement along water pipelines. Other project related impacts includes onsite occupational health and safety especially during construction phase.

Mitigation measures for identified and projected impacts were proposed for each of the adverse impacts projected, and this to an extent that they can be avoided, reduced, limited or eliminated and therefore manageable. In this context the Environmental Management Plan(EMP) and an Environmental Monitoring Plan indicating the mitigation measures, procedure to be followed, monitoring indicators, the responsible institutions to implement these measures and estimated cost of implementing each of these mitigation measures.

Given the nature, location of the proposed project, proposed works and the potential impacts associated with the implementation of project, the consultant can conclude that the nature and extent adverse impacts identified can be avoided mitigated and eliminated by the implementation of appropriate mitigation measures. In fact, the rehabilitation and extension of Karenge water treatment Plant and supply system is bound to be executed in a sustainable manner and in compliance with national environmental regulations, JICA environmental and social considerations. However, this requires full implementation of proposed mitigation measures and regular monitoring done per as proposed EMMP. The total estimated budget for the implementation and monitoring the EMP is one hundred and eighty seven thousands US$(187,000US$). Much of these fees will be used for compensation. The contractor shall prepare final budget for the implementation of proposed mitigation measures.

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ABBREVIATIONS

BESST	: Bureau for Engineering and Environmental Studies
CBA	: Cost benefit analysis
CBD	: Convention of Biological Diversity
CITES	: Convention of International Trade of Endangered Species
EA	: Environmental Assessment
EIA	: Environmental Impact Assessment
EMP	: Environmental Management Plan
ESIA	: Environmental and Social Impact Assessment
ESMP	: Environmental and Social Management Plan
FS	: Feasibility Study
GIS	: Geographic Information System
IUCN	: International Union for the Conservation of Nature
JICA	: Japan International Cooperation Agency
JST	: JICA Study Team
JV	: Joint venture
Ltd	: Limited
MCM	: Million Cubic Meters
MININFRA	: Ministry of Infrastructure
MoE	: Ministry of Environment
NISR	: National Institute of Statistics of Rwanda
NST1	: National Strategic for Transformation
OHS	: Occupational, Health and Safety
RAP	: Resettlement Action Plan
RAPEP	: Rwanda Association for Professional Environmental Practioners
RDB	: Rwanda Development Board
REMA	: Rwanda Environment Management Authority
RLMUA	: Rwanda Land management and Use Authority
RURA	: Rwanda Utilities Regulatory Agency
RWB	: Rwanda Water Board
RWFA	: Rwanda Water and Forest Authority
SDGs	: Sustainable Developments Goals
ToRs	: Terms of Reference
WASAC	: Water and Sanitation Corporation
WTP	: Water Treatment Plant

CHAPTER I: INTRODUCTION

1.1 Project background

Currently Rwanda is undergoing massive socio-economic development and is doing its best to have infrastructure that can support the country's ambitions and targets with the aim of Rwandans well being and development. Among key services to be achieved include the sustainable and reliable clean water supply and to ensure safe, reliable and affordable water supply services for all Rwandans at 100 % coverage by the year 2024, thereby ensuring universal and equitable access to safe and affordable drinking water for the people aimed at achieving NST-1 along with Sustainable Development Goals (SDGs)

In this regards, the government of Rwanda through its agency Water and Sanitation Corporation Limited (WASAC Ltd) with the support from Government of Japan through Japan International Cooperation Agency (JICA) is preparing a Water Supply Master Plan for the Kigali City and its environs with the main objective to enhance stability of water supply and to catch up growth of water demand, by preparing Master Plan for developing and maintaining water supply facilities in Kigali City, thereby contributing to provide access to safe water and stable economic growth in Rwanda.

As part of the Master Plan, Water and Sanitation Corporation (WASAC) through NIHON SUIDO CONSULTANTS CO., LTD. and YACHIYO ENGINEERING CO., LTD JV, is conducting Feasibility studies for Rehabilitation and Expansion of Karenge WTP and Transmission & Distribution Facilities in Rwamagana District, to supply clean water to both Rwamagana and Kigali City. The project intends to expand the existing Karenge WTP sourcing water from Mugesera Lake from a capacity of 12,000 m^3/day to 48,000 m^3/day in a Phase 1 and will further expand it to 120,000 m^3/day. The project is vital considering that the water demand is high and growing rapidly in the service area; the existing plant are over-used over its design capacity and the Karenge WTP has already guaranteed water abstraction permit from RWB (former RWFA) for 48,000 m^3/day.

The rehabilitation and expansion of Karenge WTP will be associated with the construction of supporting strucures such as construction of administration building, construction of water storage reservoirs, construction of water pipelines and pipes laying, construction of pumping stations (pumping building and pump) as well as other associated facilities to the project.

1.2 Project developer/Water and Sanitation Corporation

Water and Sanitation Corporation (WASAC) Ltd is an entity established by the Government of Rwanda to manage water and sanitation services as per the law Nº 87/03 of 16/08/2014. The Company was created in the on-going government reform intended to deliver water and sanitation utility sufficiently focused to deliver new infrastructure; efficient and effective service delivery; build a strong people capability; and meet key national milestones. It is expected to reverse the status quo that includes inadequate planning and investments; inefficient and wasteful operations; inadequate institutional management focus; improve viability and autonomy; and establish a sustainable and customer-centric utility to deliver an important mandate that touches people of all walks of life. The mission of the company is providing quality, reliable and affordable water and sewerage services through continuous innovations and detailed care to customers' needs.

1.3 Presentation of the consultant

BESST LTD (Bureau for Engineering and Environmental Studies) is a Rwandan private company Registered with Rwanda Development Board (RDB).The company is certified by Rwanda Association professional Environmental Practitioners (RAPEP) to conduct Environmental studies with license number RAPEP/EA/O72 (list Certified experts available at www.repep.org). The company has its headquarters in Kigali City, Gasabo District, KG 182st, Martin Plaza, Second Floor. The company is specialized in Environmental studies, Resettlement Actions Plans (RAP, climate change risk assessment, socio-economic assessment, baseline surveys, waste management, water and sanitation, advisory services in sectors ranging from Agriculture, energy development, Infrastructure and housing development, transport and water supply. For this specific assignment of preparation of EIA, the company used the following consultants:

Théogène HABAKUBAHO, Team leader – He is an authorized EIA Lead expert **(RAPEP/EA/024)**. He holds a Master of science in environmental science management and development and BSc in physical geography. He has over 12 years professional experience in the field of environmental assessment and management. He has worked on various projects as team leader of environmental studies. Key projects worked on include irrigation projects, green house agriculture, Water supply, mining projects, road and bridge construction projects, building and house constructions, schools and hospitals, among others.

NSHIMIYIMANA Fabien, Hydrologist: He is an authorized EIA Lead Expert (**RAPEP/EA/035).** He- holds a Master of Science in Water resources and environmental Management and a BSc in Biology. He is a Water Resources Engineer with over 10 years' experience in planning, management, design and construction supervision of water resources infrastructure. Conversant with water resources studies, Environmental and Social Impact Assessment Studies, hydrological, hydrodynamic and groundwater modelling, GIS & remote sensing. In this assessment he assessed impact related to water resources demand and use.

Mrs. Emma BENEMARIYA, Sociologist- holds a Master of Development Studies and a bachelor's degree in Social Sciences. She is tasked with evaluation of social impacts associated with project and has led the socio-economist survey.

KAYIJAMAHE Charles, Ecologist-He has Master of Science in geo-information system and environment with a bachelor's of science in biology. Over the last 8 years he has worked with different institutions involved in biodiversity conservation and natural resources management, research and monitoring, conservation planning, establishment and empowerment of local conservation groups. He also has skills in institutional development and leadership, strategic planning, proposal writing and projects management. He has participated in different EIA as ecologist. He assessed impacts of the project on site ecology, flora and fauna.

NSEKANABANGA Jovine, Statistician: He is an experienced data collection and analysis and he has a bachelor's degree in applied statistics with over five years in data collection and analysis. He supervised data collection, data entry and conducted data analysis.

Clarisse MUKANDINDA CYUZUZO, GIS Expert: She is an authorizer EIA Junior Expert **(RAPEP/EA/138)**. She assisted the team in data collection and in mapping, noise and vibration measurement. She also participated in assets inventory. The above team was supported by field enumerators and data entry officers

1.4 Objectives of the study

The overall objective of the EIA was to prepare an Environmental and Social Impact Assessment (ESIA) report and Environmental Management Plan (EMP) for the project of Rehabilitation and expansion of Karenge water treatment Plant. Specifically, social and environmental assessment was done with the aim of :

- Identify and evaluate environmental and social risks and impacts of the project implementation.
- Propose mitigation measures to anticipate and avoid, or where avoidance is not possible, minimize and, where residual impacts remain, compensate for risks and identified impacts to workers, affected and local community and the environment in general.
- Identify key stakeholders and their responsibilities before and during the implementation activities/ operation phase that should play roles in the EMP Framework.

1.5 Scope of the study

The study covered the impacts of the projects from planning phase, construction and operational phases and considered the decommissioning phase of the project with considerations of the project sites and its surroundings. The study was also prepared in compliance with national environmental regulations and JICA guidelines for environmental and social considerations guidelines. Therefore the scope of the study was to:

- Identify legislation, policies (both local and international) that are likely to influence the implementation of the project;
- Develop an overview of the baseline environment of the project intervention area. i.e. study area description, physical, biological and social- economic-environment etc
- Description of the likely significant impacts (both positive and negative) of the proposed project that could be caused by the project implementation on environment and local community
- Description of the methods used in the analysis, description and classification of the impacts;
- Description of Impacts on human health especially workers during the construction and operation phases.
- Propose mitigation measures against of the predicted adverse impacts identified.
- Propose an Environmental Monitoring Plan with measurable indicators and parameters for these mitigation measures to ensure sustainability of the project

1.6 Approach and methodology

To achieve the EIA objectives the consultant team followed procedures stipulated in General Guidelines and Procedures for Environment and Impact Assessment. The methodology used involves a number of stages from scoping phase that includes preliminary assessment to understand and establish boundaries of the study; the

desk review of available literature, field visits to establish baseline data, analysis of all available data (secondary and primary data), prediction of positive and negative impacts, analysis of alternatives as well as the proposal of mitigation measures leading to an Environmental and Social Management Plan and Monitoring plan. Approach and methodology used include: (a)Literature review and primary data collection, (b)Field Survey and measurements and**, (c)** stakeholder consultation and engagement The present EIA followed the conventional methods that meet the requirements of the Organic N° 48/2018 of 13/08/2018 on Environment determining the modalities of protection, conservation and promotion of environment in Rwanda, the Ministerial order No 001/2019 of 15/04/2019 establishing the list of projects that must undergo environmental Impact assessment, instructions, requirements and procedures to conduct environmental impacts assessment and JICA guidelines on Environmental and Social considerations.

- **Scoping**

A scoping study involved consultation with WASAC Ltd, JICA, Karenge WTP manager and staff. Initially a field visit at the plant was conducted to familiarise the study team with existing features and proposed project infrastructure was conducted. Scoping continued by visiting the site area again to understand project features and receiving environment. The scoping exercise further entailed the following:

- Preliminary findings of the existing environment; (primary, biological and socio-cultural environment)
- Review and discussion of the ToRs for common understanding with client and RDB the extent of the ESIA study. So far, Terms of reference has been reviewed and approved by RDB as required by Environmental law
- Preliminary predictions of likely positive and adverse impacts; and
- Finally establishing clear boundaries of the study and focus on the relevant issues concerning the study.

- **Field survey**

Field surveys were made from the initial stage of the project designs with the aim of to assess the baseline environmental and social conditions of the project areas to identify environmental and socio-economic components that are likely to be significantly affected by this proposed project. During field survey, basic data and information on the biological and physical resources, socio-economic as well as historical and cultural sites have been collected.

- **Document Review**

Secondary data and legal framework was mainly obtained through desk work review was done on existing institutional legislation, policies, plans and programs, which are likely to influence different parts of the implementation of the present project. Key legal instruments consulted include but not limited to the following:

- The law N° 48/2018 of 13/08/2018 on Environment in Rwanda
- Ministerial order N° 001/2019 of 15/04/2019 establishing the list of projects that must undergo environmental Impact assessment, instructions, requirements and procedures to conduct environmental impacts assessment,
- National Water Resources Master Plan
- Rwamagana District Development Plan.
- Water supply and sanitation policy,
- Feasibility Study Report for the project

In addition to national policies and regulations influencing this project, considered international policies and standards especially JICA guidelines on environmental and social consideration, regional protocols, World Bank safeguard policies and JICA Environmental and Social consideration guidelines.

- **Stakeholders Consultations and engagement**

Discussions with WASAC Ltd, key stakeholders and specialist experts from different institution including Rwanda Environmental Management Authority, Rwanda Water Board, Rwamagana District, Rwanda Development Board and local communities . The objectives of these consultations was:

- To ensure effective project implementation
- To make the ESIA study participative and transparent and hence build a trusting project sustainability based on principles of transparency, accountability, accuracy, trust, respect and mutual interests with affected communities and other stakeholders

- To ensure effective engagement with local communities and other key stakeholders throughout all phases of the project.

- **Impact prediction and analysis**

Impacts prediction and analysis involved assessment of the entire project cycle i.e. project mobilization, construction, operation and decommissioning phases. Positive and negative impacts of the project were identified using regulations, guidelines (national and international) standards and norms related to water supply projects, biodiversity protection, environmental protection and social-economic assessment. The impacts were assessed by its nature, location magnitude, timing (during construction, operation, immediate, delayed) duration (short term/long term, intermittent/continuous), reversibility/irreversibility, likelihood (probability, uncertainty) and significance (local, regional, global) etc. Among key tools used to predict impacts include:

- ***Geographical Information System (GIS)*** - used to show the extent of a particular project activity influence on the area by mapping it out.
- ***Checklist-*** project activities that might affect or enhance the livelihood in the project areas were listed and drawn against environment indicators and occurrence.
- ***Cost benefit analysis (CBA)*** - Which involved analysis of project activities in terms of their financial and economic effects to establish the cost implications of the impacts and the mitigation measures. Impacts was analysed according to market costs, foregone costs or opportunity cost. The CBA was used to assign economic values where feasible to impacts both adverse and beneficial.
- ***Impact Matrix-*** under the Impact matrix, the analysis by these tools of GIS, checklist, CBA, will be tested against their significant effect on recipients in the project area of intervention. Impact matrix in tabular format will be drawn, in which impacts from project activities will be tested against their significant effect on the areas of intervention.

For each adverse impact identified, its level of significance was indicated, mitigation measures proposed and an Environmental Management Plan (EMP) was developed.

1.7 Structure of the report

This report is organised in eight chapters structured as follow:
Chapter 1: General introduction
Chapter 2: Location and Description of the project
Chapter 3: Legal regulatory and institution framework
Chapter 4: Baseline information of the projects
Chapter 5: Project need and alternatives
Chapter 5: Public Consultation and Stakeholder Engagement Project need and alternatives
Chapter 7: Identification, evaluation of impacts and proposed mitigation measures
Chapter 8: Environmental Management Plan and Environmental Monitoring Plan
Chapter 9: Conclusions and recommendations

CHAPTER II: PROJECT LOCATION AND DESCRIPTION

The present chapter describes the location of the project and its proposed activities in different phases of implementation. The description was made from planning and designing phases, construction phases, operation and maintenance phase as well as the decommissioning phase.

2.1. Kigali Water Supply Master Plan and 15 Years Investment Plan

The Rehabilitation of Karenge Water Treatment Plan is part of Kigali Water Supply Master Plan, 15 Years Investment Plan and Feasibility study of selected project under financial support from the government of Japan to the Government of Rwanda.

2.1.1. Kigali Water Supply Master Plan

The Kigali Water Supply Master Plan was initiated by the government of Rwanda through Water and Sanitation Corporation(WASAC) with the support from Government of Japan through, Japan International Cooperation Agency (JICA) with the main objective to enhance stability of water supply and to catch up growth of water demand, within the Kigali City and its environs and hence contributing to access of availability to safe water and stable economic growth in Rwanda.

The Master Plan covered the City of Kigali and surrounding seven (7) sectors namely Shyorongi sector, Runda sector, Rugarika sector, Ntarama sector, Muyumbu sector, Gahengeri sector, and Nyakaliro sector. The objective of preparing the Master plan is to enhance stability of water supply and to catch up growth of water demand, by preparing Master plan for developing and maintaining water supply facilities in Kigali City, thereby contributing to provide access to safe water and stable economic growth in Rwanda.

Figure 1: Spatial Coverage of Master Plan

Source: JST, 2019

Together with Master Plan, a Strategic Environmental Assessment (SEA) was prepared and cleared by Rwanda Environment Management Authority (REMA).

2.1.2. 15-Years Investment Plan

In addition to the overall Master Plan, a 15 Years Investment Plan is under preparation. Project considered under 10yeras investments Plan include:

- A04 NRW Reduction for Ntora-Remera Area: Pressure control and pipe renewal and;
- A05 NRW reduction project through pipe renewal and pressure control are combined and will be proposed in the Master Plan as an integrated project which should be implemented in a phased manner.

- A01: Construction of Masaka WTP and Clear Water Transmission & Distribution Facilities and
- A02: Rehabilitation and Expansion of Karenge WTP and Transmission & Distribution Facilities are selected for the F/S in this study. The capacity and phasing plan should be reviewed in the F/S.
- A06: Capacity development for Sustainable Use of Water Resources and Water Supply Facilities was shortlisted under those projects.
- 07: Kigali Central Transmission Main are shortlisted without the priority since it is regarded as not an urgent project because the expansion at Nzove until 2035 will be limited to on-going projects.
- A03: Reconstruction of Nzove WTP was omitted from the shortlist because the on-going procurement of the Nzove rehabilitation work was on track as of the day of the JCC.

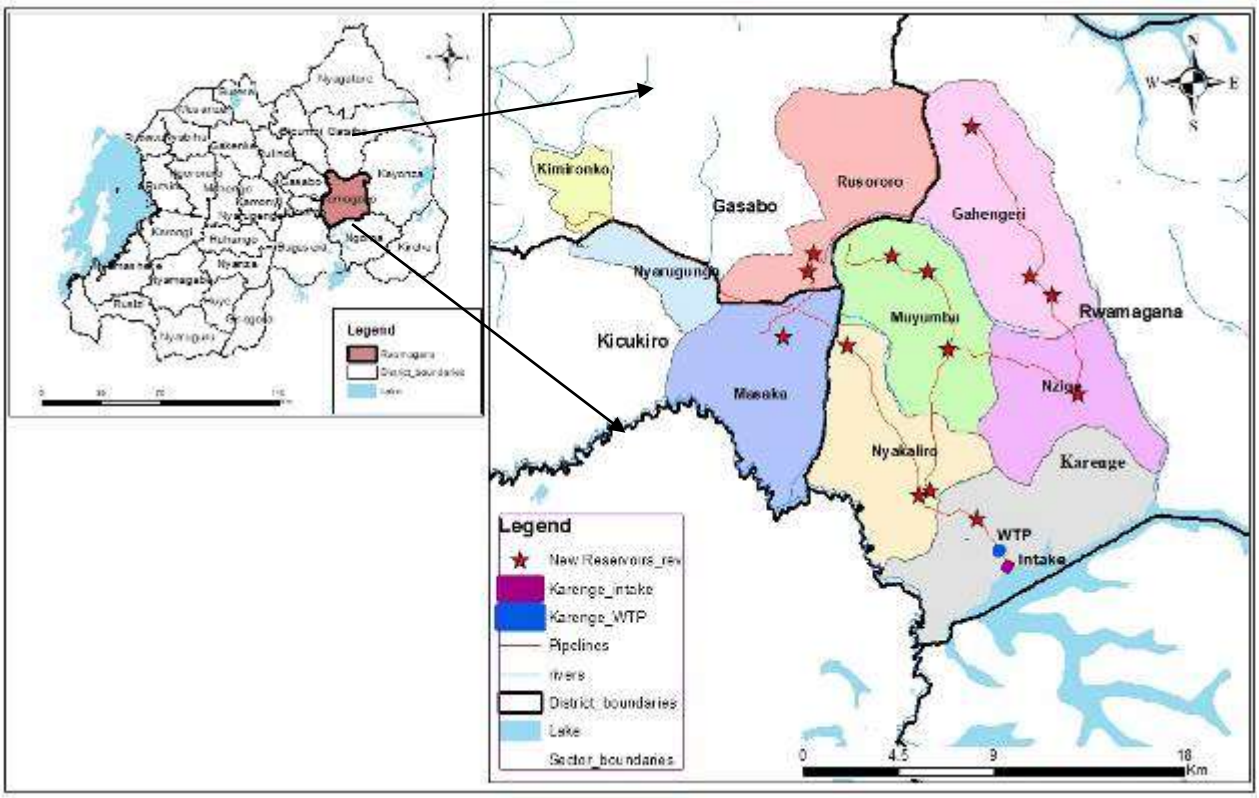
The strategic Environmental Assessment will be reviewed and updated to included details included under the 15 Years Investment Plan. Further, feasibility studies are under preparation for (i) Rehabilitation and Expansion of Karenge WTP and Transmission & Distribution Facilities and (b) Construction of Masaka WTP and Clear Water Transmission & Distribution Facilities. The present EIA covers the Karenge project and a separate EIA for Masaka Project will be prepared.

2.2. Karenge water supply project

2.2.1. Administrative location of Location of Karenge Water Treatment Plant

Administratively, Karenge WTP is located in Eastern province of Rwanda, Rwamagana District, Karenge Sectors, Byimana Cell; Rukori Village. The water pipelines with support infrastructures such as water reservoirs are located in different sectors of Rwamagana District namely Karenge, Nzige, Nyakariro, Muyumbu and Gahengeri. The project touches also a part of Rusororo and Kimironko Sectors of Gasabo District and a small portion of Masaka and Nyarugunga Sectors located in Kicukiro District. The map below shows the project intervention areas

Figure 2: Administrative Location of Karenge Project

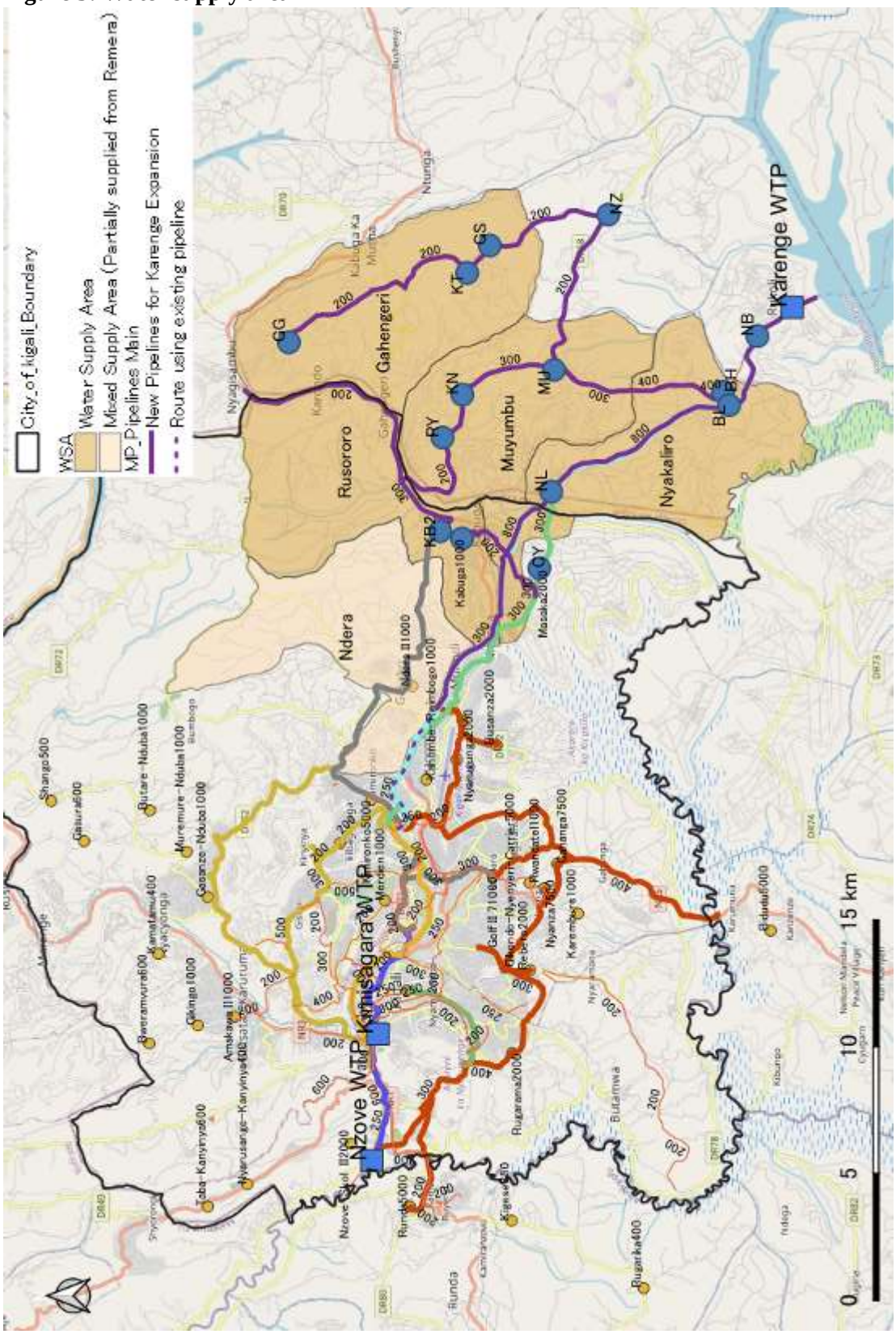


Source: BESST LTD with data from Feasibility study, 2021

2.2.2. Location of Water supply area

The reservoirs and pipelines are located in different sectors of Rwamagana district Gahengeri, Muyumbu and Nyakaliro sectors and touch the part of Ndera and Rusororo sectors of Gasabo district as shown on map below (figure) .

Figure 3: Water supply area



Source: Project FS report, 2021

2.2.3. Existing Karenge water treatment Plant

The Karenge WTP was constructed in 1975 by AIDR (Association International de Développement Rural) with a nominal capacity of 160 m^3/hour and should deserver former Bicumbi; Gashora and Kanombe. In 1985 the plant was extended in order to increase its production capacity to 300 m^3/hour. In 2008; another extension and rehabilitation by SOGEA-SATOM has increased production to 500m3/hour and strengthened distribution network to Kigali City, and the year 2014 left the plant working completely very good with 14,500 m^3 /day exceeding the nominal capacity (12,000 m^3).. Currently the plant produces 16,000 m^3/d which is much larger than the designed water treatment amount of 12,000 m^3/d. The source for the plant is Lake Mugesera located in the vicinities of the plant.

Table 1: Overview of Karenge Water Supply System

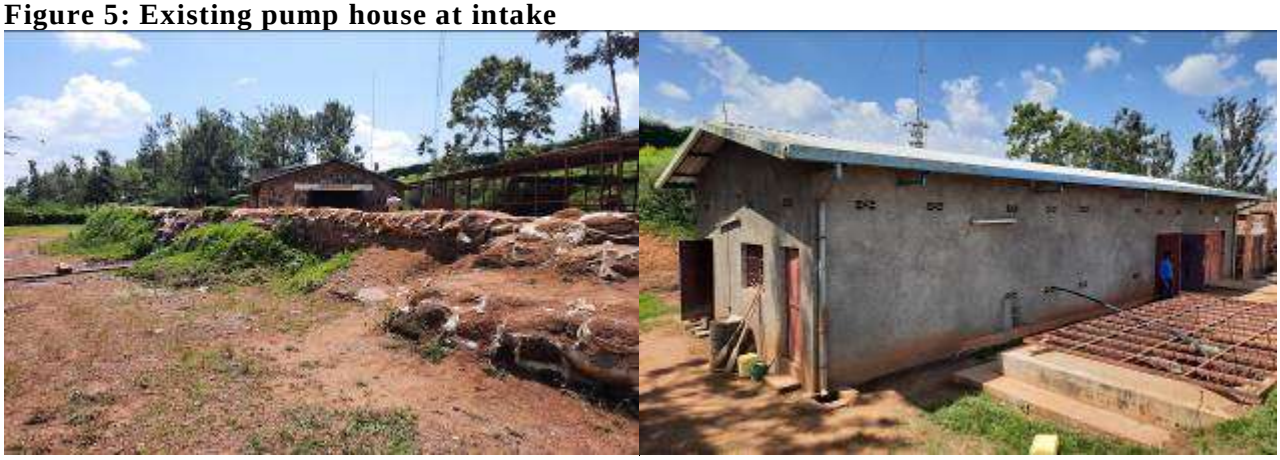
Component	Description
Water source	Mugesera lake
Water treatment plant capacity	12,000 m^3/d
Purification type	Rapid purification type
Distribution area	Gasabo ,Kicukiro, Rwamagana
Pipe length	Approx 69.5 km
Direct branch	8 places
Reservoirs	16 places :22 reservoirs

Source: WASAC Ltd

Figure 4: View of existing Karenge WTP and its surroundings

Source: BESST, photo taken during site visit, Feb 2021

Figure 5: Existing pump house at intake



Source: BESST, Photo taken during site visit, Feb 2021

2.2.4. Proposed area for Extension of WTP

The expansion KWTP will be made in the vicinity of the existing plant with the same phyisico- geographical characteristics and administrative boundaries. The new site is currently used for agricultural with different agro forestry plants including coffee plantations, bananas, maize etc. The plot also accommodates one household which will be inevitably removed to pave the way the project implementation during phase one and four households for phase Two. However as the site and land is privately owned by local resident fair compensation is expected during the project implementation.

Figure 6: Existing settlement and land use at New Karenge extension site

Source: BESST, photo taken during site visit, Feb 2021

2.2.5. Location of the new intake

The new intake is located adjacent to the exiting intake pumping station. As the existing intake is within the buffer zone of Mugesera Lake (within 50 m from lakeshores) and is affected by repetitive floods, the relocation of the new intake was recommended. This will also include expansion of the intake pipelines to approx. 500m far from the shore of the Mugesera Lake near to the existing intake location.

Figure 7 : Area for development at the intake expansion on Mugesera lake

Source: Project FS report

The land use nearby the intake is dominated by agricultural forestry mixed with some plantation tress dominated by grevillea robusta plantations. The common crops found near the site are banana plantations, cassava plantations, sweet potatoes, coffee plantation,.

Figure 8: Vegetation characteristics at new intake site

Source: BESST, Photo taken during site visit, 2021

2.2.6. Location of Water storage reservoirs and pipelines

The routes and the diameters of the transmission pipelines were determined based on the hydrological models used during the elaboration of feasibility study. The water demand in each sector was divided and allocated to the nodes in the model according to the water demand as follows

i) ***Rusororo*;** water demand in the Rusororo was divided into 3 nodes; Rusororo-Kabuga (RU, where there is existing Maisson de Jeunes Kabuga), Masaka-Cyimo (CY) and Rusororo Kabuga 2 (KB). Note that the Masaka Cyimo is not in the Rusororo Sector but in the Masaka sector located on the opposite side of Kabuga across National Road (NR4). However, the development in Kabuga, Rusororo is seamlessly spread to the north side of Masaka covered by the Cyimo reservoir; low-middle rise establishments are stretched across both sectors' boundary. This area is currently the most developing areas in the Rusororo sector, so can be regarded as an inseparable township in the Rusororo. In the future, the development is expected to stretch to the north along the NR4. The demand along the NR4 up to the boundary mainly located in the low-elevation area, from the Kabuga to the sector and the Fumbwe sector in the Rwamagana district located in the west. The Kabuga (RU) has an enough elevation to supply water to the Fumbwe sector by gravity; therefore the important main reservoir should be located in the RU.

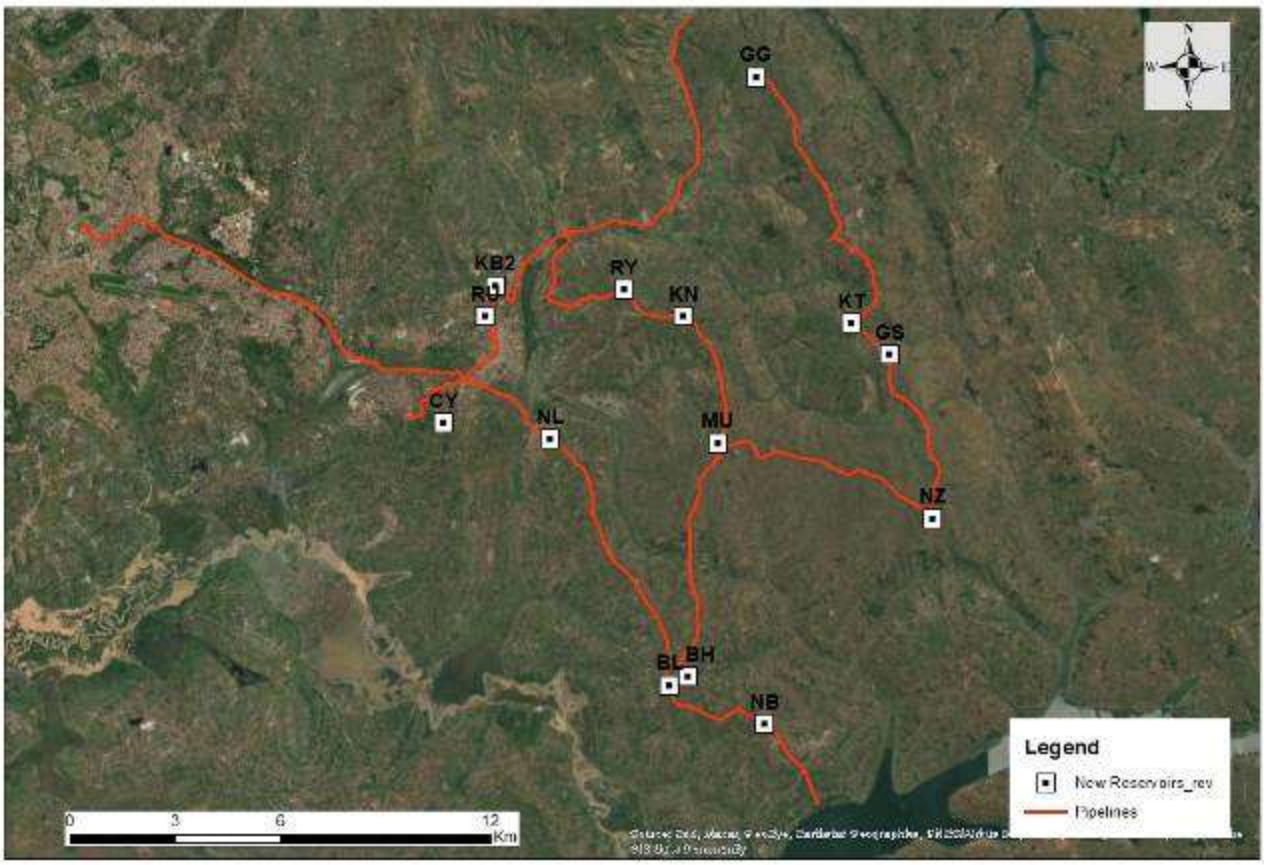
ii) ***Muyumbu*:** most of the demand is centred at the hilly area through Muyumbu-Gatsata, Ryabahesha to Muyumbu-Murehe. Those areas can be supplied from the Bihembe-high reservoir. The demand was allocated to the Murehe and Ryabahesha splitting into to.

iii) ***Gahengeri*:** The known water supply route is only from Nzige, pumping up once at the Gasutamo pumping station. The alternative water supply route may be seen from the north through Kabuga to Fumbwe, but was not adopted because of no existing pipeline routes.

iv) ***Nyakaliro**:* The demand was split into two; one at Bihembe-low and one at the Nyakaliro-Gishore a town next to the CoK.

v) ***Other area in Rwamagana*;** 9,500 m3/day of the given demand was allocated to the end of Kabuga-Fumbwe line and Nzige.

Figure 9: Location of water reservoir[1] and pipeline



Source: BESST, Photo taken during site visit, 2021

2.2.7. Project Components

The proposed Karenge water supply project includes:

- **Rehabilitation of intake facility**
  - Rehabilitation of Raw Water Transmission pipes (ND300)
  - Relocation of the pump house and upgrading the capacity of pumps and motors
  - Expansion of WTP capacity from 15,000m3/d to 18,000 m3/d (Filtration Basins, Clear Water Reservoirs)
- **Expansion of Karenge WTP and forwarding infrastructures**
  - Expansion of Intake and WTP for 30,000 m3/d (Intake pumps, Treatment facilities, Clearwater reservoirs and pumps
- **Construction of New Transmission Pipeline**s (ND700, L= 33 km)

The rehabilitation and expansion of the plant is meant to increase the capacity of the plant in two different phases as shown in the table below:

Table 2: Summary of the expansion stage and the plants

Name	Total Capacity	Remarks
Existing Karenge WTP	12,000 m3/day	(Currently over-used 15,000 m3/day in an yearly average supply)
New Karenge WTP (Karenge 2)	Phase 1: 36,000 m3/day (Total 48,000 m3/day)	Subject to Preliminary Design and Cost Analysis
	Phase 2: 72,000 m3/day (Total 120,000 m3/day)	Conceptualized in the F/S for Future Expansion

Source: Project FS report

Note: "Expanded Karenge WTP" refers to the Existing + New Karenge WTP in this report

[1] **KN**: Muyumbu_Kanyinya, **BH**: Bihembe_High, **GS:** Gasutamo, **GG**: Gahengeri_Mont_Rugarama, **BL**: Bihembe_Low, **KT:** Gahenger_Karutimbo_PS, **NB**: Nyabubare, **RY**: Ryabahesha, **NL:** Nyakaliro, **MU**: Muyumbu_Murehe, **CY**: Cyimo Masaka Middle, **RU**: Maison des Jeunes Kabuga, **KB2**: Kabuga2, **NZ:** Nzige_Akanzu

2.2.8. Water supply and demand

The Water Supply Area of existing Karenge WTP includes Ndera, Rusororo, Kanombe, Nyarugunga, and Masaka sectors in the City of Kigali and some part of Muyumbu and Nyakaliro sectors in Rwamagana district. According to the KWSMP, Masaka, Nyarugunga, and Kanombe are to be supplied from the Masaka WTP and the Kanzenze WTP (Kigali Bulk Water Supply). The projected water demand in the year 2015 in the supply area as shown in the table below (table 10) is estimated at is 222,303 m3/day. In the same line th total projected demand for the supply is 68,303 m3/day in 2035. However, this demand is far beyond the existing water supply capacity of 12,000 m^3/day as well as the currently permitted water abstraction of 48,000 m3/day from Mugesera Lake.

Table 3: Water demand projection in the supply area

	2035				2050			
	Demand	Supply (Rounded, m3/day)			Demand	Supply (Rounded, m3/day)		
	(m3/day)	Remera	Masaka	Karenge	(m3/day)	Remera	Masaka	Karenge
Ndera	20,859	20,900			77,062	77,100		
Rusororo	22,874			22,900	67,335	25,000		42,300
Muyumbu	4,880			4,900	16,371			16,400
Gahengeri	5,397			5,400	18,106			18,100
Nyakariro	4,792			4,800	16,229			16,200
Rwamagana	9,500			9,500	27,200			27,200
Total	**68,303**	**20,900**		**47,500**	**222,303**	**102,100**		**120,000**

Source: project FS Report

2.2.9. Project activities

Different activities will be done throughout the project implementation and among them include: Construction of intake facility that will consist at the rehabilitation of Raw Water Transmission pipes, relocation of the pump house and upgrading the capacity of pumps and motors and expansion of WTP capacity from 15,000m3/d to 18,000 m3/d (Filtration Basins, Clear Water Reservoirs) in Phase one. In phase two, there will be ***e***xpansion of Karenge WTP and forwarding infrastructures and expansion of Intake and WTP for 30,000 m3/d (Intake pumps, Treatment facilities, Clearwater reservoirs and pumps, construction of New Transmission Pipelines. These construction works will involve different activities including pre-construction, construction and operational activities.

- ✓ **Pre-construction activities**

Pre-construction activities consist at preparatory survey to provide the project orientation, project effectiveness, technical and economic validity of the Project, preliminary design, and scope of project as well as the outline of project cost and implementation plan. The pre-construction activities will results in three main output including:

- **Preliminary technical design**: The preliminary technical design provides information on size and location of project features, mapping of project area that need to be cleared, associated structure/infrastructure such as access paths, road crossing, estimates of staff and duration, construction materials and its sources and storing, equipment and tools, etc.
- **Environmental Impact Assessment(EIA):** the environmental and Social Impact Assessment provide baseline information of the projects area both physical and Social, assess the legal requirement, identify potential impacts associated with the projects and proposes an environmental management and monitoring plan;

Pre-construction works do not have any environmental and social impacts but provide the basis for deep analysis of potential impact during construction, operation and decommissioning phases.

- ✓ **Construction phase activities**

The construction works will consist at construction of the Intake, the WTP and the installation of water pipes As a result, of preliminary design, most efforts have been made to install new pipeline in parallel with existing one, but where not possible maximum efforts were made to limit the environmental and social impacts. The proposed pipeline will cover a distance of 33 km. Others works connected to the project and involved in the construction phases include:

- Manufacturing and importation construction materials (pipes, pumping machines)
- Site clearance and excavation;
- Stones masonry with mortar
- Electrical installation
- Roofing

- Plumbing
- Construction of sedimentation tanks and reservoirs
- Construction of administrative building
- Construction of pumping station
- Pipe installation;

Table 4: Summary of project facilities

Summary of the List of Facilities	
Intake Pumping Stations	
Intake Pipes	ND800, L= 300m Buried/Fixed on the lake bottom with Intake Screen and Connecting well (D=4m)
Intake Pumping Station Building	W=8m, L24m
Intake Pumps	ND300/ND200 x 12m3/min x 115.6m x 340 kw x 3 units +1 standby
Raw Water Transmission Pipeline	DIP ND600, L=1.1km
Miscellaneous	Earthwork, Retaining Wall, Access road (L=100m)
Water Treatment Plant	
Receiving Well	V = 84 m^3, L=10.3m x W=5.0m x H=4.5m
Coagulation-Flocculation Basin	Horizontal-mixed flow, L=18.4m x W=10.6m x H=4.5m
Sedimentation Basin	Baffled wall, Up-flow inclined tube settler L=18.4m x W=18.4m x H=4.5m
Rapid sand filter Basin	Sand Filter 56 m2 x 6 (t=1.0m, D_{ave} =1.0 mm) L=32.9m x W=24.4m x H=4.5m
Clear Water Reservoirs and Pumping Station	V=3,400 m3, He=5.0m, L=40.4m x W=25.7m
Clear Water Transmission Pumps	300φ/250φ x 6.66 m3/min x 214.7m x 345 kw x （5unit +1 standby）with Flywheel
Backwash Tank	V=400 m3
Sludge Basin	V=200 m3 x 2 nos.
Drainage Basin	V=250 m3 x 2 nos.
Sludge Drying Bed	V=500 m3
Administration Building	With the Branch Office
Transmission and Distribution Systems	
a-1. Transmission pipelines from Karenge WTP to Kimichanga reservoir	
Transmission Pipelines	DIP, ND700, L=5.7 km
a-2. Transmission pipelines from Kimichanga to Rusororo and Ndera	
Transmission Pipelines	HDPE, ND315, L=2.5 km DIP, ND400, L=7.6 km DIP, ND500, L=14.5 km Connecting to existing Karenge II pipeline
b. Transmission Pipelines from Rusororo Kabuga to the Rwamagana District	
Transmission Pipelines	HDPE, ND315, L=13.4 km DIP, ND400, L=1 km
c. Kimicanga Pumping Station and Transmission to Rwamagana	
Kimicanga Pumping Station (Pumping Station Building and Pumps)	Pumps: 300/200 x 8.3 m3/min x 59.8m x 120 kw x (1unit +1 standby)
Transmission Pipelines	HDPE, ND225, L=23.6 km HDPE, ND315, L=8.1 km DIP, ND400, L=7.4 km
Booster Pumping Station	BPS1, MU-NZ BPS2, NZ-GS BPS3, KT-GG
d. Water Distribution Systems d-1. Water Distribution Systems in Ndera and Rusororo	
Ndera, Pipelines	HDPE, ND50-63, L=72.2 km HDPE, ND75-90, L=75.2 km HDPE, ND100-110, L=48.3 km
Rusororo, Distribution Reservoirs	V=100 m3, 4 nos V=500 m3, 1 nos V=2000 m3, 2 nos
Rusororo, Pipelines	HDPE, ND50-63, L=85.8 km
	HDPE, ND75-90, L=89.3 km
	HDPE, ND100-110, L=57.4 km
d-2. Water Distribution Systems in Gahengeri and Muyumbu	
Muyumbu, Distribution Reservoirs	V=100 m3, 3 nos, V=500 m3, 2 nos
Muyumbu, Pipelines	HDPE, ND50-63, L=20.4 km
	HDPE, ND75-90, L=21.2 km
	HDPE, ND100-110, L=13.6 km
Muyumbu, Civil and M&E	V=100 m3, 2 nos, V=500 m3, 3 nos
Gahengeri, Pipelines	HDPE, ND50-63, L=22.5 km
	HDPE, ND75-90, L=23.4 km
	HDPE, ND100-110, L=15.1 km
d-3. Water Distribution Systems in Nyakaliro	
Muyumbu, Civil and M&E	D V=100 m3, 2 nos, V=500 m3, 3 nos

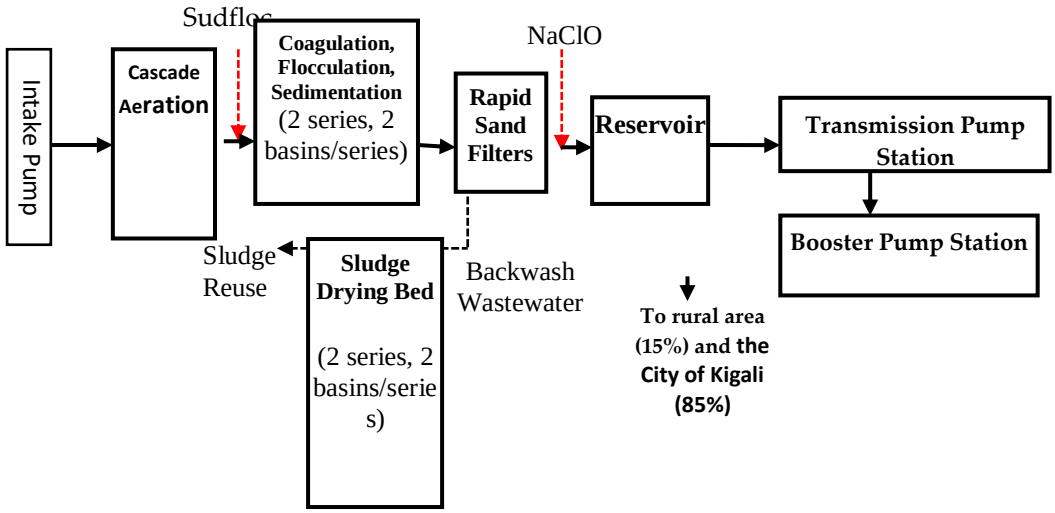
Summary of the List of Facilities	
	Distribution Reservoirs
Nyakaliro, Pipelines	HDPE, ND50-63, L=20 km
	HDPE, ND75-90, L=20.8 km
	HDPE, ND100-110, L=13.4 km

Source: Project FS report

- ✓ **Operation and maintenance activities**

After construction testing and inauguration of the plant, no major works are expected except the raw water treatment processes that are planned during the operation phase. Only monitoring work and chemical analysis will be conducted to check any defect or leakage as well as the quality of water for both raw water and water and treated water to be supplied. If any defect or leakage is identified then, rehabilitation works will be undertaken. The quality is monitored frequently to avoid any water pollution within the system. Mitigation measures are also established to correct pollution that may occur or detected. The following chart illustrates the treatment processes.

Figure 10: Water treatment flow chart



Source: Feasibility study

Table 5: Summary of operation and maintenance system

Item	Content	Remarks
Total number of staff	33 (including OM on distribution network)	Permanent: 16 Temporary: 17 (one year contract)
OM system	2 shift/day (07:00 – 17:00: 4 staff/shift) (17:00 – 07:00: 4 staff/shift)	One shift including 2 staff for process and E&M[1)], 1 for laboratory, 1 workers.
Water sampling location	1: Raw water 2: After sedimentation 3: After filtration 4: Reservoir	Raw water sampling at receiving well.
Sampling frequency	1 sample/hr (raw water) 1 sample/2 hr (filter)	
Analysis items	➢ pH, turbidity ➢ pH, turbidity, residual chlorine (Cl_2) ➢ Turbidity, Cl_2, coliform, E.coli ➢ Others (such as Fe, Mn, organic matter, NO_2, NO_3, PO_4, F^-, CN^- and heavy metals)	Raw water Filtered water and reservoir Distribution network Monthly monitoring

Source: FS report

The major challenges associated to the current O& M system are summarized in the table below

Table 6: Major challenges for O&M in the Karenge WTP

Item	Content	Remarks (Urgency)
Technical aspect	Lack of stable intake in the lake	High
	Intake pump station exposed to inundation during the rainy season (Mar. to Jun.)	High
	Insufficient algae removal	High
	Insufficient capacity of storage reservoir for production and distribution with the risk of intermittent overflows in case of a blackout.	High-Medium
Organizational aspect	Capacity development of OM staff	Low
	Shortage of staff number	Medium

Item	Content	Remarks (Urgency)
Financial aspect	High OM cost, especially high power consumption	High
Others	Improvement of standard operation procedure (SOP)	Low
	Limitation land for an extension.	Low

Source: Feasibility Study

- ✓ **Decommissioning activities**

Major activities to be considered in this project include movement and demolition of construction facilities such as temporary construction yard; remove all construction debris and restoration of the area. It is important to note that the restoration of the damaged areas is mostly recommended and this trough plantation of anti-erosive plants and other trees on the susceptible areas and the backfilling of the excavated areas.

2.3. Project land requirement

The construction of intake as well as the new WTP will require land in the proximity of the existing structures as descried above in this chapter. The total required land for each structure is provided in the tables below. Considering that the existing intake is located within the buffer zone of Mugesera lake and as it is experiencing floods especially during the rain season between April and June, it was recommended that the new intake be located not in the buffer zone of the Lake and in area non susceptible to flooding considering the existing topography of the site. The required land for the expansion of the intake is provided in the table below.

Table 7: Required land for the expansion of intake

Item	Approximate Dimensions	Existing Household
Existing Land	**55 m x 63 m (1.28 ha)**	-
Expansion Phase 1	47 m x 31 m (0.14 ha)	0
Expansion Phase 2	71 m x 14 to 47 m (0.26 ha)	0

Source: Feasibility Study

The installation of the pipelines will be made on the total length of 33 km and does not require much land since the excavated land is resorted through backfilling along the pipelines, it is also important to note that most of the pipelines are located in the buffer of the districts roads and where not possible maximum effort are recommended to avoid damages especially on privates structures such as houses, walls and fences. There is no permanent land take long the pipelines, However the land for WTP and for reservoirs will be taken permanently. Considering that some of this land is privately owned by local population, fair compensation will be done before project implementation.

Table 8:Required land for the expansion of WTP

Item	Approximate Dimensions	Necessary before	Existing Household
Existing Land	**80 m x 160 m (1.28 ha)**	**-**	
Expansion Phase 1	100 m x 170 m (1.7 ha)	July 2022	1
Expansion Phase 2	80 m x 170 m (1.36 ha)	(Year 2039)	4

Source: Feasibility Study

The locations of the new reservoirs were determined based on the water demand projections in their respective supplied areas as well as based on the topography of the sites. The future development projections of the supplied areas were also taken into consideration when allocating and design new reservoirs capacities. The elevation factor of each site for new reservoirs was considered as maximum efforts were done during designs to locate the reservoirs at the area where supply will be done by gravity.

Therefore, the elevated sites were also of priority when allocating the new reservoirs. A total number of 16 new reservoirs will be constructed during the project implementation. Considering that the land for reservoirs will be taken permanently fair compensation of land , crop and trees as well as other assets to be damaged was recommended in this report The table below illustrate the location of the proposed new reservoirs. Full list of all plots likely to be affected by intake, reservoirs and WTP is presented in annex 2

As described above the pipelines of the project will be following the existing roads connecting the supply area to the rest of the District. Maximum efforts were made to locate the pipelines in the buffer zones of the roads. A total of 2059 plots have been identified to be affected by the pipelines construction. However, considering that after construction works of the pipelines the affected land will not be used permanently by the project, easement with land owners prior to the project implementation will be secured and fair compensation of crops , trees and others affected assets should be done.

Figure 11: Existing WTP and required land for extension

Source: Feasibility Study report

2.4. Project Schedule

The project schedule includes preliminary works and construction works that will be undertaken for completion of the project. The project will be done in two different phases; phase One 2021- 2015 and phase two from 2015-2028. The project phases include the project appraisal and approvals of the designs and budget, land acquisition as well as construction works.

Table 9: Project implementation schedule

Item		2021/2022												2022/2023												2023/2024												2024/2025											
		7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
	Months																																															
Project Appraisal	6																																															
Project Approval and Budetary Arrangement by GoR	6																																														
Approval of Consultant Procurement for D/D	3																																														
Bidding Procedures and Contract Agreement for D/D	6																																														
Detailed Design	12																																														
Bidding Procedures	6																																														
(1) Rehabilitatoin and Expansion of Intake and Raw Water Transmission	24																																														
(2) Water Treatment Plant and Clear Water Pumping Station	24																																														
(3) Transmission and Distribution Systems																																															
a. Water Transmission Systems from Karenge to CoK via Kimichanga	18																																														
b. Transmission Pipelines from Rusororo Kabuga to the Rwamagana District	36																																														
c. Kimichanga Pumping Station and Transmission to Rwamagana	36																																														
d. Distribution Pipelines																																															
Land Acquisition														▲																																			

Item		2025/2026												2026/2027												2027												2028											
		7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
	Months																																															
Project Appraisal	6																																															
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Land Acquisition																																															

CHAPTER III: POLICY, LEGAL AND REGULATORY FRAMEWORK

The project of rehabilitation and expansion of Karenge WTP and transmission & distribution facilities in Rwamagana district will be funded by JICA. Accordingly the Rwandan environmental policy and regulations, as well as the JICA guidelines on environment and social considerations, the project developer is requested to establish an overarching policy defining the environmental and social objectives and principles that guide the project to achieve sound environmental and social performance.

This chapter describes policies, laws, regulations and institutional framework that will govern the implementation of the proposed projects and the implantation of proposed mitigation measures. Both international and national regulations were reviewed in order to come up with a consolidated legal and regulatory framework to ensure that the project is implemented in compliance with national regulations and international Policies and standards.

3.1 National Legal and Regulatory Framework

3.1.1 Rwanda's Constitution of 2003 with Amendments through 2015

The Constitution of the Republic of Rwanda, adopted in June 2003 and revised in 2015, ensures the protection and sustainable management of environment and encourages rational use of natural resources. In consideration of the Constitution as amended to date, Article 22 on "Right to a clean environment": Everyone has the right to live in a clean and healthy environment. Article 53 on "Protection of the environment": Everyone has a duty to protect, safeguard and promote the environment. It also indicates that the State ensures the protection of the environment. Lastly, it stipulates that a law determine modalities for protecting, conserving and promoting the environment.

The state shall protect the environment. The law determines the modalities for protecting, safeguarding and promoting the environment. To comply with this constitutional statement and to ensure that the country development is done in sustainable manner, the government has adopted different sectoral policies, laws and set up different institution. Those institutions are responsible of implementation of different policies and laws enforcement.

3.1.2 National Policy on Environment and Climate Change, 2019

This policy has been adopted by the cabinet in 2019, sixteen years since the adoption and implementation of National Environmental policy of 2003. This 2019 policy calls for stocktaking of the achievements, setbacks, future opportunities and alignment with global, regional and national development agenda. The policy provides strategic direction and responses to the emerging issues and critical challenges in environmental management and climate change adaptation and mitigation. This policy is designed within the context of national, regional and global development commitments; and it has the goal for Rwanda to have a clean and healthy environment resilient to climate variability and change that supports a high quality of life for its society." The key issues and challenges identified include high population density, water, air and soil pollution, land degradation, fossil-fuel dependency, high-carbon transport systems, irrational exploitation of natural ecosystems, lack of low-carbon materials for housing and green infrastructure development, inadequate waste treatment for both solid and liquid waste, increase of electronic, hazardous chemicals and materials waste, among others.

The implementation of the proposed project must be in line with objectives and goals of this policy so as to help the institutions in charge to deal with challenges mentioned in the policy and to ensure the sustainable environment for future generations.

3.1.3 National Strategy for Transformation (NST1), 2017-2024

In the medium term, the National Strategy for Transformation, NST1/Seven Years Government Program (2017-2024) sets the priority for a green economy approach in its Economic Transformation pillar that promotes "Sustainable Management of Natural Resources and Environment to Transition Rwanda towards a Green Economy". Moreover, environment and climate change were highlighted in NST1 as cross-cutting areas of policy concern which can be positively impacted by a range of development activities with priority given to agriculture, urbanization, industries and energy.

Among the main focus of the NST1 in improving cross sectoral coordination, infrastructures are included so as to ensure the smooth implementation of environmental policies and regulations.

Additional emphasis will be put on strengthening monitoring and evaluation. High impact areas selected include implementation of:

(a) Environmental and social Impact Assessments which is also required before the implementation of rehabilitation and expansion of Karenge WTP,
(b) Biodiversity and ecosystem management,
(c) Pollution and waste management.

In terms of (b) and (c) the project is intended to affect a part of wetland, Mugesera lake and edge of the lake where is found a variety of ecosystem. And the construction work will result to waste generation of different types as well as pollution of air due to dust and used machines, and/or water pollution as well.

In terms of water supply, NST1's water supply priority is be to ensure universal access by 2024. This will be achieved through the construction, extension and rehabilitation of 1,937 km of water supply systems in Kigali City and other towns, and 1,851 km of water supply systems in rural areas. Daily water production capacity will be increased from 1 82,120 to 303,120 cubic meters per day (MINECOFIN & OPM, 2017). Further infrastructure will be provided to ensure universal access to improved drinking-water on premises as well as availability of safe water when needed. Water production will be stepped up to meet water consumption demand of 80 litres per capita per day in urban areas, and 20 litres per capita per day in rural areas. Water supply will ensure affordability, reliability and quality.

3.1.4 National Biodiversity Strategy (NBS), 2016

The revised and updated Rwanda National Biodiversity Strategy (NBS) has a long-term vision which is in line with the Convention on Biological Diversity (CBD) strategic plan to 2020 and states that: "by 2040, national biodiversity be restored and conserved, contributing to economic prosperity and human well-being through delivering benefits essential for Rwandan society in general." NBS as a 'living document', responsive, flexible and practical, including biodiversity conservation in economic decisions and turn it into a driver for national development. Relevant economic development sectors such as agriculture and animal resources, fisheries, forestry, mining and infrastructures will incorporate biodiversity conservation activities into their planning systems as well as in the annual budgets of upcoming years.

The strategy on biodiversity aims at: improving conservation of protected areas and wetlands; sustainable use of biodiversity in natural ecosystems and agro-ecosystems; rational use of biotechnology; development and strengthening of policy, institutional, legal and human resources frameworks; and equitable sharing of benefits derived from the use of biological resources.
Among the goals of NBS 2016 are included

- To address the main causes of national biodiversity loss by mainstreaming biodiversity conservation in the decision making process across all governmental, private and civil society's development programs and,
- To reduce anthropogenic pressures on biodiversity resources and promote their sustainable use.
- To ensure equitable sharing of benefits arising from the use of biodiversity and ecosystem services.

The project of rehabilitation and expansion of Karenge WTP should be implemented in compliance with the NBS goals and national targets for sustainable biodiversity conservation as the water intake is close to the lake buffer zone and some of the water transmission pipes pass through wetlands.

3.1.5 National water supply policy, 2016

National water supply policy approved in 2016 outlines initiatives to overcome challenges and exploit existing opportunities in an integrated manner, and will effectively contribute towards achieving the goals of the National Development Agenda. The Policy outlines initiatives to overcome challenges and exploit existing opportunities in an integrated manner, and will effectively contribute towards achieving the goals of the National Development Agenda.

One of the objective of water supply policy is to ensure safe, reliable and affordable urban water supply services for all while striving for financial sustainability Urbanization is a key element of Rwanda's development strategy, as laid out National Strategy for Transformation (NST1).The policy will ensure increased sustainability and access to safe and clean water through improving operations and maintenance of existing water supply infrastructure and providing new water facilities. The policy has the following specific objectives:

- Raise rural water supply access to 100 per cent by fast-tracking implementation of a strategic investment programme;
- Ensure sustainable functionality of rural water supply infrastructure by strengthening operation and maintenance management arrangements;
- Ensure safe, reliable and affordable urban water supply services for all while striving for financial sustainability;
- Ensure safe and reliable water supply services for schools, health facilities and other public places;
- Strengthen and consolidate the sector's institutional, legal and capacity building framework and;
- Provide Policy directions on cross-cutting issues.

The proposed rehabilitation and extension of Karenge water treatment plant and water supply system is aligned with this Policy in essence that it is providing water for achieving policy objectives in City of Kigali and its surroundings.

3.1.6 Integrated Water Resources Management Policy (IWRMP), 2018

The IWRMP is the latest development in Government's consistent and continuous efforts to strengthen the water resources management sub-sector. It replaces the 2004 policy and has been necessitated by the ill-alignment between the 2004 policy and water law No. 62/2008, which embraced many modern and cutting-edge principles of sustainable water resources. Additionally, the government has been introducing reforms in the water sector that have significantly changed the context for water resources management and rendered the 2004 policy out of date.

With the promulgation of a law establishing the Rwanda Water and Forestry Authority (RWFA) with the mandate to lead the management of water resources across sectors, there is potential to achieve a coordinated approach to water resources management, in line with the integrated water resources management concept. In order to address the capacity limitations being faced by the sector, it will require concerted efforts in resource mobilization, human resource development and institutional capacity building.

The Water Resources Policy is very relevant to the proposed Karenge project given that is the one providing guidance on water source management and allocation of water to various users. Water abstraction permit required by the policy and water law is already acquired by WASAC LTD. .

3.1.7 National Land Policy, 2019

This policy comes at a very important stage when Rwanda is embarking into a shift towards becoming an upper-middle income country by 2035 and a high-income country by 2050.
The expansion and rehabilitation of Karenge WTP project will require the land for intake structures, land for the WTP as well as land for water reservoirs and pipelines

The efficient use and management of land is critical to ensure sustainable development. Concerning sustainable land management, the overall principle of this policy is that land must be used for productive and development purposes without compromising its use by future generations.

The policy is further expected to:

- Guide, develop, and monitor the implementation of land use plans.
- Ensure effective and efficient land utilization and management across various sectors such as agriculture, industry, forestry, livestock, human settlement, mining, and other public investment.
- Support investment promotion through allocation of land for strategic investment.
- Strengthen the current land administration system for enhanced land-based service delivery.
- Strengthen mechanisms for effective administration of land fees and real property taxes (e.g., proper and up-to-date land records, maximization of real property tax and lease fees collection, and capacitate decentralized administrative entities in tax administration).
- Enforce land sub-sector coordination to ensure an integrated approach for efficient cross-sectorial land utilization and collaboration towards sustainable land use and management.

The Land policy is relevant to the mentioned project given that the proposed expansion and rehabilitation of Karenge WTP will need land and hence may change land tenure and may require expropriation.

3.1.8 Urbanization Policy,2015

Approved in 2015, the National Urbanization Policy addresses all aspects of cross-sectoral action in urban development and governance. Rwanda guides urbanization in a way to efficiently use and manage its natural resources while promoting sustainable development, reinforce its system of urban areas and human settlements for local economic development based on local potentialities and inter-linkages, promote densification for cost effective public investment and infrastructure service delivery, and to reserve for agricultural production, open space and conservation of the environment, and plan for the needs of transportation, housing, culture, recreation, utilities, waste management, information and telecommunication, commercial and industrial development in response to macro-economic strategies and citizens views.

The overall intent of the policy is to create the conditions for well-managed growth generating vibrant urban environments and sustainable economic development.

Rwanda's urban agenda encourages multi-institutional cooperation, for the development of safe public space, quality education, medical and transport facilities, and a friendly city ambiance offering public services and infrastructure. As part of this vision, the government seeks to prevent unplanned growth in support of the urban development system and an increasing quality of life. Given that water supply is a major component in urban development the Karenge project is alined with the policy and is intended to meeting the need of growing population in the city and its surroundings.

- **Sanitation policy, 2016**

National Sanitation policy approved in 2016 outlines initiatives to overcome challenges and exploit existing opportunities in an integrated manner, and will effectively contribute towards achieving the goals of the National Development Agenda. The policy aims at ensure expanded access to safe and sustainable sanitation services through a number of means including: establishing District sanitation centres providing a wide range of sanitation technologies; improving operation and maintenance of sanitation facilities; and assisting Districts and the City of Kigali to plan and design projects to mitigate urban storm water issues. Specific objectives of the sanitation policy are:

- Raise and sustain household sanitation coverage to 100 per cent by 2020;
- Implement improved sanitation for schools, health facilities and other public institutions and locations;
- Develop safe, well-regulated and affordable off-site sanitation services for densely populated areas;
- Enhance storm water management in urban areas to mitigate impacts on properties, infrastructure, human health and the environment;
- Implement integrated solid waste management;
- Ensure safe management of e-waste, industrial waste, nuclear/radioactive waste and health-care waste
- Develop the sanitation sub-sector's institutional and capacity-building framework

3.2 Relevant Laws

3.2.1 Law N° 48/2018 of 13/08/2018 on Environment

As adopted by the cabinet in 2018, it is relevant to the project of expansion and rehabilitation of Karenge WTP as it determines the modalities for protecting, conserving and promoting the environment. In its Chapter II regarding the fundamentals that govern environmental conservation, it states that Every person has the right to be informed of the state of the environment and to take part in strategies and activities aimed at conserving the environment, Activities considered or suspected to have negative impacts on environment must not be implemented pending results of a scientific assessment ruling out the potentiality of such impacts , The right to development must be achieved in consideration of the needs of present and future generations.

Water resources must be protected from any sources of pollution; for that, Swamps with permanent water and full of swamp vegetation must be given special protection considering their role and importance in the preservation of the biodiversity.

In article 9 the Law states that, regarding the Use and management of soil and subsoil any land exploitation project for research, industry, urbanisation, rural settlement, **infrastructure**, intensive farming or extraction is subject to authorisation issued in accordance with relevant laws.

As the expansion and rehabilitation of Karenge WTP is an infrastructure project, the exploitation licence might be needed following the considerations elaborated in Article 10 of this law as detailed in the paragraph below.

For the purposes of the protection of environment, the soil and subsoil exploitation licence are issued after consideration of the following:

- the significance and effectiveness of measures to prevent environmental degradation;
- the considerations of interests of the local community in the vicinity of the project;
- the obligation to rehabilitate the damaged area in any possible way in order to restore the beauty of the landscape or the natural systems modified by human activity in accordance with a pre-established rehabilitation plan approved by the competent authority

In its article 26, The State has the following general obligations to protect and conserve the environment:

- to design a general and integrated policy on the environment and ensure its implementation;
- to conclude agreements with other organs for the enforcement and implementation of this Law;
- to take necessary measures to protect and respect the obligations stipulated in international agreements which it signed;
- to prohibit any activity carried out on its behalf or in its capacity that may degrade the environment in another country or in regions beyond its national jurisdiction;
- to co-operate with other states in taking decisions to fight trans-boundary pollution;
- to protect, conserve and manage properly the environment using appropriate measures
- to establish a national policy on climate change and develop strategies, plan and programs aiming at slowing down the increase of greenhouse gas emissions and enhancing adaptive capacity to the impacts of climate change including research and impact assessment studies.
- And the Article 40 states that Obligations of the population in the protection and conservation of environment are as follows:
- to protect, conserve and promote the environment by individual action or through collective activities;
- to inform competent authorities a phenomenon that may affect the environment.

3.2.2 Law N° 49/2018 of 13/08/2018 determining the use and management of water resources

As adopted by the cabinet in 2018, the purpose of this law is to determine the use and management of water resources in Rwanda. The natural water identified by this law include Permanent Streams and rivers, Lakes, Wetlands, springs and aquifers. Protection and rational use of water resources constitute the obligations of each and every person.

Except activities related to the protection of groundwater protection areas, any other activity is subjected to prior authorization by the competent authority.
Regarding the priority for water allocation, all persons are entitled to an equitable and reasonable share on the water resources available.
However, in allocating water resources the priority is given to:

- 1º domestic needs;
- 2º environmental protection;
- 3º economic activities.

The article 21 states that the use of water resources in different activities and installations susceptible to modify the flow or the level of water or to degrade their quality, or to threaten water-related ecosystems, wetlands and the environment are subjected to water use permit. A Ministerial Order establishes the list of activities and installation that are subject to a water use permit and determine conditions and procedures of acquisition and use of water permit.

Water abstraction for existing Karenge WTP and the proposed expanded Karenge WTP is in Mugesera Lake at around 500m from the edge of lake, and the pumping station is straight at the edge of the lake where during the rainy season, Lake water occupy a large part of the station.

The Water Law states that it is prohibited to build in water sources, streams, rivers and lakes and in the buffer zone in a distance of ten meters (10 m) away from streams and fifty meters (50 m) away from lakes and the boundaries of streams, rivers and lakes, are delimited by the line reached by the highest waters before overflowing. Therefore this line constitutes the starting point for the delimitation of the longitudinal strip of land included in the public domain. Article 7, Water resources are used and managed in accordance with the following principles:

- prevention of pollution with priority to source;
- precaution, according to which activities considered or suspected to have negative impacts on water resources shall not be implemented even if such impacts have not yet been scientifically proved. Scientific uncertainty must not be taken into consideration for the benefit of destroyers of water resources, instead it may be used in conservation of water resources;

- integrated management of water resources within catchment, taking into account the interests of all water users, land and other natural resources and related ecosystems;
- participation, according to which all interested stakeholders, including water users through their representatives, are entitled to participate in water resources management and planning;
- "user-pays and polluter-pays" principles, according to which the user of water and the polluter must support a significant part of expenses resulting from measures of prevention, of pollution reduction and restoration of the water resources in quality and quantity;
- subsidiary, whereby development and protection of water resources is planned and implemented at the lowest appropriate level

3.2.3 Law N° 32/2015 of 11/06/2015 relating to expropriation in the public interest

This law determines the procedures relating to expropriation in the interest of the general public. The law stipulates that the government has the authority to carry out expropriation. However, the project, at any level, which intends to carry out acts of expropriation in public interest, shall provide funds for inventory of assets of the person to be expropriated. According to the organic law, no person shall hinder the implementation of the program of expropriation on pretext of self-centred justifications and no land owner shall oppose any underground or surface activity carried out on his or her land with an aim of public interest. In case it causes any loss to him or her, he or she shall receive just compensation for it.

Eligibility for compensation is enshrined under the Rwandan constitution (article 29) and the expropriation law. The two laws regulate and give entitlement to those affected, whether or not they have written customary or formal tenure rights.

The person to be expropriated is defined under article 2(7) of the expropriation law to mean any person or legal entity who is to have his or her private property transferred due to public interest, in which case they shall be legally entitled to payment of compensation.

This law is relevant to the present project as there will be people's land and properties around the current water treatment plant and the actual intake as well that will be affected during the project implementation. Those will be expropriated to free the land for expansion of Karenge WTP and other related infrastructures. So far, one people need to be relocated for phase one and 4 for phase two. Further, land will be acquired for both WTP, intake and new reservoir as mentioned earlier

3.2.4 Organic law N° 43/2013 of 16/06/2013 governing land in Rwanda

The land law was initially adopted in 2005 and then revised in 2013 and was gazetted in the official gazette no special of 16/06/2013. It determines the use and management of land in Rwanda. It also institutes the principles that are to be respected on land legal rights accepted on any land in the country as well as all other appendages whether natural or artificial. According to the law, land in Rwanda is categorized into two: individual land and public land. The latter is subdivided into two categories: the state land in public domain and the state land in private domain. State land in public domain includes national land reserves for environment conservation; land over which administration building are erected, state roads, land containing lakes, rivers, stream and springs. State land in private domain include swamps that may be productive in terms of agriculture, vacant land with no owner, land purchased by the State, donation, land acquired through expropriation and land occupied by state owned forests.

The Organic land law also provides two types of formal land tenure: full ownership/ freehold and long-term leasehold. So far, all land in the country has been registered and land titles issued to citizens. According to article 10 of new land law of June 2013, private individual land shall comprise land acquired through custom or written law. That land has been granted definitely by competent authorities or acquired by purchase, donation, inheritance, succession, ascending sharing, and exchange or through sharing. This law offers equal protection to rights over land resulting from all channels stipulated in the preceding paragraph. All types of land tenure must be in compliance with the designated land use and environmental protection measures as outlined in the Land Use Master Plan.

The area of land will be required for this project implementation especially for the expansion of WTP, intake and distribution of other facilities. This makes the land law relevant to this project as it determines the modalities of allocating, acquisition, transfer, use and management of land in Rwanda.

3.2.5 Law N° 66/2018 OF 30/08/2018 Regulating Labour in Rwanda

The article 5 of the labor law in Rwanda sets the Minimum age for admission to employment as sixteen (16) years. The article 6 of the same Law emphasize that it is prohibited to subject a child below the age of eighteen (18) years to any of the following forms of work:

- forms of work which are physically harmful to the child;
- work underground, under water, at dangerous heights or in confined spaces;
- work with dangerous machinery, equipment and tools, or which involves the manual handling or transport of heavy loads;
- work in an environment which exposes the child to temperatures noise levels or vibrations damaging to his/her health;
- work for long hours or during the night or work performed in confined spaces.

The law also prohibits Sexual harassment in any form against supervisee
During the implementation of the project, employment will be created either being permanent or of short term. The contractor will ensure that the labor law is respected and applied to the project works accordingly.

3.2.6 Law N° 37 /2008 of 11/08/2008 on mining and quarry exploitation

During the implementation of this project, the construction works (WTP, intake and pipelines) will require some materials including stones and sand. Therefore, the mining and quarry exploitation laws provide the process of acquiring quarries for mining activities, the licensing process and the environmental consideration in exploiting a quarry. Nevertheless the quarry component will be conducted by a contractor who will be required to fully respect strictly the process. Actually, an EIA Certificate is required for each quarry to be exploited. Thus, the contractor will be requested to acquire material from a certified mines and quarry and in respect to environmental requirement.

3.2.7 Ministerial order N°. 001/2019 on environmental assessment requirements and procedures

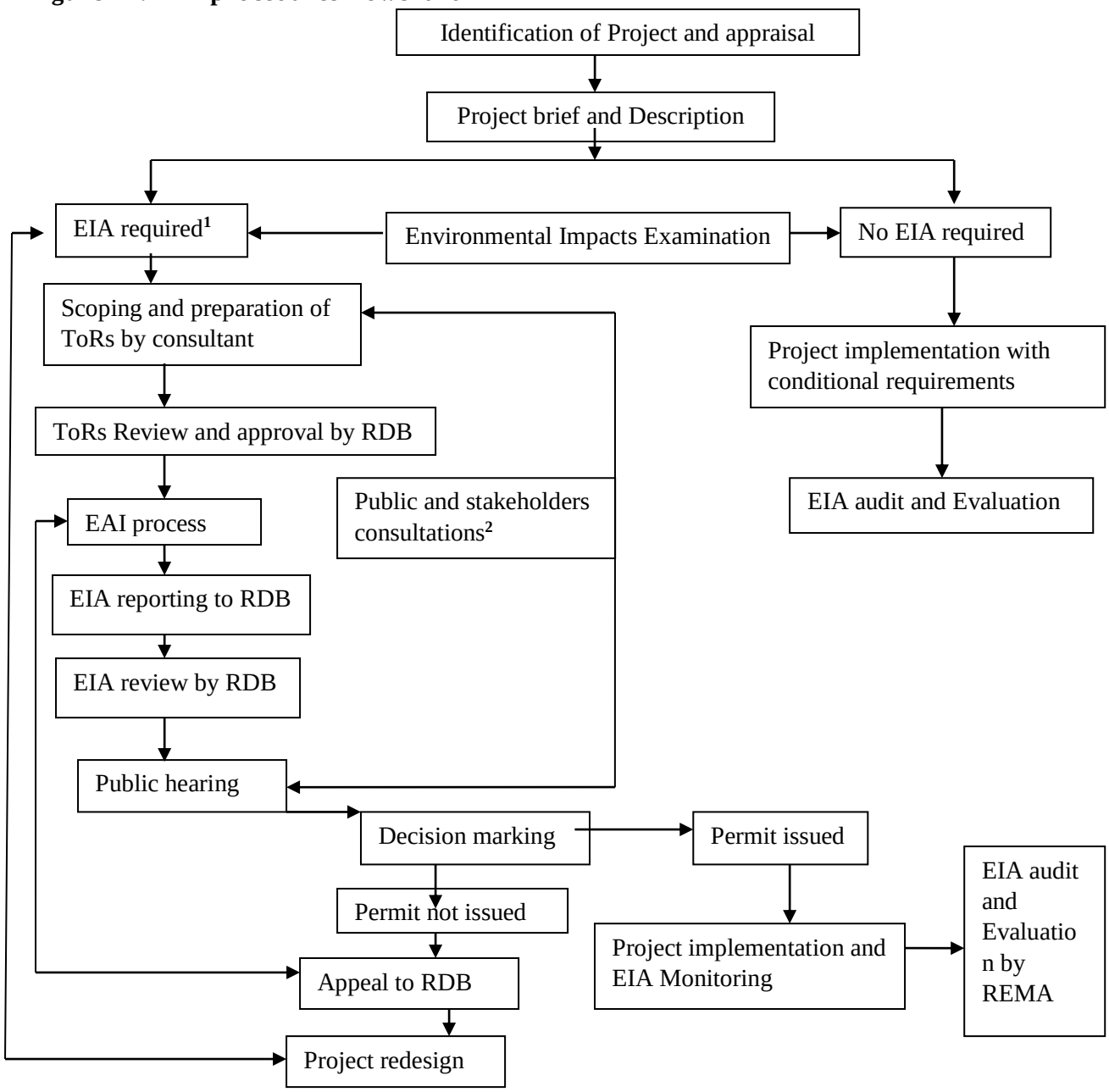
This Order establishes:
1° the list of projects that must undergo an environmental impact assessment before they obtain authorisation for their implementation;
2° instructions, requirements and procedures for conducting environmental impact assessment.

In its Article 3, Annex 1 it gives the list of works, activities and projects that have to be subject to a full environmental impact assessment before being granted authorization before their implementation. And the article 4, Annex II clarifies the list of works, activities and projects that must undergo a partial environmental impact assessment before being granted authorisation for their implementation.

Projects, works and activities which are not listed on the Annex I and II to this Order are not subject to the environmental impact assessment. However, when it is evident that work, activity or project not listed on the Annex I and II to this Order has a negative and irreversible impact on the environment and is similar in nature to the work, activity or project listed in Annex I and II of this Order, the Authority or authorised organ may request the developer to conduct an environmental impact assessment.

In the water treatment plant and pumping station are performed a variety of activities for which might be hazardous to the workers and the environment as well. In those can be considered the inhalation of chemicals by operator working inside the chamber, electric circuit, risks of drowning during water sampling in the lake. All these hazardous risks and others which are not mentioned in this paragraph makes the proposed project fall under the projects that must undergo full EIA as mentioned in the Annex I of this law in buildings with activities which can cause hazards.

Figure 12: EIA procedures flowchart



3.2.8 Ministerial Order N°007/2008 establishing the list of protected animal and plant species

Chapter II Article 2 of this order classifies protected animals in three categories as Mammals, birds, and reptiles. The list is published in Appendix 1 of this Order as follows:

- **Animals:** Gorilla, Chimpanzee, Black rhinoceros, Elephant, Roan antelope, Sitatunga, Lions, Leopard, Klipspringer, Buffalo, Cheetah, Zool mongoose, Cephalophus, Zoolserval, Wild dog, Bushbuck, Hippopotamus, Burchell's zebra
- **Birds**: Black-headed Heron, Cattle Egret, Grauer's Swamp Warbler, Owls, All Lemuroids, Grey Crowned-Crane, wallow, Arrow-marked Babbler, Cape Robin-Chat, All pangolins, Vulture, Bee eater, Scimitar bills, Hamerkop, Sunbirds.
- **Reptile:** Tortoises (all species), Python, Crocodile, Viper.
- **Plants:** Ficus thonningii, Prunus Africana, Pentadesmareindersii, Myrianthusholstii, Thonningiasanguine,Hypoestestrifolia,Aloesp.,Syzygiumguineense,Erythrinaabyssinica,Fagarachalybea,Kigelia,Africana,Orchidaceae,Eulophiastreptopetala,Eulophiahorsafalli,Diaphananthebilosa,Disaemili,Disperiskilimanjarica,Euggelingialigulifolia,Polystachyiahastate,Tridactyleanthomaniaca,Entandopheragmasp,Podocarpususambarensis,Albizziasasa,PiptadeniaAfricana,Podocarpusmilinjianus,grandiflora,Strombosia,Scheffleri.

The Order specifies that the listed animals and plant species shall not be destroyed without permission of the competent authorities. For that, the proposed project will be implemented in the watershed of Mugesera Lake

where different species can be found especially birds, reptiles and plants that makes this order relevant to the proposed project. Ecological survey was conducted and results are presented in Chapter 4.

3.2.9 Water Use Permit

Rwanda Water resources are under increasing pressure. We need to use them efficiently, effectively and wisely if we want to build a sustainable bright future for ourselves and for upcoming generations.

The article 21 of law **N° 49/2018 of 13/08/2018** states that the use of water resources in different activities and installations susceptible to modify the flow or the level of water or to degrade their quality, or to threaten water-related ecosystems, wetlands and the environment are subjected to water use permit. A Ministerial Order establishes the list of activities and installation that are subject to a water use permit and determine conditions and procedures of acquisition and use of water permit. The water permit helps

- **To manage water resources** effectively and efficiently for optimal beneficial use of water for economic development of the country
- **To ensure fair share allocation**: to be able to allocate water, the water resource managers must know both how much water is available and how much is being used
- **To protect the environment**: water resources managers must ensure that water use is efficient, is well planned, and that pollution is reduced to a minimum. When allocating water resources to different uses, water resources managers have to make sure that the water for environmental flow remains available.

Below are the required documents for application for water use permit

1. Application letter addressed to the director general of Rwanda water resources board through the Mayor of the district in which the activities will be carried out
2. Identification of the applicant and other necessary document to enable easy understanding of the category and activities of the applicant
3. A detailed and complete description of the project
4. A certificate and copy of EIA report for new project or Environmental Audit report for existing project certified by the competent institution where required
5. The receipt of payment of thirty five thousands Rwandan francs

Benefits of having a water permit are as that:

- Your water use promptly and correctly will improve your claim to lawful use established in accordance with water law and related regulations
- You will not have to face prosecution for non-compliance
- If you do not have a water permit, you might lose your claim to use water
- If you do not have water permit, the water resources managers will not be aware of your use and your place (abstraction point) may be allocated to anyone because you are not known
- In case of shortage of water, you will have a priority over those who have not a permit depending on priority order in water allocation.

It is important to note that water abstraction permit from Mugesera lake was guaranteed from Rwanda Water Board with permission of 48,000 m^3 /day

In terms of operations licensing, , Rwanda Utilities Regulatory Authority (RURA) does the licensing of water supply operators. Currently, there are three categories of licenses.

- **Water (and sewerage) utility license:** The licensee under this type of license shall run as a commercial entity in accordance with good business practices in water service provision and shall adhere to the performance indicators as directed by the Regulatory Authority. This type of license shall be granted to any operator who owns and manages water infrastructures and sells water to customers. Currently, only WASAC has this type of license in urban areas.
- **Water supply infrastructure management license:** The license for water supply infrastructure management is granted to operators that are under or willing to conclude for management contract with the owners of infrastructures. It authorizes the licensee to operate, manage and use appointed water supply infrastructures for supplying water in the service area to customers. There shall be an agreement between asset holder and the operator willing to provide water supply services in a specific area. Before the signature of such agreement, the draft agreement shall be submitted to the Regulatory Authority for

advice. The Regulatory Authority shall always keep one copy of the signed agreement for record purposes. Operators under this license are managing water supply system on behalf of districts for water supply system in rural area and the license is valid for 5years renewable.

- **Bulk water supply license:** A license of bulk water supply permits the holder to sell in bulk water to an appointed water utility company, water and sewerage utility or any other operator for the purpose of resale or retail it to customers at eligible premises. Kigali water Limited that constructed Kigali Bulk water supply project in Kanzenze to supply water in Kigali and Bugesera area is the only operator with this type of license.

✓ **Other water use permitting**

Other water permitting and license procedures are provided under water user's association law and water law 2018. The use of water resources in different activities and installations susceptible to modify the flow or the level of water or to degrade their quality, or to threaten water related ecosystems, wetlands and the environment are subjected to water use permit. According to this law, the person requesting to be a holder of water use permit, get this permit renewed or transferred pays fees whose amount is determined by a Ministerial Order. Such a Ministerial Order also determines the basis of calculation and amount of annual fees to be paid for water use. A law on water fees is under discussion.

3.3 Institutional arrangement for the environmental management in Rwanda

3.3.1 Ministry of Infrastructure (MININFRA)

The missions of the Ministry of Infrastructure includes:

- to initiate programs, to develop, rehabilitate and maintain an efficient and integrated national transport infrastructure network, including roads, bridges, airports, railways, and water supply which will contribute towards economic development and regional integration.
- To initiate programs aimed at increasing access to affordable energy, water and sanitation, and transport infrastructure and related services for the population;
- To supervise the implementation of quality standards and norms, cost effectiveness, response to environmental sustainability, safety and cross-cutting issues in infrastructure development;
- To work towards implementation of programs to enhance human resource capacities under the transport, energy, habitat & urbanism, water and sanitation, and meteorology sub-Sectors respectively;
- To supervise activities meant to elaborate, monitor and assess the implementation of national policies and programs on matters relating to habitat and urbanism, transport, energy, water and sanitation..

3.3.2 Ministry of Environment (MoE)

The Ministry of Environment was established to ensure the protection and conservation of the environment and ensure optimal and rational utilization of Water Resources, Lands and Forests for sustainable national development.

The ministry has different responsibilities as stipulated in the Prime Minister's Order Nº 108/03 of 15/10/2020 Determining mission, responsibilities organizational structure, salaries and fringe benefits for employees of the Ministry of Environment.

1. To develop and disseminate the environment and climate change policies, strategies and programs through the following activities:
   a. To develop strategies to promote partnership and enhance capacity of private sector to invest in activities of environment and climate change for sustainable economic development;
   b. To develop laws and regulations to ensure protection of the environment and conservation of natural ecosystems;
   c. To develop institutional and human resources capacities in environment and climate change.
2. To monitor and evaluate the implementation and mainstreaming of environment and climate change policies, strategies and programs across all sectors, especially productive sectors;
3. To oversee and evaluate institutions under its supervision by providing guidance on the implementation of specific programs to be realised by the institutions under its supervision and local government;
4. To mobilise necessary resources for the development, protection and conservation of the environment for the climate change adaptation and mitigation.

3.3.3 Water and Sanitation Corporation Limited (WASAC Ltd)

WASAC Ltd is the entity set up to manage water and sanitation services in Rwanda and was created by the law Nº 87/03 of 16/08/2014. The company was created in the on-going government reform intended to deliver water and sanitation utility sufficiently focused to deliver new infrastructure; efficient and effective service delivery; build a strong people capability; and meet key national milestones. It is expected to reverse the status quo that includes inadequate planning and investments; inefficient and wasteful operations; inadequate institutional management focus; improve viability and autonomy; and establish a sustainable and customer-centric utility to deliver an important mandate that touches people of all walks of life. The mission of the company is providing quality, reliable and affordable water and sewerage services through continuous innovations and detailed care to customers' needs.

As implementing agency, WASAC Ltd will play a critical role in project implementation but also in the implementation of Environmental and Management Plan as well as conditions of approval to be issued by Rwanda Development Board. WASAC Ltd is also responsible for monitoring of the implementation of mitigation measures and report back to Rwanda Environment Management Authority and JICA.

3.3.4 Rwanda Environment Management Authority (REMA)

REMA was established in 2004 to act as the implementation organ of environment related policies and laws in Rwanda. Under supervision of the Ministry of Natural Resources, from Law N°63/2013 of 27/08/2013 determining the mission, organization and functioning of REMA, it has the legal mandate for national environmental protection, conservation, promotion and overall management, including advisory to the government on all matters pertinent to the environment and climate change. REMA has different key responsibilities where for according to this proposed project, it will:

- Closely monitor and assess development programs to ensure compliance with the laws on environment during their preparation and implementation;
- Participate in the preparation of activities strategies designed to prevent risks and other phenomena which may cause environmental degradation and propose remedial measures;
- Provide, if necessary, advice and technical support to project developer and implementer in terms of natural resources management and environmental conservation.

3.3.5 Rwanda Water Resources Board (RWB)

Rwanda Water Resources Board (RWB) is established by the law N° 71/2019 of 29/01/2020 with the following responsibilities:

- To implement national policies, laws and strategies related to water resources;
- To advise the Government on matters related to water resources;
- To establish strategies aimed at knowledge based on research on water resources knowledge, forecasting on water availability, quality and demand;
- To establish strategies related to the protection of catchments and coordinate the implementation of erosion control plans;
- To establish floods management strategies;
- To establish water storage infrastructure;
- To establish water resources allocation plans;
- To establish water resources quality and quantity preservation strategies;
- To control and enforce water resources use efficiency;
- To examine the preparation of roads, bridges, dams and settlements designs in order to ensure flood mitigation and water storage standards;
- To monitor the implementation of flood mitigation measures and water storage during the implementation of roads, bridges and settlements' plans;
- To cooperate and collaborate with other regional and international institutions with a similar mission.

According to the mission of RWB and the nature of this project, RWB will ensure enough and well managed water resources for sustainable development and issue water permit

3.3.6 Rwanda Land Management and Use Authority (RLMUA)

RLMUA is responsible for putting in place and operationalizing an efficient system of land administration, use and management that secures land ownership, promotes investment in land for socio-economic development and poverty reduction.

Responsibilities of RLMUA are

- Put in place mechanisms which procure security of land tenure for the promotion of investments in land.
- Promote proper allocation of land, and proper use of land resources, according to their potential.
- Avoid the splitting up of plots, and to promote their regrouping in order to bring about optimum production.
- Establish mechanisms which facilitate an optimum exploitation of land, targeting the social-economic development of the country.
- Orient land management towards a more profitable and sustainable production, by making good choices among methods of land development.
- Develop methods that protect land resources from various types of land degradation.
- Establish institutional frameworks which enable land to become more valuable in the economy or at the market.
- Promote research as well as the education of the public on all aspects concerning land tenure, management, and transactions.
- Establish order and discipline in the allocation of land, as well as in land transactions in order to control the pressure on land, inappropriate development, speculation and trafficking of land.
- Involve and sensitize the public at all levels in order to ensure protection of the environment and good management of the land.
- Ensure the sustainable use of wetlands.

3.3.7 Rwanda Development Board (RDB)

RDB was created by Organic Law N° 53/2008 of 02/09/2008. It has a mission of improving the well-being of all Rwandans by fast-tracking development, catalysing sustainable economic growth, and creating prosperity for all. This a one stop institution bringing together several government bodies in Rwanda focused at promoting investment in Rwanda. Initially the responsibility for reviewing and approving EIA reports was entrusted to REMA, this duty has now been transferred to the newly created Rwanda Development Board (RDB) where a department of EIA has been created and tasked with review and approvals of all EIA reports for proposed projects and programmes before they are approved for implementation. The project of expansion and rehabilitation of Karenge WTP requires an EIA, for which RDB has the responsibilities to:

- Receive and register EIA Applications (Project Briefs) submitted by developers;
- Identify relevant Lead Agencies to review Project Briefs and provide necessary input during screening,
- Review Project Briefs and determine project classification at screening stage,
- Transmit Project Briefs to relevant Lead Agencies and concerned Local Governments to provide input on Terms of Reference (ToR),
- Publicize Project Briefs and collect public comments during development of ToR,
- Receive EIA documents submitted by a developer and verify that they are complete,
- Transmit copy of EIA Reports to relevant Lead Agencies, Local Governments and Communities to review and make comments,
- Review EIA reports and make decision on approval, organize and conduct public hearings, appoint an officer from Authority to chair public hearings, receive public comments and compile public hearing reports,
- Appoint the Technical Committee and its representative to the Technical Committee,
- Forward EIA Documents (EIA Report, Environment Monitoring Plan and Public Hearing Report) to the Technical Committee,
- Chair the Executive Committee which makes final decision on approval of a project,
- Communicate decision on whether or not a proposed project is approved,
- Issue to developers EIA Certificate of Authorization if their projects are approved.

3.3.8 Rwanda Utility Regulatory Authority (RURA)

Rwanda Utilities Regulatory Authority (RURA) was initially created by the Law n° 39/2001 of 13 September 2001 with the mission to regulate certain public Utilities, namely: telecommunications network and/or Telecommunications services, electricity, water, removal of waste products from residential or business

premises, extraction and distribution of gas and transport of goods and persons. This Law was further reviewed and replaced by Law Nº 09/2013 of 01/03/2013 establishing Rwanda Utilities Regulatory Authority (RURA) and determining its mission, powers, organisation and functioning. This Law gives to RURA the mandate to regulate:

- Telecommunications, information technology, broadcasting and converging electronic technologies including the internet and any other audio-visual information and communication technology;
- Postal services;
- Renewable and non-renewable energy, industrial gases, pipelines and storage facilities;
- Water supply including tariffs;
- Sanitation;
- Transport of persons and goods; and
- Other public utilities, if deemed necessary.

The regulation of water supply activities and other public utilities are among the mandates of RURA which makes it important in the proposed project as it is about the expansion and rehabilitation of Karenge WTP and transmission & distribution facilities.

3.3.9 Local Governments

Generally, decentralized entities are responsible for the implementation of laws, policies, strategies, objectives and programmes relating to protection, conservation and promotion of the environment in Rwanda. Article 61 of environmental law state that in the framework of conservation and protection of the environment, decentralized entities are particularly responsible for:

- ensuring activities related to better management of land, especially controlling soil erosion and tap rain water;
- Afforestation, protection and proper management of forests;
- efficient management of rivers, lakes, sources of water and underground water;
- efficient management and effective use of swamps;
- Protection and proper management of reserved areas, historical sites, endangered animal and plant species.

Under the General Guidelines and Procedure for EIA, Rwamagana district basically Karenge sector is tasked to perform the following functions:

- Provide information or advice to developers and EIA Experts when consulted during EIA process,
- At the request of RDB, review EIA reports and provide comments to RDB,
- Assist RDB in organizing public hearings,
- Host public hearings,
- Host individual consultations,
- Gather written comments from public and transmit them to RDB.
- Facilitate the land acquisition process through land bureau office;
- Plan and complaints resolutions.

3.4 International legislative and policy framework

In addition to national environmental legislations, Government of Rwanda is also a party to a number of regional and international conventions and protocols on environment. Therefore, the projects of rehabilitation and expansion of Karenge WTP will be implemented in compliance with international policy and regulations particularly World Bank safeguards Policies and JICA Environmental and Social considerations.

3.4.1 JICA guidelines on Environmental and Social Consideration

The project of rehabilitation and expansion of Karenge WTP will be funded by JICA. It is therefore, critical to ensure that the project is implemented in compliance with JICA Environmental and Social Consideration. JICA encourages host country governments, including local governments, borrowers, and project proponents, to implement the appropriate measures for environmental and social considerations when engaging in cooperation activities. At the same time, JICA provides support for and examinations of environmental and social considerations in accordance with the guidelines.

The guidelines cover five schemes: (1) Loan aid, (2) Grant aid (excluding projects executed through international organizations), (3) Preliminary studies of grant aid undertaken by MOFA, (4) Technical cooperation for development planning, and (5) Technical cooperation projects.

- **Objectives of JICA guidelines**

The objectives of the guidelines are to encourage project proponents and to have appropriate consideration for environmental and social impacts, as well as to ensure that JICA's support for an examination of environmental and social considerations are conducted accordingly. The guidelines outline JICA's responsibilities and procedures, along with its requirements for project proponents etc., in order to facilitate the achievement of these objectives. In doing so, JICA endeavors to ensure transparency, predictability, and accountability in its support for an examination of environmental and social consideration.

- **Key principles of JICA guidelines**

Key principles of JICA guidelines on environmental and social considerations can be summarized as follows:

1. Environmental impacts that may be caused by projects must be assessed and examined in the earliest possible planning stage. Alternatives or mitigation measures to avoid or minimize adverse impacts must be examined and incorporated into the project plan.
2. Examinations must be endeavored to include an analysis of environmental and social costs and benefits in the most quantitative terms possible, as well as a qualitative analysis. These must be conducted in close harmony with the economic, financial, institutional, social, and technical analyses of projects.
3. The findings of the examination of environmental and social considerations must include alternatives and mitigation measures, and must be recorded as separate documents or as a part of other documents. EIA reports must be produced for projects in which there is a reasonable expectation of particularly large adverse environmental impacts.
4. For projects that have a particularly high potential for adverse impacts or that are highly contentious, a committee of experts may be formed so that JICA may seek their opinions, in order to increase accountability.

- **Responsibility of JICA in EIA process**

While project proponents take the initiative to deal with the environmental and social considerations of projects, JICA provides support for and examinations of the environmental and social considerations for that project proponents in accordance with Sections 2 and 3 of the guidelines and depending on the nature of cooperation projects. Project proponents are required to incorporate the output of environmental and social considerations studies into project planning and decision-making processes. When JICA provides support for and examinations of environmental and social considerations, JICA examines the requirements that must be met.

- **Categorization of projects and JICA guidelines**

JICA classifies projects into four categories according to the extent of environmental and social impacts, taking into account an outline of project, scale, site condition, etc.

Category A: Proposed projects are classified as Category A if they are likely to have significant adverse impacts on the environment and society. Projects with complicated or unprecedented impacts that are difficult to assess, or projects with a wide range of impacts or irreversible impacts, are also classified as Category A. These impacts may affect an area broader than the sites or facilities subject to physical construction. Category A, in principle, includes projects in sensitive sectors, projects that have characteristics that are liable to cause adverse environmental impacts, and projects located in or near sensitive areas.

Category B: Proposed projects are classified as category B if their potential adverse impacts on the environment and society are less adverse than those of category A projects. Generally, they are site-specific; few if any are irreversible; and in most cases, normal mitigation measures can be designed more readily. The proposed project of expansion and rehabilitation of Karenge WTP falls under this category.

Category C: Proposed projects are classified as Category C if they are likely to have minimal or little adverse impact on the environment and society.

Category FI: Proposed projects are classified as Category FI if they satisfy all of the following requirements: JICA's funding of projects is provided to a financial intermediary or executing agency; the selection and appraisal of the sub-projects is substantially undertaken by such an institution only after JICA's approval of the funding, so that the sub-projects cannot be specified prior to JICA's approval of funding (or project appraisal); and those sub-projects are expected to have a potential impact on the environment.

- **Impacts to be assessed**

The impacts to be assessed with regard to environmental and social considerations include impacts on human health and safety, as well as on the natural environment, that are transmitted through air, water, soil, waste, accidents, water usage, climate change, ecosystems, fauna and flora, including trans-boundary or global scale impacts. These also include social impacts, including migration of population and involuntary resettlement, local economy such as employment and livelihood, utilization of land and local resources, social institutions such as social capital and local decision-making institutions, existing social infrastructures and services, vulnerable social groups such as poor and indigenous peoples, equality of benefits and losses and equality in the development process, gender, children's rights, cultural heritage, local conflicts of interest, infectious diseases such as HIV/AIDS, and working conditions including occupational safety. Items to be addressed in the specific project are narrowed down to the needed ones through the scoping process.

In addition to the direct and immediate impacts of projects, the derivative, secondary, and cumulative impacts as well as impacts associated with indivisible projects will also be assessed with regard to environmental and social considerations, so far as it is rational. The life cycle impact of a project period is also considered. Various kinds of relevant information are needed in order to assess impacts on the environment and local communities. There are, however, uncertainties in predicting such impacts caused by the incomplete understanding of impact mechanisms and the limited information available. Therefore, if the scale of uncertainty is considered to be large, project proponents etc. provide environmental and social considerations that include preventive measures as much as possible.

3.4.2 World Bank Environmental and Social Framework (ESF)

- **ESS1: Assessment and management of environmental and social risks and impacts;**

ESS1 sets out the Borrower's responsibilities for assessing, managing and monitoring environmental and social risks and impacts associated with each stage of a project supported by the Bank through Investment Project Financing, in order to achieve environmental and social outcomes consistent with the Environmental and Social Standards (ESSs). Objectives of ESS1 are:

- To identify, evaluate and manage the environment and social risks and impacts of the project in a manner consistent with the ESSs.
- To adopt a mitigation hierarchy approach to: (a) Anticipate and avoid risks and impacts; (b) Where avoidance is not possible, minimize or reduce risks and impacts to acceptable levels; (c) Once risks and impacts have been minimized or reduced, mitigate; and (d) Where significant residual impacts remain, compensate for or offset them, where technically 2 and financially 3 feasible;
- To adopt differentiated measures so that adverse impacts do not fall disproportionately on the disadvantaged or vulnerable, and they are not disadvantaged in sharing development benefits and opportunities resulting from the project;
- To utilize national environmental and social institutions, systems, laws, regulations and procedures in the assessment, development and implementation of projects, whenever appropriate and;
- To promote improved environmental and social performance, in ways which recognize and enhance Borrower capacity.

To comply with the requirement of ESS1, an Environmental and Social Management Framework (ESMF) is being prepared to guide the implementation of proposed project.

- **ESS2: Labour and working conditions;**

ESS2 recognizes the importance of employment creation and income generation in the pursuit of poverty reduction and inclusive economic growth. Borrowers can promote sound worker-management relationships and enhance the development benefits of a project by treating workers in the project fairly and providing safe and healthy working conditions. The objectives of the ESS2 are:

- To promote safety and health at work;
- To promote the fair treatment, non-discrimination and equal opportunity of project workers;
- To protect project workers, including vulnerable workers such as women, persons with disabilities, children (of working age, in accordance with this ESS) and migrant workers, contracted workers, community workers and primary supply workers, as appropriate.
- To prevent the use of all forms of forced labor and child labor;
- To support the principles of freedom of association and collective bargaining of project workers in a manner consistent with national law; and
- To provide project workers with accessible means to raise workplace concerns.

- **ESS4: Community health and safety;**

ESS4 addresses the health, safety, and security risks and impacts on project-affected communities and the corresponding responsibility of Borrower to avoid or minimize such risks and impacts, with particular attention to people who, because of their particular circumstances, may be vulnerable. This Standard applies to the proposed project given that schools are constructed within the community and the community will be affected by construction works. The objectives of this standard are:

- To anticipate and avoid adverse impacts on the health and safety of project-affected communities during the project life cycle from both routine and non-routine circumstances;
- To promote quality and safety, and considerations relating to climate change, in the design and construction of infrastructure;
- To avoid or minimize community exposure to project-related traffic and road safety risks, diseases and hazardous materials.
- To have in place effective measures to address emergency events.
- To ensure that the safeguarding of personnel and property is carried out in a manner that avoids or minimizes risks to the project-affected communities.

- **ESS5: Land Acquisition, Restrictions on Land Use and Involuntary Resettlement**

Objective of ESS5

The objective of Environmental and Social Standard 5 on land acquisition, restriction on land use and involuntary resettlement are:

- To avoid involuntary resettlement or, when unavoidable, minimize involuntary resettlement by exploring project design alternatives.
- To avoid forced eviction.
- To mitigate unavoidable adverse social and economic impacts from land acquisition or restrictions on land use by: (a) providing timely compensation for loss of assets at replacement cost and (b) assisting displaced persons in their efforts to improve, or at least restore, their livelihoods and living standards, in real terms, to pre-displacement levels or to levels prevailing prior to the beginning of project implementation, whichever is higher.
- To improve living conditions of poor or vulnerable persons who are physically displaced, through provision of adequate housing, access to services and facilities, and security of tenure.
- To conceive and execute resettlement activities as sustainable development programs, providing sufficient investment resources to enable displaced persons to benefit directly from the project, as the nature of the project may warrant.
- To ensure that resettlement activities are planned and implemented with appropriate disclosure of information, meaningful consultation, and the informed participation of those affected.

- **Scope of application**

The ESS5 applies to all PAPs regardless of the total number affected, the severity of the impact and whether or not they have legal title to the land. Informal or traditional tenure is to be treated in the same manner as formal, legal titles. Therefore, this SEA covers permanent or temporary physical and economic displacement resulting from the following types of land acquisition or restrictions on land use undertaken or imposed in connection with project implementation:

- Land rights or land use rights acquired or restricted through expropriation or other compulsory procedures in accordance with national law;
- Land rights or land use rights acquired or restricted through negotiated settlements with property owners or those with legal rights to the land, if failure to reach settlement would have resulted in expropriation or other compulsory procedures;
- Restrictions on land use and access to natural resources that cause a community or groups within a community to lose access to resource usage where they have traditional or customary tenure, or recognizable usage rights;
- Relocation of people without formal, traditional, or recognizable usage rights, who are occupying or utilizing land prior to a project-specific cut-off date;
- Displacement of people as a result of project impacts that render their land unusable or inaccessible;
- Restriction on access to land or use of other resources including communal property and natural resources such as marine and aquatic resources, timber and non-timber forest products, fresh water, medicinal plants, hunting and gathering grounds and grazing and cropping areas;
- Land rights or claims to land or resources relinquished by individuals or communities without full payment of compensation; and
- Land acquisition or land use restrictions occurring prior to the project, but which were undertaken or initiated in anticipation of, or in preparation for, the project.

- **Compensation measures**

The Standard also requires that resettlement plans are implemented before any project-related impacts on project affected people. Therefore, the land acquisition, displacement or any restriction of access should not occur before necessary measures for resettlement and compensation are in place. For selected sites involving land acquisition, it is further required that these measures include provision of compensation and/or other assistance necessary for relocation, prior to displacement, and preparation and provision of resettlement sites with adequate facilities, where required. In particular, the taking of land and related assets may take place only after compensation has been paid, and where applicable, resettlement sites, related infrastructure and moving allowances have been provided to displaced persons. All activities project activities requiring relocation, loss of shelter or other impacts, the policy requires that measures to assist affected persons are implemented in accordance with the project resettlement plans of action.

- **ESS6: Biodiversity Conservation and Sustainable Management of Living Natural Resources**

ESS6 recognizes that protecting and conserving biodiversity and sustainably managing living natural resources are fundamental to sustainable development. Biodiversity is defined as the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species, and of ecosystems. Biodiversity often underpins ecosystem services valued by humans. Impacts on biodiversity can therefore often adversely affect the delivery of ecosystem services. The objectives of ESS6 are:

- To protect and conserve biodiversity and habitats.
- To apply the mitigation hierarchy4 and the pre-cautionary approach in the design and implementation of projects that could have an impact on biodiversity.
- To promote the sustainable management of living natural resources.
- To support livelihoods of local communities, including Indigenous Peoples, and inclusive economic development, through the adoption of practices that integrate conservation needs and development priorities.

- **ESS510-Stakeholder engagement and information disclosure**

This ESS recognizes the importance of open and transparent engagement between the Borrower and project stakeholders as an essential element of good international practice. Effective stakeholder engagement can improve the environmental and social sustainability of projects, enhance project acceptance, and make a significant contribution to successful project design and implementation. The objectives of stakeholder Engagement and information disclosure are:

- To establish a systematic approach to stakeholder engagement that will help Borrowers identify stakeholders and build and maintain a constructive relationship with them, in particular project-affected parties.
- To assess the level of stakeholder interest and support for the project and to enable stakeholders' views to be taken into account in project design and environmental and social performance;
- To promote and provide means for effective and inclusive engagement with project-affected parties throughout the project life cycle on issues that could potentially affect them;
- To ensure that appropriate project information on environmental and social risks and impacts is disclosed to stakeholders in a timely, understandable, accessible and appropriate manner and format.

3.4.3 Framework convention on climate change

This convention takes into account the fact that climate change has trans-boundary impacts. The basic objective of this convention is to provide for agreed limits on the release of greenhouse gases into the atmosphere so as to prevent the occurrence of climate change. It also aims to prepare countries to minimize the impact of climate change, should it occur.

3.4.5 Convention on Biological Diversity

The convention on biological diversity has three goals. These are:

- Conservation of biodiversity;
- Sustainable use of the components of biodiversity; and
- Fair and equitable sharing of the benefits arising from the use of genetic resources. Rwanda has ratified this convention and all project developers are urged to implement the convention during project implementation.

3.5 GAP Analysis between the JICA Guidelines and Laws of Rwanda

	JICA Guidelines	National Laws	Gaps	Policies/ measures applied to fill the gap
1	Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives.	No similar provisions in the Rwandan National Law.	Expropriation of land for public interest is regarded as inevitable and the affected persons shall be given fair and just compensation Article 3 of the expropriation law	Alternative analysis, including no project option and alternatives pipelines is conducted to minimize impacts of involuntary resettlement and loss of means of livelihood.
2	When population displacement is unavoidable, effective measures to minimize impact and to compensate for losses should be taken.	In the Rwandan National Law on expropriation, compensation of destroyed properties is considered	No gap identified. However, no measures to minimize impact of the displaced people are provided.	Alternative analysis, including no project option, is conducted to minimize impacts of involuntary resettlement and loss of means of livelihood. Compensation will be made for any loss caused by the project based on legislations of the country and JICA guidelines.
3	People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be fairly compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels	There are no explicit provisions on livelihood restoration	The Rwandan legislation is silent on this matter.	Compensation will be based on full replacement cots and provided before resettlement. Assistance and supports will be provided to PAPs to restore their livelihood at least at its original level, if not better.
4	Compensation must be based on the full replacement cost as much as possible.	Compensation is calculated considering the size, nature and location and considering the prevailing market prices. (Article 22 of the Expropriation Law)	No gap is identified. Although the word "market price" used in the Expropriation Law actually includes any fees, costs, taxes, etc. hence it is actually the same as "full replacement cost."	Compensation will be based on the full replacement cost, including any fees and costs involved
5	Compensation and other kinds of assistance must be provided prior to displacement.	The Expropriation Law, Article 23 stated that compensation shall be awarded to the	No gap. Compensation will be provided prior to relocation.	Compensation and other kinds of assistance will be provided prior to

	JICA Guidelines	National Laws	Gaps	Policies/ measures applied to fill the gap
		expropriated person before he or she relocates.		displacement.
6	For projects that entail large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public	It is not indicated in the Rwandan National Law, however it is requested by the Rwandan Development Board to be mentioned in the EIA report	No gap.	Since this project will not trigger a large scale resettlement, an ARAP will be prepared in accordance with Rwandan Laws and JICA guidelines
7	In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance.	The expropriation law governs the specifics of land acquisition. The law provides for public dissemination on the importance of the project to be established and the need for expropriation. (Article 11, 12, 13)	No major gap.	Consultations with PAPs and communities were held during the conduct of this study as well as individual PAP consultations and local authorities were done. However, consultation will continue during the ARAP preparation.
8	When consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people.	The medium of exchange in Rwanda is Kinyarwanda and all Rwandans can hear and speak Kinyarwanda language.	No gap	Kinyarwanda will be used in consultation and Compensation payment agreements with PAPs will be prepared in Kinyarwanda.
9	Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of resettlement action plans.	General Guidelines and Procedure for EIA states public participation in planning and decision making for the project.	There are no specific guidelines for participation of affected people in planning, implementation, and monitoring of RAP.	Consultations during EIA and ARAP preparation will be used as opportunities for public participation in ARAP planning, implementation and monitoring
10	Appropriate and accessible grievance mechanisms must be established for the affected people and their communities.	The expropriation law article 26 provides complaints procedures for individuals dissatisfied with the value of their compensation. The law stipulates that the dissatisfied person has a period of 30 days after the project	No gap.	An appropriate and accessible grievance mechanism will be established in the ARAP.

	JICA Guidelines	National Laws	Gaps	Policies/ measures applied to fill the gap
		approval decision has been taken to appeal (Article 19)		
11	Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socioeconomic survey), preferably at the project identification stage, to prevent a subsequent influx of encroachers of others who wish to take advance of such benefits. (WB OP4.12)	According to the Rwandan expropriation law, the census of the affected people is conducted as well as inventory of their properties at the beginning of the land survey, which is considered the cut-off date. (Article 17)	No gap in terms of conducting inventory and establishment of cut –off date. However, no socio-economic survey is conducted by government funded projects.	An initial baseline survey (including socio-economic survey) will be conducted based on WB OP 4.12 and JICA guidelines . A cut-off date for this project will be then communicated after project approval.
12	Eligibility of benefits includes, the PAPs who have formal legal rights to and (including customary and traditional land rights recognized under law), the PAPs who don't have formal legal rights to land at the time of census but have a claim to such land or assets and the PAPs who have no recognizable legal right to the land they are occupying. (WB OP4.12 Para.15)	The Rwandan legislation (organic land law 5, 6, 7) defines the eligibility as both formal (legal) and informal (customary) owners of expropriated land. Article 18 of the Expropriation law considered in addition to legal documents, a document or testimony of the neighbors confirming ownership for the land as an evidence	There is a gap. The Rwandan legislation does not specifically recognize all users of land to be expropriated while OP 4.12 chapter 14(a),(b),(c) entitles those with formal legal rights to land, those with no formal legal rights to land and those who have no recognizable right or claim to the land they are occupying.	Follow the OP 4.12 guidelines and principles. Eligibility to benefits includes both formal and informal owners of land and owners of other assets affected by the Project.
13	Preference should be given to land-based resettlement strategies for displaced persons whose livelihoods are Land-based. (WB OP4.12 Para.11)	Article 23 of the expropriation law provides for fair and just compensation and it stipulates that this could be monetary or an alternative land or a building equivalent to the determination of just monetary compensation	No major gap.	Discussion with PAPs will be held to opt for compensation measures either being for full payment compensation or land to land compensation or monetary based compensation.
14	Provide support for the transition period (between displacement and livelihood restoration). (WB OP4.12 Para.6	There are no explicit support for transition period and livelihood restoration	The Rwandan legislation is silent on this matter.	Since full compensation is envisaged to be by cash transfer payment, there will be no need for support during transition period. It shall be observed

	JICA Guidelines	National Laws	Gaps	Policies/ measures applied to fill the gap
				that property can only be acquired after PAP has been paid
15	Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities etc. (WB OP4.12 Para.8)	No clear provision on the vulnerable groups among those displaced	The Rwandan legislation is silent on this matter.	No vulnerable groups were found in this project areas hence would not applicable
16	For projects that entail land acquisition or involuntary resettlement of fewer than 200 people, abbreviated resettlement plan is to be prepared. (WB OP4.12 Para.25)	No indication in the Rwandan National laws	The Rwandan legislation is silent on this matter	PAPs were fewer than 200 people(only One HH in Phase I and 4 HHs in Phase II) hence for the first phase, willing seller willing buyer principals will be applied while ARAP for Phase 2 will be prepared for this project.

CHAPTER IV: BASELINE DATA AND CONSIDERATIONS

The present Chapter of this ESIA report presents the social economical baseline data of the project area of intervention and was made in order to ascertain environmental and socio-economic baseline conditions and then assess the impacts as a result of the proposed project. Data presented were collected on:

- Physical environment(land and soil-water-air & climate);and
- Biological environment (flora and fauna);
- Socio-economic environment (demography, livelihood, income socio-economic etc.)

Data presented herewith are from different sources of information including field survey, literature review, interviews with local population and stakeholders, etc. Despite the pandemic of COVID- 19 that handicapped the formal meeting gathering with local population and residents other different discussions were held during the site visits with the local population and authorities, project affected persons and local government/non-government organisations in formal or informal way and this provided very useful information that are presented in this report. Other sources of information mainly related to line route of the pipelines, project facilities, size, project designs and locations were collected from FS of the project elaborated by JICA study team.

4.1 Physical environment

4.1.1 Topographical Make up

The project site is relatively flat with similar topographical characteristics of Rwamagana District located in step slops characterized, in general, by lowly undulating hills separated by valleys some of which are swampy and boggy. The entire study area expands on the topography ranging from 1332 m above sea level (hereafter masl) to 1795 m asl at both intake and the highest point of the water supply area. While the slop is ranging from 0 to 65 % in the project area

4.1.2 Climate

The District of Rwamagana is situated between 1°57'2, 7''of south latitude and 30°26'8''of longitude. It experiences a moderate tropical climate with four seasons of which: two are cold and the rest dry (district self-assessment report). The district experiences relatively large quantities of rains especially in the months of April-May and October-December of every year. The average temperature ranges between 19° and 30° C and it is constant all over the year. However, due to the current challenge of global climate change issues, the four seasons are sometimes irregular, and one cannot precisely fix the temporal limits of each season. The rainy season may extend for some weeks into the dry season and vice versa.

4.1.3 Soil characteristics and land use

According to the Geological Map of Rwanda, the regional geology consists of Pelitic rocks and Quartz-Phyllites, Granites to Granite-Gneisses, Quarzite and Mica-Schists as well as Meta-Volcanics. Metamorphic rocks form the major part of the rock mass and some magmatic rocks are also present. The soils encounter at project area has an average depth of 1.20 m. Generally the soils identified at the proposed area are Alluvial Clay to Silt Clay Soil; Red Silt; Black Clay; Black Hard Silt;

Rwamagana district has very fertile soils almost in all its sectors. Most of the soils are loamy and few others are sandy with loam mixture. In some boggy areas, clay soil is also found. The soils permit growth of most types of foods such as: bananas, maize, cassava, beans, coffee, Pineapples and rice only to mention some. The soil for the intake and the WTP is also as the rest of the study area used for agricultural and woodlots . Most of the crops found at the sites during the conduct of the sites visits between February and March 2021 are bananas, cassava, eggplants, coffee and sweet potatoes etc. There are also woodlots and other tree and shrubs species scattered in the project areas.

4.1.4 Air quality in project area

The project sites are located in the neighbourhoods with similar characteristics of rural areas where the ambient air is relatively not polluted based on the surrounding activities and daily human business. Even if no measurement related to air quality have been conducted in the project area, it is expected that the implementation of this project may cause air pollution in its surroundings and impact on environment and people's health.

The main sources of air pollution may result from combustion fuels via transportation of construction materials and workers, use of machinery, excavation works, and construction activities. The mitigation measure to avoid air pollutions and related impacts were provided in this report highlighting mitigation measure of identified impacts.

4.1.5 Hydrology of the project area

i. Catchment of the project area

According the National Water Resources Master Plan (2014), the present project is located in the Upper Akagera catchment. The Upper Akagera catchment commences at the confluence of the Lower Nyabarongo and the Akanyaru Rivers and belongs to the Nile basin. The first half of the catchment is located within Rwanda but after Lake Rweru, the Akagera River forms the boundary between Rwanda and Burundi. The principle tributaries cum lakes of the Upper Akagera catchment are Lake Mugesera and Rweru, the Nyabarongo River, and finally the Ruvubu River which takes its water exclusively from Burundi and Tanzania and enters the Akagera just upstream of Rusumo falls. The upper Akagera catchment is characterized by the following hydrological data:

Table 10: summary of hydrological data of upper Akagera catchment

Catchment name	Surface area (km^2)	Renewable resources (000 m^3)	Potable water supply use (000 m^3)	Irrigation water use (000 m^3)	Total water use in (000m^3)	Av. annual rainfall(mm/yr)	Av. annual evaporation (water balance) [mm/yr]	Av. annual surface water runoff [mm/yr]	Av. annual ground water recharge [mm/yr]	Ground water volume storage [MCM]
Upper Akagera	2,939	504,000	9,776	16,034	25,809	925	760	165	115	3580

Source: Rwanda Water Master Plan, 2014

ii. Mugesera Lake

Lake Mugesera has a surface area estimated to at 43.5 km^2 and touches the Districts of Rwamagana, Ngoma and Bugesera. The lake is part of a complex of lakes and wetlands in a flat valley running in a South Eastern direction. The lake is fed by a number of rivers and minor streams originating on ridges to the north, east and south, which deliver most water during the rainy seasons. The Nyabarongo River meanders southward through the valley, flooding it to create a zone of permanent swamps and lakes.The rainy seasons in the region of Lake Mugesera are from March to May and again from September to December which makes it to have abundant water throughout the year. The total volume of the lake is estimated at 162,000,000 m^3.

The climatic conditions of the area of lake Mugesera including Karenge area comprises of four seasons which are two rainy seasons (March to May and September to November) and two dry seasons (June to August and December to February). The mean annual rainfall in the area is 882 mm. The potential evaporation of the area is about 1482 mm per year. The table below (table 10) summarizes the hydrological data of lake Mugesera.

Table 11:: Summary of hydrological data of lake Mugesera

No	Parameters	Value
1	Lake surface area	43.5 km^2
2	Runoff coefficient	0.26
3	Maximum depth of lake	11.5 m
4	Mean lake depth	4 m
5	Estimated water volume	162,000,000 m^3
6	Water temperature	23-25^oC

Source: Rwanda Water Resources Master Plan, 2014

iii. Raw water quality of Lake Mugesera

Raw water quality and treated water quality of both Mugesera lake and Karenge WTP are presented in the table below (table 10). As shown, the turbidity of raw water is very low which resulted in poor coagulation and sedimentation. In addition, although some parameters such as colour, iron, manganese, nitrogen, phosphorus and cyanide show higher levels, the treated water can still meet the drinking water quality for Rwandan and east African standards. . It should be pointed out that the Mugesera Lake is in the eutrophic state as the total nitrogen and phosphorus concentrations are 5.96 mg/L and 0.99 mg/L, respectively and have exceeded the eutrophication limit of nitrogen (0.6 to 1.5 mg/L) and phosphorus (0.03 to 0.1 mg/L).

Table 12:Raw water and treated water quality

Parameters	Unit	Raw water	Treated water	RSB & EAST AFRICAN STANDARD
Total Coliforms	<1 MPN/100ml	10253	0	**0 cfu/100 ml**
Fecal coliforms	<1 MPN/100ml	245	0	**0 cfu/100 ml**
E. Coli	<1 MPN/100ml	44	0	**0 cfu/100 ml**
Fecal Streptococcus	Cfu/100ml	452	0	**0 cfu/100 ml**
pH		8.5	7.5	**6.5-8.5**
Color	APHA	284	9	**15 APHA**
Turbidity	NTU	10.8	0.75	**< 5 NTU**
Suspended matter	mg/L	42	0	**0 mg/l**
Residual free Chlorine	mg/L		1.25	**0.2 - 0.5mg/l**
T-N	mg/L	5.96	-	
T-P	mg/L	0.99	-	
Calcium	mg/L	8	15.2	**150mg/L**
Magnesium	mg/L	9.24	8.36	**100mg/l**
Dissolved Oxygen	mg/L	14.5	7.5	
Organic matter	mg/L	5.4	1	**2 mg/l**
Iron	mg/L	0.85	0.05	**0.3 mg/l**
Manganese	mg/L	0.62	0.009	**0.1 mg/l**
Nitrites	mg/L	0.35	0.002	**0.9 mg/l**
Nitrates	mg/L	12.2	0.5	**45mg/l**
Ammoniacal Nitrogen	mg/L	0.3	0.003	**0.5 mg/l**
Phosphates	mg/L	1.2	0.1	**2.2mg/l**
Copper	mg/L	0.5	0.035	**1mg/l**
Zinc	mg/L	0.72	0.04	**5mg/l**
Silica	mg/L	0.5	0.03	**IND**
Fluoride	mg/L	1.5	0.3	**1.5mg/l**
Cyanide	mg/L	0.2	0	**0.01 mg/l**
Chromium	mg/L	0.2	0.003	**0.05mg/l**
Sulphates	mg/L	4	0	**400 mg/l**
Aluminium	mg/L	0.4	0.004	**0.2 mg/l**
Temperature	°C	24.6	24.2	**25°C**

Source: WASAC, Karenge water treatment Plant

iv. Ecosystem Services of Lake Mugesera

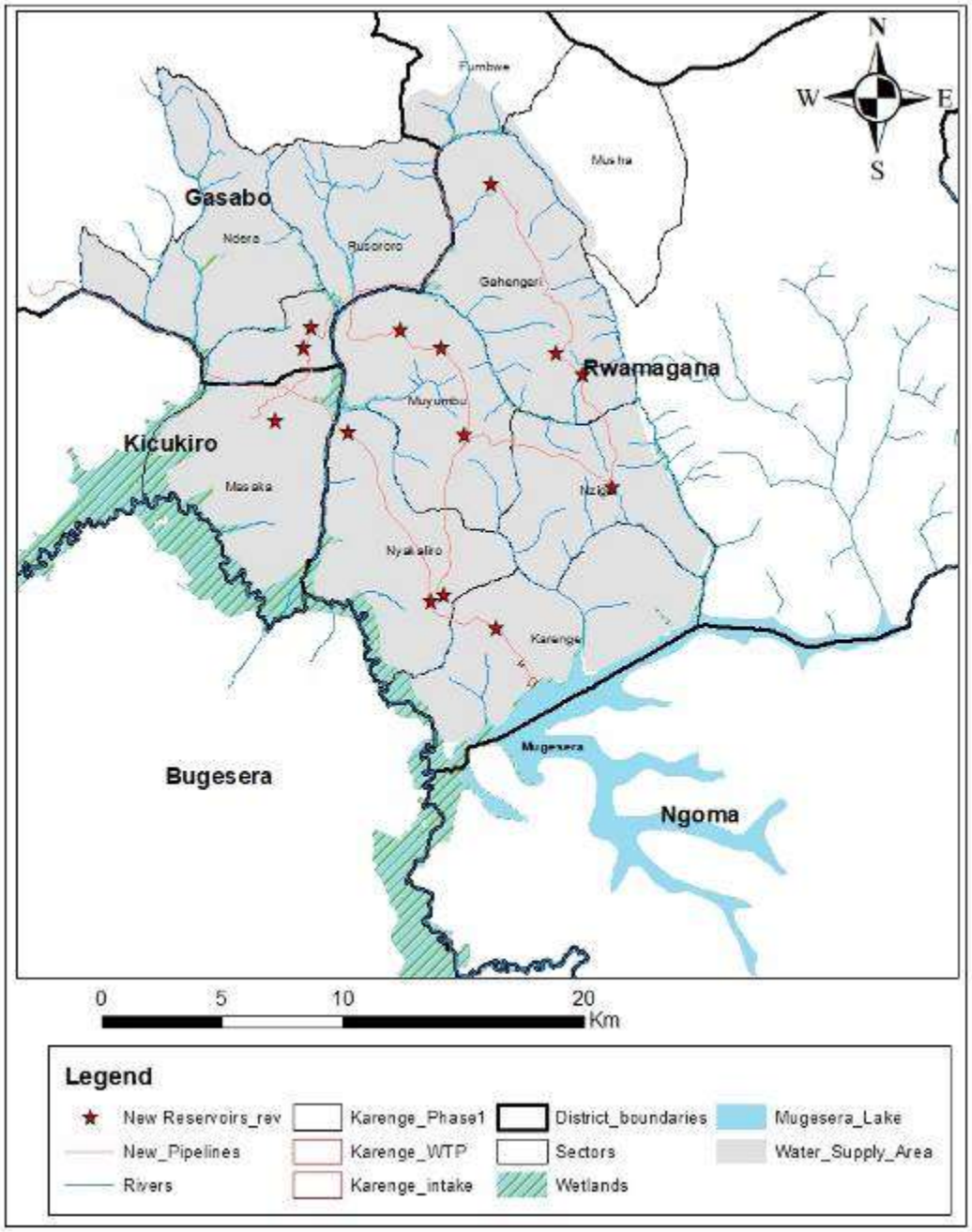
Apart for being used as main source of water for Karenge water treatment plant, the majority of the population of Karenge Centre and its environs acknowledge that Mugesera Lake represents an important aspect of their life. Most of them use water from the lake for domestic purposes in case of treated water shortage. The lake is also used in agricultural as well as for fishing.

The lake also serves as navigation and transport means to link Karenge and Gisaka area (Ngoma district). Therefore, the lake is perceived as an important asset for the livelihood of local population as they appreciated the measure taken for its protection including the relocation of houses in the prone areas nearby the lake, the establishment of the buffer zone around the lake (50 m), excluding polluting activities within and in the buffer of the lake etc.

v. Hydrological network of the project area

The assessment of the existing water course in the project area was made using field survey and secondary data collection from different sources of information as well as using interviews from local residents. The hydrology of the study area and its vicinity is mostly made up of some slam streams and rivers that are part of the Akagera river basin. Some of them are of low importance and the main identified are Nkungu, Cyaruhogo, Nyirabidiri and Ruvomo. The figure below shows the hydrological network of the project area.

Figure 13: Hydrological network map of the project area



Source: BESST Ltd,2021

4.2 Biological and ecological data

4.2.1 Methodology

The ecological survey followed three main steps. The first step consisted of desktop work. During this phase, a literature review was undertaken. Species lists, species databases, existing documents, and previous studies and assessments for Rwanda (with much focus on the study area) were consulted. As output, a list of species that occur, or could occur, in the study area based upon their habitat affinities and ranges were established. The second step consisted of field survey where data on species and diversity were collected based on standards survey methods as per animal taxa and plant species; and were recorded on pre-designed datasheets. The last step included data entry, processing, analysis and report writing.

- ✓ **Setting up sampling units**

The project area was divided into 3 components: Water Treatment Area, Water Intake Area and Pipeline and Storage Area. The 3 components were considered independently as separate sampling units. The Water Treatment Area was defined as the water treatment plant and its surrounding area within the 2-kilometer radius. The Intake Area or the well field was defined as the lake and its surrounding swamp within the radius of 1 kilometer around the water pumping station located in the buffer zone of Mugesera lake. Lastly the Pipeline and Storage Area was the area around 100-meters around pipeline and planned water reservoirs.

Two reconnaissance routes were established. One was established within the Water Treatment Area, while another was established within the swamp along Mugesera lake. For the pipeline and storage area, the area was divided into 3 segments: the central segment covering Muyumbu Sector, the eastern covering Gahengeri Sector and the western segment covering Nyakaliro Sector. For each segment, we selected area for sampling using satellite imagery and we ensured that sampling area was most representative of the whole segment in terms of physical and ecological conditions. For each selected area, we walked along the proposed pipeline area recording plant and animal species diversity.

- ✓ **Data collection on Fauna**
- **Birds**

Two (2) methods were used for data collection on birds. The first method consisted of **point counts**, where observation points were established at an interval of 200 meters along the reconnaissance route. At each point the observer waited for three (3) minutes to allow birds to settle down and then record all sightings and calls of birds for a period of 10 minutes (Sutherland, W. 2000). The observers then moved on to the next point and repeated this same process. The second approach consisted of opportunistic sampling where all bird species seen or heard were recorded. For bird species identification, we used the identification keys provided by Stevenson & Fanshawe (2002).

- **Amphibians and reptiles**

Visual Encounter Sampling (VES) approach was be used. According to this approach, each amphibian reptile encountered along the reconnaissance route was recorded. In case the species was not identified at place, a description of the species was made and photographs were taken for further identification.

- **Fishes**

We relied on information provided by local community members, especially those involved in fishing and fishermen. We asked them the vernacular names of fish species living in nearby rivers and lake. Vernacular names of species were then cross-checked to find their equivalent in English and their species names from different reports and fish database in Rwanda.

- **Other species**

For other species taxa, mainly mammals, data were recorded along established reconnaissance routes. All signs including animal sighting, animal voices and other signs including dung, footprint or spoor, hairs, digging and nests were recorded. In addition, we relied on local community knowledge about species occurring in the area.

- ✓ **Data collection on Flora**

For surveying flora, 2 methods were used. The first method consisted of recording all plant species in a 10x10 meter plot that were established in both the Water Treatment Plant Area and the Intake Area (swamp around Musegera lake). The plots were established in a most representative area of the study area in terms of physical and ecological conditions. The second method consisted of recording any new plant species encountered along the reconnaissance routes that were established during fauna survey. For the pipeline area, data was collected along the proposed pipeline location, while for the storage area, data was collected in a 100-meters radius around the area proposed for water reservoir construction. These both methods helped in maximizing the number of plant species to be recorded. All plant species encountered were recorded. '**Flore du Rwanda**' in 4 volumes (Troupin 1978, 1983, 1985, 1988) were used as the main source for plant species identification. The circumscription of plant families followed APG (2009).

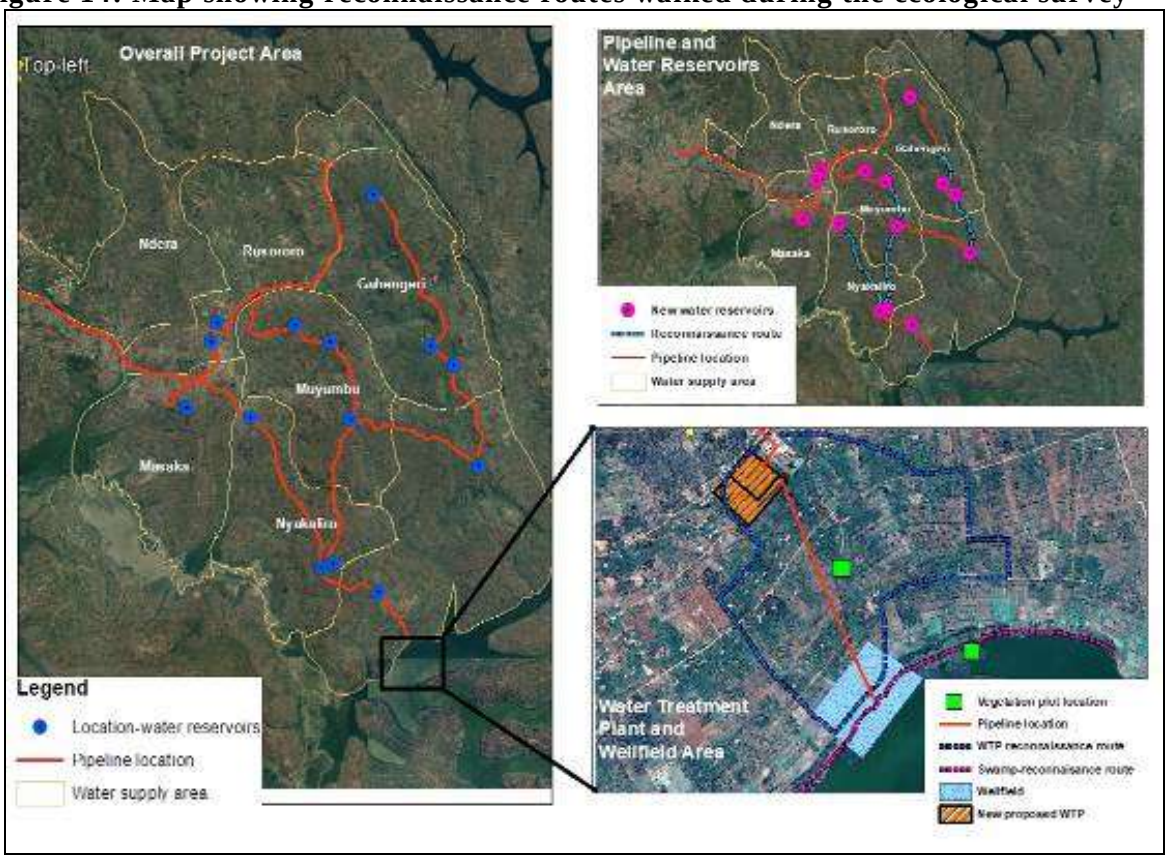
- ✓ **Assessing conservation status of species**

For assessing the conservation status of each species, the IUCN Red List of Threatened Species, version 2020-2 (IUCN, 2020) was used. In addition, the ministerial order No 007/2008 of 15/08/2008 establishing the list of protected animal and plant species was consulted to identify plant and animal species protected in Rwanda. Any endangered or listed species on IUCN red list or any species protected in Rwanda were highlighted and brought to the client's attention.

- ✓ **Data processing and analysis**

All collected data were entered in Excel sheets and analysed. Species lists along with species conservation status and their occurrence location were produced.

Figure 14: Map showing reconnaissance routes walked during the ecological survey



Source: BESST Ltd,2021

4.2.2 Vegetation and Flora

The overall Project Area, including Water Intake Area, Water Treatment Plant Area and Pipeline and Reservoir Area is characterized by the following main habitat types: anthropic landscape dominated by agriculture and human settlement, swamp and aquatic vegetation around Mugesera Lake; and forest woodlot which makes a buffer zone around Mugesera Lake.

A total of 58 plant species were recorded in the project area. These are divided into 23 orders and 32 families. Details on plant species are provided in the annex. The sections below provide details on the flora composition per each project components.

(a) Water Intake Area

The water intake area consists of Mugesera lake where water is abstracted from, its surrounding swamp and buffer zone layer where water pumping station is located.

Swamp and aquatic vegetation consist of plant communities that are waterlogged permanently or for extended periods of the year. It includes also floating aquatic vegetation mainly non-native invasive species of Common Water Hyacinth ***Eichhornia crassipes*** and Blue Lotus ***Nymphaea nouchali***.

The swamp associated to the lake is covered by plant community dominated by Papyrus Sedge ***Cyperus papyrus***, Giant Reedmace ***Typha latifolia***.

Other plant species include grasses such as ***Vossia cuspida*** and ***Echinochloetum pyramidalis*** and woody shrubs of ***Mimosa pigra***. The other swamp and aquatic plant species included ***Polygonum pensylvanicum***, ***Cyperus alternifolius***, ***Polygonum coccineum*** and ***Setaria glauca***,

The water pumping station is located in within the lake and swamp buffer zone dominated by ***Grevillea robusta*** and some ***Markhamia lutea*** trees. According to the new proposed upgrade plan, the water pumping station is planned to be moved up beyond the lake's buffer zone area to avoid current flooding of the area that occur during the long rainy season

(b) Water Treatment Plant Area

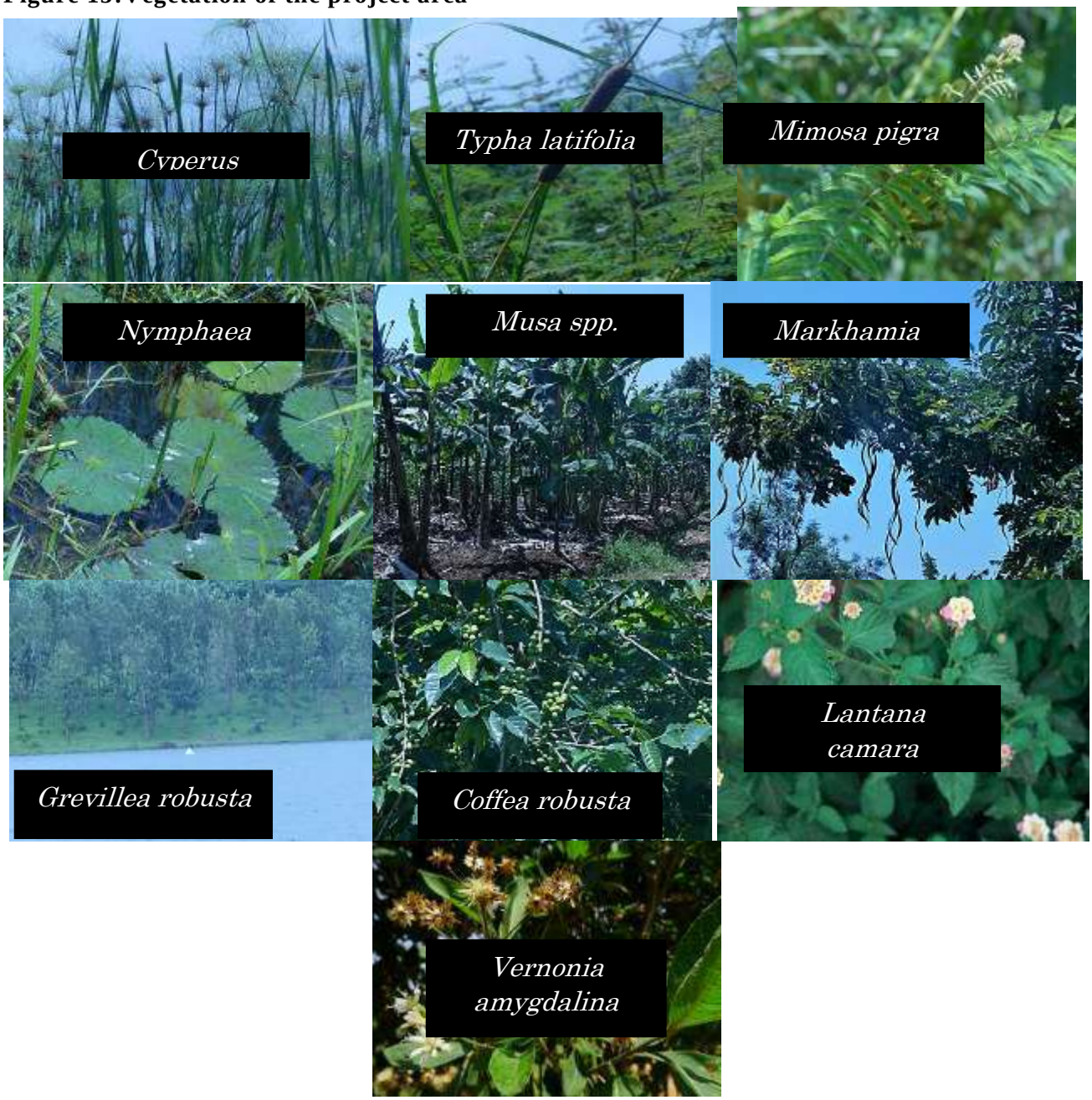
The Water Treatment Plant Area is located within the anthropic landscape dominated by agriculture and human settlement. The area is dominated by perennial crop such banana plantation (***Musa spp.***) and coffee (***Coffea robusta***) and scattered trees of ***Markhamia lutea*** and ***Grevillea robusta, Pinus patula, Cupressus spp***., etc**.** Other tree species include fruit tree species avocado (***Persea gratissima***), mango (***Mangifera***

indica), orange (***Citrus sinensis***), etc. Seasonal crops include among others: maize, potatoes, sorghum, beans, cassava and others.

(c) Pipeline and Reservoir Area

The Pipeline and Reservoir Area is located in the anthropic landscape. The proposed pipeline will pass along the existing roads that connect different sectors in Rwamagana and Kicukiro District. Similarly, to the water treatment area, this landscape is dominated by agriculture land, human settlement and woodlots. Dominant species include banana plantation, ***Markhamia lutea*** and forest woodlots dominated by ***Grevillea robusta, Eucalyptus*** and ***Pinus spatula.*** Bush thickets around the road and in several areas are dominated by ***Lantana camara, Vernonia amygdalina*** and several other species. Crops include seasonal crops such as maize, potatoes, sorghum, beans, cassava, etc. A full list is provided in the annexes.

Figure 15:Vegetation of the project area



Source: BESST field survey, March 2021

4.2.3 Fauna and avifauna

- ✓ **Birds**

A total of 21 bird species were recorded across the project area during the field survey. These are distributed in 10 orders and 18 families. Passeriformes were the most represented. The most common species recorded included Slender-Billed weaver ***Ploceus pelzelni***, African-Pied Wagtail ***Motacilla aguimp***, Spickled Mousebird ***Colius striatus*** and Collared sunbird ***Hedydipna collaris.*** The swamp around Mugesera lake where is located the intake was richer in terms of bird diversity with 11 species recorded. 9 species were recorded

exclusively in the swamp area (Intake Area), while 12 bird species were found in more than one project component locations (Table 16)

Table 13: bird species recorded within the location of project areas

No.	Location - Project component*	Order	Family	Scientific Name	Common Name	Vernacular Name	IUCN Redlist Status**
1	IA, WTP, PSA	Passeriformes	Ploceidae	*Ploceus pelzelni*	Slender-Billed weaver	Isandi	-
2	WTP, PSA	Passeriformes	Passeridae	*Passer griseus*	Common Grey-Headed Sparrow++	Igishwi	LC
3	WTP, PSA	Passeriformes	Motacillidae	*Motacilla aguimp*	African-Pied Wagtail	Inyamanza	LC
4	WTP, PSA	Passeriformes	Estrildidae	*Lagonosticta rubricata*	African Firefinch	Ifundi	LC
5	IA	Passeriformes	Muscicapidae	*Cossypha heuglini*	White-browed Robin-chat	Inyombya	LC
6	WTP, PSA	Apodiformes	Apodidae	*Apus caffer*	white-rumped swift	Intashya	LC
7	WTP, PSA	Columbiformes	Columbidae	*Columba larvata*	Lemon dove	Inuma	LC
8	WTP, PSA	Accipitriformes	Accipitridae	*Milvus migrans*	Black kite	Sakabaka	LC
9	WTP, PSA	Passeriformes	Corvidae	*Corvus albus*	Pied Crow	Icyiyoni	LC
10	IA, WTP, PSA	Coliiformes	Coliidae	*Colius striatus*	Spickled Mousebird	Umusure	LC
11	IA	Passeriformes	Nectariinidae	*Hedydipna collaris*	Collared sunbird	Umununi	LC
12	WTP, PSA	Passeriformes	Pycnonotidae	*Pycnonotus tricolor*	Dark-capped bulbul	Ikirogoryo	LC
13	IA, WTP, PSA	Accipitriformes	Accipitridae	*Accipiter melanoleucus*	Great sparrowhawk	Agaca	LC
14	IA	Charadriiformes	Charadriidae	*Ardea melanocephala* #	Black-Headed Heron	Uruyongoyongo	LC
15	IA	Cuculiformes	Cuculidae	*Centropus superciliosus*	White-browed Coucal	Ikibiribiri	LC
16	IA	Galliformes	Phasianidae	*Pternistis hildebrandti*	Hildebrandt's Francolin	Inkware	LC
17	IA	Columbiformes	Columbidae	*Streptopelia semitorquata*	Red-eyed dove	Inuma (intunguru)	LC
18	IA	Pelecaniformes	Ardeidae	*Bubulcus ibis*	Cattle Egret	Inyange	LC
19	IA, WTP, PSA	Accipitriformes	Accipitridae	*Polyboroides typus*	African harrier-hawk	Ikizu	LC
20	IA	Pelecaniformes	Scopidae	*Scopus umbrette* #	Hammerkop	Injongo	LC
21	IA	Coraciiformes	Alcedinidae	*Ceryle rudis*	Pied Kingfisher	Murobyi	LC

* Location - Project component| IA =Intake Area, WTP = Water Treatment Plant, PSA = Pipeline and Storage Area
** IUCN Redlist status| LC = Least Concern, - = not currently assessed by the IUCN Redlist
# Protected species by the Ministerial Order N°007/2008 of 15/08/2008

Figure 16: bird species in the project area

Source: BESST ltd, on field survey

- ✓ **Amphibians**

During the field data collection, only one species of amphibian was encountered and recorded in the area around the Water Treatment Plant. This is commonly called African common toad (***Sclerophrys regularis***). However, 13 other amphibian species are found around Mugesera Lake according to a study of Dehling conducted in 2011 (Table 2-2). It is important to mention that there is one endemic species: the Rwanda Long Reed Frog **Hyperolius rwandae** that is likely to occur in the study area. According to IUCN Redlist, this

species has been recorded within the Mugesera and Akagera wetlands. However, no recent study has been able to record this species in Rwanda.

Table 14: Amphibian species diversity as recorded in the project area

No.	Species	Family	IUCN Redlist Status*	Endemic Status**	Habitat affinity***
1	*Sclerophrys regularis*	Bufoniadae	LC	W	AL
2	*Afrixalus quadrivittatus*	Hyperoliidae	LC	W	AS
3	*Hyperolius acuticeps*	Hyperoliidae	LC	W	AS
4	*Hyperolius kivuensis*	Hyperoliidae	LC	W	AS
5	*Hyperolius lateralis*	Hyperoliidae	LC	GL	AS
6	*Hyperolius viridiflavus*	Hyperoliidae	LC	W	AS
7	*Kassina senegalensis*	Hyperoliidae	LC	W	AL, AS
8	*Phrynobatrachus kakamikro*	Phrynobatrachidae	LC	GL	AS
9	*Phrynobatrachus natalensis*	Phrynobatrachidae	LC	W	AL, AS
10	*Xenopus victorianus*	Pipidae	LC	GL	ASV
11	*Ptychadena anchietae*	Ptychadenidae	LC	W	AL, AS
12	*Ptychadena mascareniensis*	Ptychadenidae	LC	W	AL, AS
13	*Ptychadena porosissima*	Ptychadenidae	LC	W	AL, AS
14	*Amietia angolensis*	Pyxicephalidae	LC	W	AL, AS

* IUCN Redlist status| LC = Least Concern

** Endemic status|W = widespread in Africa, GL = regional endemic of the Great Lake region

*** Habitat affinity| AL = anthropic landscape dominated by agriculture and human settlement, AS = aquatic and swamp area

Figure 17: Amphibians in the study area

Source: BESST ltd field survey 2021

- ✓ **Reptiles**

No reptile species was encountered during the field survey. Community members we asked reported 3 snake species as the most encountered reptiles in the area – These included: African Green Snake (***Philothamnus heterolepidotus***), Puff Adder (***Bitis arietans***) and Striped Sand Snake (***Psammophis sibilans***). They also reported Crocodile (**Crocodylus niloticus**) as present in the lake and another species of tortoise (***Pelusios subniger***) that lives in swamps around the lake. According to literature review, Dehling (2011 and Fischer (2011), both recorded 7 reptile species around Mugesera Lake and Mugerera-Rweru lake complex respectively. These were divided into 3 orders and 6 families (Table 19).

Table 15: Reptile species diversity as recorded in the project area

No.	Species	Order	Family	IUCN Redlist Status*	Endemic Status**	Habitat affinity***
1	Nile crocodile *Crocodylus niloticus* #	Crocodilia	Crocodylidae	LC	W	AS
2	Black-bellied Hinged Terrapin *Pelusios subniger* #	Testudines	Pelomedusidae	LC	W	AS
3	Elliot's Groove-throated Chameleon *Trioceros ellioti*	Squamata	Chamaeleonidae	-	W	AL
4	African Green Snake *Philothamnus heterolepidotus*	Squamata	Colubridae	-	W	AL, AS
5	Forest cobra *Naja melanoleuca*	Squamata	Elapidae	-	W	AL, AS
6	Spitting cobra *Naja nigricollis*	Squamata	Elapidae	-	W	AL
7	Puff Adder viper *Bitis arietans* #	Squamata	Viperiade	-	W	AL

No.	Species	Order	Family	IUCN Redlist Status*	Endemic Status**	Habitat affinity***

* IUCN Redlist status| LC = Least Concern, - = not currently assessed by the IUCN Redlist

** Endemic status|W = widespread in Africa, GL = regional endemic of the Great Lake region.

*** Habitat affinity| AL = anthropic landscape dominated by agriculture and human settlement, AS = aquatic and swamp area

Protected species by the Ministerial Order N°007/2008 of 15/08/2008

✓ Fishes

Information on fish species occurrence in Mugesera Lake was mostly obtained from community members and people involved in fishing activities in the project area from fishing cooperative- Cooperative des Pêcheur et Pisciculteurs de Karenge (COPPIKA). Four (4) main species are found in Mugesera lake and constitute the main fish catch in the area (Table 19). These include the Nile Tilapia ***Oreochromisniloticus***, African Catfish ***Clariasgariepinus***, lungfish ***Protopterusaethiopicus*** and Ray-finned fish ***Haplochromis sp.***

Table 16:Fish species found in Mugesera lake

Common Name	Vernacular Name	Scientific Name	Fish Catch (Kg)
Tilapia	Ingege	*Oreochromisniloticus*	3,557
Lungfish	Imamba	*Protopterusaethiopicus*	5,520
African Catfish	Inkube	*Clariasgariepinus*	4,407
Ray-finned fish	Indugu	*Haplochromis sp.*	52,803 *
Total fish catch			**66,287**

Source: COPPIKA (2020)

* Data for July 2018-2019 (the species was not fished since 2020, due to ongoing restrictions aimed at enhancing species recovery and improving fishing practices.

✓ Mammals

During the field survey, no mammal species was observed or sign recorded. We requested community members in the study area about mammal species commonly encountered in the area. According to the information they provided, the hippos (***Hippopotamus amphibius***) are found in Mugesera lake and sometimes they roam around the lake. They reported also 2 primate species - the Blue monkey (***Cercopithecus mitis***) and the Velvet monkeys (***Chlorocebus pygerythrus***). Other species associated to the swamp habitat included the Marsh Mongoose (***Atilax paludinosus***) and Sitatunga (***Tragelaphus spekii***). However, they reported Sitatunga have not been seen for a long time. Other species that are commonly found in the anthropic landscape include jackal, the Gambian rat and African Hare, etc. (Table 20). They also reported the presence of leopard (***Panthera pardus***) though this information needs to be verified and confirmed.

Table 17: Mammal species diversity found in the project area

No.	Class	Order	Family	Species	Common name	Local Name	IUCN Redlist Status*	Habitat affinity**
1	Mammal	Artiodactyla	Hippopotamidae	*Hippopotamus amphibius #*	Hippopotamus	Imvubu	VU	AS
2	Mammal	Primate	Cercopithecidae	*Cercopithecus mitis*	Blue monkey	Inkima	LC	AL
3	Mammal	Primate	Cercopithecidae	*Chlorocebus pygerythrus*	Vervet monkey	Inkende	LC	AL
4	Mammal	Carnivore	Canidae	*Canis adustus*	Jackal	Imbwebwe	LC	AL
5	Mammal	Carnivore	Canidae	*Canis familiaris*	Feral dog	Imbwa y'agasozi	-	AL
6	Mammal	Carnivore	Herpestidae	*Atilax paludinosus*	Marsh Mongoose	Inzibyi	LC	AS
7	Mammal	Carnivore	Herpestidae	*Helogale parvula*	Dwarf Mongoose		LC	AS
8	Mammal	Artiodactyla	Bovidae	*Tragelaphus spekii*	Sitatunga	Inzobe	LC	AS
9	Mammal	Carnivore	Felidae	*Panthera pardus #*	Leopard	Ingwe	VU	AL
10	Mammal	Rodent	Nesomyidae	*Cricetomys gambianus*	Gambian rat	Isiha	LC	AL
11	Mammal	Lagomorpha	Leporidae	*Lepus victoriae*	African hare	Urukwavu rw'agasozi	LC	AL

Source: field survey

* IUCN Redlist status| VU = Vulnerable, LC = Least Concern, - = not currently assessed by the IUCN Redlist

** Habitat affinity| AL = anthropic landscape dominated by agriculture and human settlement, AS = aquatic and swamp area

Protected species by the Ministerial Order N°007/2008 of 15/08/2008

4.2.4 Threatened species (IUCN Red List) and Locally-protected species

- ✓ **Plant species**

Only one species – Macadamia (**Macadamia *integrifolia***) is on IUCN Redlist as Vulnerable. This is a commercial fruit tree species introduced back in 1980s. Another species – ***Erythrina abyssinica*** (Umuko) is on the list of protected species in Rwanda (Ministerial Order N°007/2008 of 15/08/2008).

- ✓ **Bird species**

No species recorded during the survey was found on the threatened species Redlist of IUCN. However, one Endangered species – the Grey crowned-crane (***Balearica regulorum***) may be present in the area despite the fact that it was not recorded during the survey as it share same habitat characteristics as the swamp in the project area. Two species are found on the list of protected species in Rwanda. These are the Black-headed heron (***Ardea melanocephala***) and the Hammerkop (***Scopus umbrette***).

- ✓ **Reptiles**

Three (3) species are on the list of protected species in Rwanda. These are: the Nile crocodile (***Crocodylus niloticus***), Black-bellied Hinged Terrapin (***Pelusios subniger***) and Puff Adder viper ***(Bitis arietans)***.

- ✓ **Mammals**

Two (2) species are categorized as Vulnerable on the IUCN Redlist: Hippopotamus (***Hippopotamus amphibius***) and Leopard (***Panthera pardus***). These same are protected by Rwandan law in addition to Sitatunga (***Tragelaphus spekii***).

4.3. Socio economic baseline data

4.3.1. Overview of Rwamagana socio-economic environment

Rwamagana District has a total area of 682 km^2 and the 2012 census gave the total population as 313,461 (51% female and 49.0% male) and a population density of 460/km^2. About 53% are aged 19 years or younger. People aged 65 years and above make up 4%. The majority of the population is young, with about 82% still under 40 years of age. The District is inhabited by 51% female and 49% male. The literacy rate for the population above 15 years in Rwamagana District is 77.7% (EICV4).The average age of the Rwamagana population is between 14 and 35 years (Rwanda Census, 2012). In terms of employment, Rwamagana's employment indicators are dominated by independent farmers. The employment report indicates a heavy reliance on agriculture which employs more than 56.3% of working age population registered as independent farmers, and 7.8% as independent non-farmers (EICV 5 report- 2017).The overall labour force participation rate is 52.2% of the resident population aged 16 years and above, while the unemployment rate is 8.6%[2] (EICV 5 report - August 2017).

Given the close proximity to Kigali city, high rapid industrial development, attractive business environment and the upgraded infrastructures in place, the District provides high potential employment opportunities for its citizens in the next six years (2018-2024). The index shows that the level of extreme poverty is 4.8% compared to 16% at Country level while the poverty incidence rate is 18.9% compared to 38.2% at National level (EIVC 5).

To complement the available data and understand the socio-economic context in the project area, as socio-economic survey was conducted. Data presented in this report are from 99 households located in Rwamagana District in the respective Sectors of the project area and making the sample size of this ESIA study. These data were complemented with data collected during the preparation of Water Supply Master Plan and available data in EICVS 3, 4 and 5. The selection of house hold was done randomly from different household located in the sectors of Rwamagana as shown in the table below:

Table 18:: Number of household covered by socio-economic survey

District	Sector	Number of HH	Number of sampled HH
Rwamagana	Karenge	5,268	29
	Nyakarilo	4,841	20
	Muyumbu	6,058	30
	Gahengeri	5,575	20

Source: Socio-economic survey, 2021

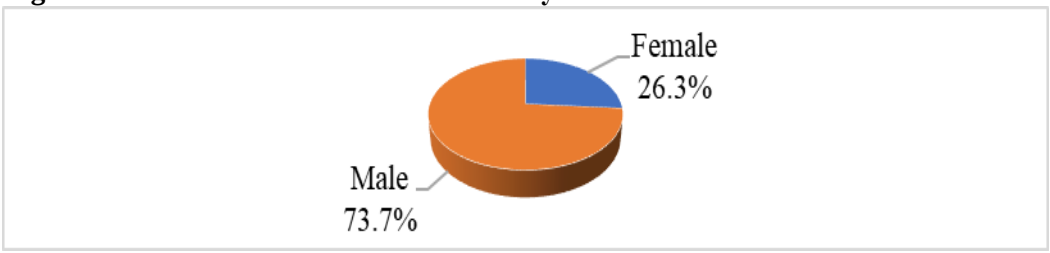
[2] Rwanda Labor Force Survey, 2017, unemployment rate based on the new ILO definition

4.3.2. Profile of households

- ✓ **Sex ration**

To make more participative for both sexes the interview was conducted on both sexes female and male of the study area. The sex ration of the interviewed population is presented in the next fugure table below:

Figure 18: Share of household's head by sex



Source: Socio-economic survey, 2021

As seen from figure above, from 99 sampled households 73.7% of households were males and 26.3% of were females. The figure above (figure 18) shows that the conduct of this ESIA study was participative for both men and women. Therefore the outcomes of the social economic analysis show that both women and men were consultant and that the projects impacts being positive or negative will be beneficial or harmful to both women and men.

- ✓ **Age of heads of households**

Table 19: Age of heads of households

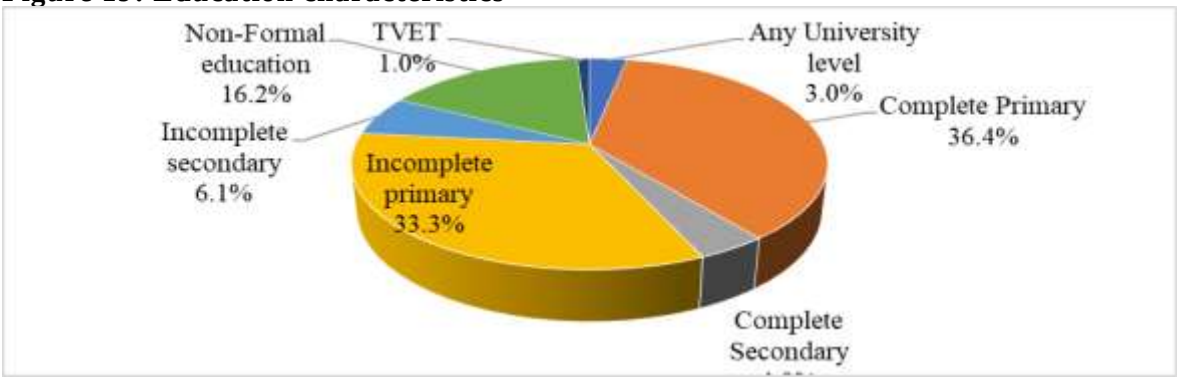
Ages (Head of HH) (Unit: Years)	Frequency	Percent
23-33	18	18.2
34-44	35	35.4
45-55	21	21.2
56-66	19	19.2
67+	6	6.1
Total	**99**	**100**

Source: Socio-economic survey, 2021

Table 22 above shows that the average age of heads of households is around 45 years. This shows that the study area is almost young as most of the households are headed by young generation as shown in the table.

- ✓ **Education level**

Figure 19: Education characteristics



Source: Socio-economic survey, 2021

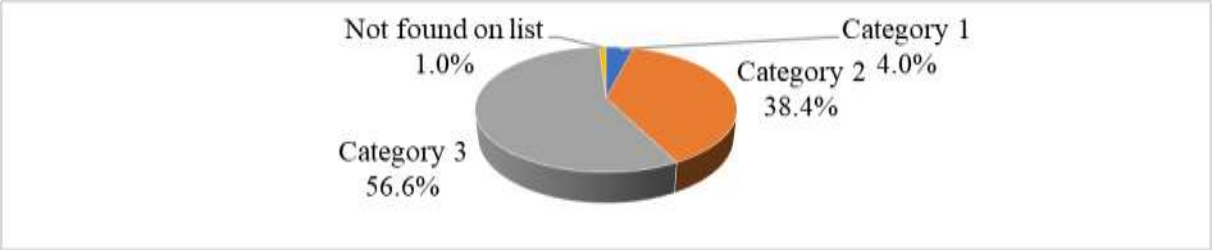
The above future shows that, from 99 sampled households, 36.4% have completed primary education, 33.3% did not complete primary education, 16.2% did not attended any formal education, 6.1% did not completed secondary education (but attended), 4% were completed secondary education, 3% have any university level and 1% have graduated from TVET.

- ✓ **Poverty level**

As stated in EICV5 report, with the new ubudehe categorization framework created in 2014, households are ranked on a scale of 1 to 4, based on their social-economic status, and property ownership in terms of land and other belongings, and what the household members do to earn a living. For the ubudehe categories relevant for

VUP participation, 25% of households in ubudehe category 1 and 18% of households in ubudehe category 2 are in the lowest quintile (EICV5, 2016/2017).

Figure 20: Households by ubudehe categories



Source: Socio-economic survey, 2021

From the figure above (Figure 16), it is noted that from the sampled households in the study area, 56.6% are classified in the 3rd category of socio-economic development, 38.4% were in 2nd category, 4% in 1st category and 1% were not found on list of ubudehe socio-economic categories.

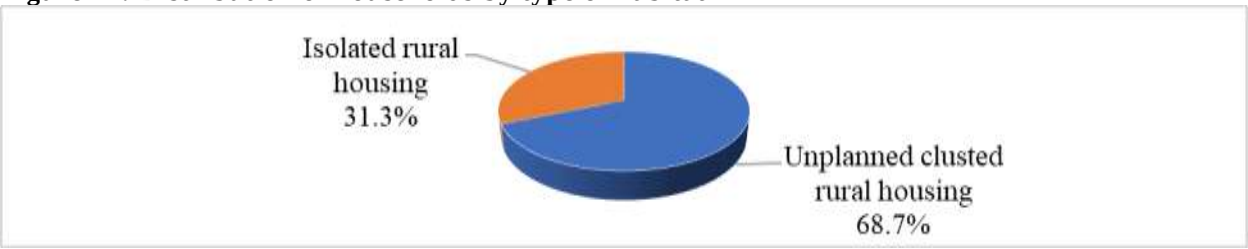
Categorization plays an important role in planning given that some services and subsidies are provided based on ubudehe category. EICV5 shows that household in Ubudehe category 1, 14.1% are direct support beneficiaries; about 10% are beneficiaries of Public works and 0.4% is beneficiaries of financial services. Currently household in category 1 of Ubudehe are used to receive support from government or different partners for improving their living conditions.

The assessment of the level of category stands to provide the extent of impact that the project can have mostly on the category one classified as most vulnerable people. Considering that most of the households are within category 2 and 3, this implies that the project will affect less or no individuals of category 1 of Ubudehe classification.

4.3.3. Housing characteristics

Housing characteristics are based on type of habitat, type of dwelling, number of households sharing the dwelling, main construction materials of exterior wall, main materials used for roofing, main materials used for the floors of the dwelling, estimated value of the house, rent costs, renting period and renting time etc.

Figure 21: Distribution of households by type of habitat



Source: Primary data, 2021

The above figure shows that, from 99 sampled households in the project area, 68.7% are living in unplanned clustered rural housing and 31.3% in isolated rural housing.

Table 20: Distribution of households by type of dwelling

Type of dwelling	Frequency	Percent
Single house occupied by one household dwelling	82	82.8
A house occupied by multiple households	17	17.2
Total	**99**	**100.0**

Source: Primary data, 2021

Table above table indicates that 82.8% of households stays in single house occupied by one household and 17.2% are with a house occupied by multiple households.

The analysis of the type of habitat in the study area will determine the level of impacts that the project can have in terms of water supply facilities, time spend to clean water availability as well as the related cost implication to water infrastructure distribution.

The analysis of main construction materials is done to assess whether the project implementation will have any impacts to the existing current situation in terms of availability and types of building materials such as sand, cements, burnt bricks, stones and gravels etc. The results of the survey are presented in the table below:

Table 21: Distribution of households by main construction material of household

Main construction material of household exterior wall	Frequency	Percent
Mud bricks	28	28.3
Mud bricks with cement (stucco)	49	49.5
Oven fired bricks	3	3.0
Tree trunks with mud	13	13.1
Tree trunks with mud and cement	6	6.1
Total	**99**	**100.0**

Source: Primary data, 2021

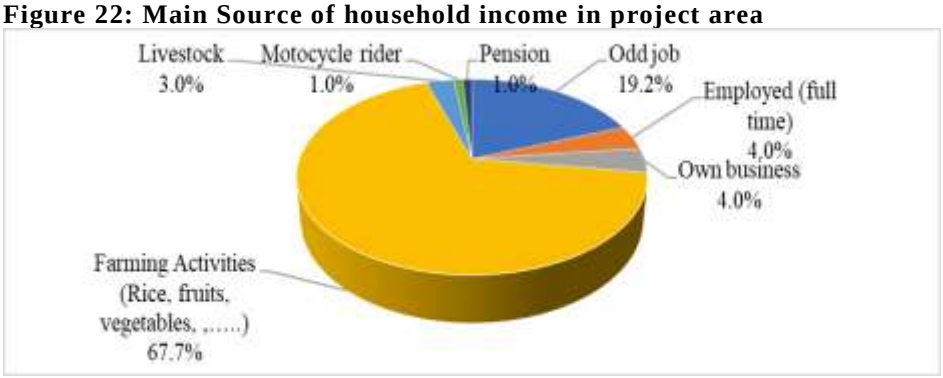
4.3.4. Source of income and occupation

- **Source of income**

The overall District of Rwamagana is characterized by business related activities in some parts of Rwamagana town and in other rural trading centres. Agriculture and live stock is the principal economic activity that employees over 80% of the population in rural areas of whom, at least 85% use traditional agriculture practices. The major crops of the district include bananas, rice, maize, pineapple and coffee. The District is also rich in Minerals (Cassitérite, Colombo tantalite and Wolfram) especially in parts of the sectors of Musha, Mwulire and Gahengeri which is exploited by mining companies.

The Socio-economic survey results show that most of the population of the project area of intervention depend on the agriculture activities 67.7 % followed by 20.2% odd job, 9.0% employed full time, 5.1% own business, 4.2% other activities,3.0% livestock, 1.0% employed part time. The figure below illustrates the income generating activities in the project area:

Figure 22: Main Source of household income in project area



Source: Socio-economic survey, 2021

It is seen that 67.7% consider farming activities (Rice, fruits, vegetables, …) as main income source, 19.2% depend on odd jobs, 4% own business, 4% employed (full time), 3% livestock, 1% motorcycle rider and 1% consider pension as main income source.

The implementation of the project will no doubt contribute to income generation through creation of employment for local population that shall be employed by the project.

- **Monthly income**

Table 22: Distribution of households by total average household monthly income (in Frw)

Average total household Income/ Month (in Frw)	Frequency	Percent
800-3,000	2	2.0
3,001-10,000	3	3.0
10,001-50,000	43	43.4
50,001-100,00	27	27.3
100,001-200,000	20	20.2
200,001-300,000	2	2.0
Not Attended	1	1.0
Total	**99**	**100.0**

Source: Socio-economic survey, 2021

- **Monthly expenses**

Table 23: Distribution of households by average household monthly expenses

Average household monthly Expense (in Frw)	Frequency	Percent
500-5,000	7	7
5,001-20,000	33	33
20,001-80,000	57	58
120,000	1	1
Not Attended	1	1
Total	**99**	**100**

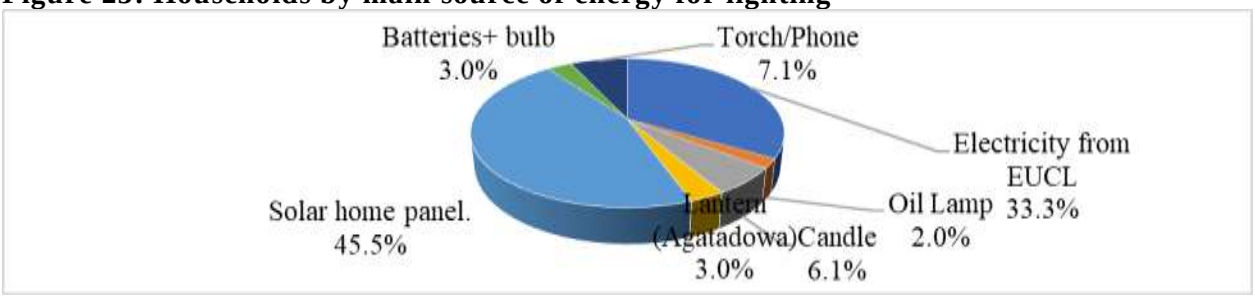
Source: Socio-economic survey,2021

Results of survey show that the average monthly expenses in surveyed households is 31,730 Rwfs per month per household, which makes 380,760 Frw per year. From all these households 41. 5% has consumption capacity ranged between 0-20,000 Rwfs per month per household, 38.3% in range of 20,000-50,000 Rwfs, 15.2% in range of 50,000-80,000 Rwfs, 2.0% in range between 80,000-120,000 Rwfs ,1.00% in range between 120000-160000Rwf and 2% has consumption equal or greater 160,000 Rwfs per month per household. For the households headed by males, average household consumption is 34,479 Rwfs per month compared to the households headed by females 24.011Rwf

4.3.5. Energy and water supply

- **Main source of energy for lighting**

Figure 23: Households by main source of energy for lighting



Source: Socio-economic survey,2021

The above figure shows that from 99 sampled households in Rwamagana District 45.5% are using solar panels as main source of energy for home lighting, 33.3% are using electricity from EUCL (Energy Utility Corporation Ltd), 7.1% are using torch/telephone, 6.1% are using candle, 3% are using batteries + bulb, 3% using lantern (Agatadowa) and 2% using oil lamp.

- **Main source of energy for cooking**

The table below (table 30) shows the results of the survey in the study area in terms of availability of main source of energy for cooking. It was revealed that in the project area , the main source of energy for cooking is firewood representing 75.8% as primary source for cooking followed by the use of charcoal representing 24.2%.

Table 24: Distribution of households by primary source of energy for cooking

Primary source of energy for cooking	Frequency	Percent
Firewood	75	75.8
Charcoal.	24	24.2
Total	**99**	**100.0**

Source: Primary data, 2021

- **Water availability**

In terms of access to clean water,56% of Households have access to clean water while 88.3% of HHs in Rwamagana use improved drinking water sources mainly from public standpipe (28.8%), protected spring (48.8%). Unimproved or other drinking water sources are at small percentages like 0.0 % still using unprotected well, 0.4% using unprotected spring and 7.6% using surface water. Additionally, travelling time to improved water source is on average at 12.2 minutes.

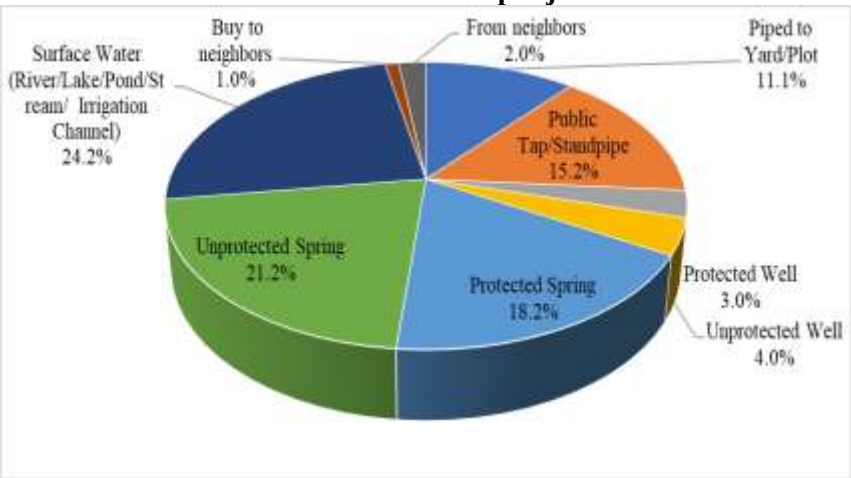
Despite the efforts made countrywide to increase the access clan water resources and reduce time spent to reach main water source, some of the challenges need to be to be addressed and are noted in the project area including:

- Insufficient infrastructures allowing access to clean water supply especially for those living in remote area of the Karenge WTP such as Gahengeri area.

- Water tariffs that are high
- Poor management of rural water supply schemes that are already in place.
- Poor maintenance and perfect management of existing infrastructures;
- Inadequate storm water management to supplement other sources of water

The results of the survey are presented in the following figure

Figure 24: Main source of water for domestic use in project area



Source: Socio-economic survey,2021

Figure 28 shows that from 99 sampled households in the study area, 24.2% use surface water (River/Lake/Pond/Stream/ Irrigation Channel) for domestic uses. This is an indicator that this water directly used without any pre-treatment for household uses. The implementation of the project would therefore increases the number of households with access to clean water in the project area.

- **Distance travelled to water source**

Table 25: Distance from domestic water source and household

Distance in Meters	Frequency	Percent
0-10	11	11.1
11-30	4	4.0
31-60	3	3.0
61-120	6	6.1
121-300	10	10.1
301-1,500	43	43.4
1,501-10,000	22	22.2
Total	**99**	**100.0**

Table 31 shows that 43.4% households in the project area travel the distance ranged between 301 m to 1,500 m from household to domestic water source. The better the distance travelled to water sources is reduced the better the impacts associated to water shortage are minimized. In Rural area the recommended distance is 500m

- **Water consumption**

Table 26: Distribution of households by number of daily waters consumed[3]

Number of jerrican (each with 20 ls)	Frequency	Percent	Valid Percent
1	5	5.1	5.1
2	33	33.3	33.3
3	29	29.3	29.3
4	12	12.1	12.1
5	11	11.1	11.1
6	4	4.0	4.0
7	1	1.0	1.0
8	3	3.0	3.0
10	1	1.0	1.0
Total	**99**	**100.0**	**100.0**

Source: Socio-economic survey, 2021

[3] [3] (number of jerrican per day, 20 liters per jerrican)

It is noted that from the results of the survey 33.3% use 2 jerricans of water for domestic activities, 29.3% use 3 jerrican per day, 12.1% use 4 jerrican per day, 11.1% use 5 jerrican per day, 5.1% use 1 jerrican per day, 4% use 6 jerrican per day, 3% use 8 jerrican per day, 1% use 7 jerrican per day and 1% use 10 jerrican per day

Table 27: Willingness to connect to the nearest public water supply pipe

Willingness to connect to nearest water	Frequency	Percent	Valid Percent
Yes	76	76.8	91.6
No	7	7.1	8.4
Sub-Total	**83**	**83.8**	**100.0**
Not concerned	17	17.2	
Total	**99**	**100.0**	

Source: Socio-economic survey, 2021

Most of the households of the project area (76.8% households) are willing to connect to nearest public water supply system (located in less than 300 meters). The project will therefore increase the number of local households connected to the public water supply system as those not connected either lack the system within their vicinities or the system is not reliable to due to inadequacy in water supply system of the area (old pipes, inadequacy in water availability etc).

4.3.6. Sanitation

In terms of sanitation, the percentage of households with access to improved sanitation is 92.3 %(ECIV 5 report for 2017). The sanitation status herewith presented describes the existing situation in the project area.

Table 28: Distribution of households by type of toilette facility

Type of toilette used by the household	Frequency	Percent
Pit Latrine with constructed floor slab	88	88.9
Pit latrine without slab	11	11.1
Total	**99**	**100.0**

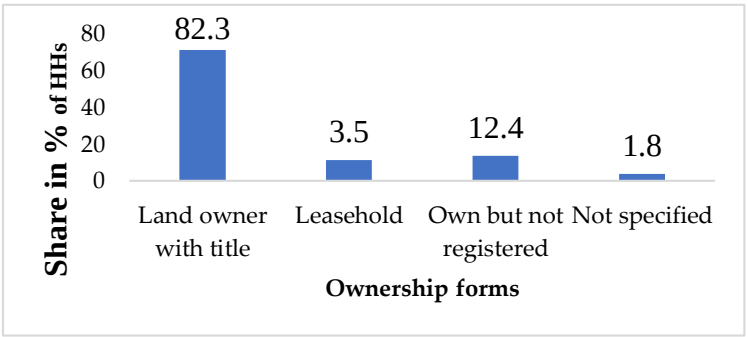
Source: Socio-economic survey, 2021

Survey results indicates 35.4% of households are using pit latrines accumulating wastewater from domestic use and 64.6% have no canal created for domestic wastewater management.

4.3.7. Land ownership in the project area

In Rwanda all plots have been registered and given a Unique Personnel Identification (UPI) that shows the land owner. In some instance the land owner may lease his land to someone else for a given period. There also people who are using the government land especially in marshlands. The collected information during the study survey show that more than 82 % own land in the study area. Therefore it is no doubt that similar findings shall be applied during the compensation exercise of damaged properties and assets.

Figure 25: **Land ownership status**



Source: Socio-economic survey, 2021

It is then considered that the project will no doubt affect private land owned and therefore fair compensation should be done before project activities.

CHAPTER V: PROJECT NEED AND ALTERNATIVES

5.1 Justification and overview

The purpose of the analysis of alternatives during the conduct of this ESIA study is to select the best among all possible project options. During the analysis of project alternatives, different options were examined and discussed with the aim of designing the proposed project and identify other alternatives, which would achieve the same objective with maximum efforts to minimize and avoid project socio and environmental adverse impacts .The analysis of alternatives was then conducted in a bid to privilege positive impacts of the project implementations.

The "no project" alternative was also assessed to demonstrate environmental and social conditions without the project implementation. Other alternatives consideration includes the projects sites, design, construction techniques, phasing and schedule, operating and maintenance procedures. Alternatives were compared in terms of potential environmental and social impacts; suitability under local conditions; and institutional, and monitoring requirements.

5.2 No- Project alternative

The project of Rehabilitation and expansion of Karenge WTP is aiming at access to clean water, improving the health, and hygiene standards with provision of improved water supply services. The implementation of the present project will deliver sufficient clean water with new infrastructures and facilities and will as well help the country to meet key national targets and ambitions of supply reliable, efficient and effective clean water to the local population. The project is expected to reverse the status quo of lack of clean water in both Rwamagana and Kigali city and will improve the living conditions of supplied population. ;

In the case of no project option, this means that Rehabilitation and expansion of Karenge WTP is not undertaken. Therefore this will necessitate leaving the population of Rwamagana District and the supplied area of Kigali in the present situation and this option is not desirable considering the increasing need of water supply associated to population growth and country development. Besides, there are many significant and specific benefits that would not be accrued if the proposed development is not to be implemented. It is expected that the implementation of the project will add more than 18.000 m^3/d to the daily water supplied by existing Karenge WTP besides being old and needs rehabilitation.

5.2.1 Benefits of the No-Project Option

The benefits of the No-Project Option are described below:

- The existing water balance of Lake Mugesera will be maintained considering its inflows and out flows.
- The impacts related to water abstraction from the lake would not exist.
- The relocation of 5 houses identified and located within the new Water Treatment Plant site and as other associated impacts would not exist.
- The compensation cost related to the project implementation would not occur.
- Possible water contamination associated to human activities within the project area nearby project sites and Mugesera Lake would not exist.
- The loss of land and shelter to the water intake and water treatment plant, water storage reservoirs and water pipelines as well as to other project's infrastructures location would not exist.
- Short term impacts caused by construction activities e.g. noise, dust generation, vibrations, etc, would not exist.
- Temporary inconvenience caused by construction activities e.g. temporary road closure for pipeline crossings, would not exist.
- Possible loss of vegetation associated to the project activities would not exist.
- Possible work accident and other socio impacts connected to the project implementation would not occur.

5.2.2 Negative Effects of the No-Project Option

The negative effects of the No-Project Option are:

- The growing population of Rwamagana District and Kigali City will continue to suffer from acute water shortages caused by inadequate existing water supply system and infrastructures and a large percentage of the population would continue having no access to safe drinking water.
- The current poor operating condition of Karenge WTP would remain and aggravated.
- The flooding issues accounted during rain seasons at the intake would be aggravated since no rehabilitation would be undertaken.

- The location of the intake within the buffer zone of the lake would remain and this is against the existing laws and regulation related to the water resources management and environmental protection.
- The ambitious and target set by Rwanda to have access to clean water to all population will not be achieved within the fixed period.
- Occurrence of diseases caused by consumption of untreated drinking water would continue to be high in the area of project intervention as described in details in the next chapters.
- Employment opportunities connected to the Project implementation would not be available.
- Economic development of the area expected as a result of the Project would also be absent.

For the above reasons the consultant could not recommend No-Option alternative. Instead, the consultant is recommending the implementation of the proposed project with appropriate mitigation measures.

5.3 Sites alternatives

5.3.1 Alternatives for Intake site

The existing location for the intake is located in the Buffer zone of Mugesera lake (with 50 m from lake banks) as contrary to the Ministerial Order N° 007/16.01 of 15/07/2010 determining the length of land on shores of lakes and rivers transferred to public property. The existing intake location is also experienced heavy floods especially during rainy season from April to June of each year. This causes the damaged of some infrastructures as it was seen that some of the pipes have been removed from the Lake due to the flooding that occurred in previous periods. These floods are sometimes causing the cut of operational procedures of the plant and hence affect the daily production of the plant which in return affects the amount of clean water supplied by the Plant.

The best alternative recommended by the consultant and related to the location of the new intake is to relocate the new intake in area far from the buffer zone of lake Muhazi in order to comply with the laws and regulations in place. This site location is also recommended to be at an elevated altitude compared to the existing one where the probabilities of flooding are less based on the current topographical conditions of the intake site.

5.3.2 Alternatives for the WTP and intake

The selected new site for water treatment plant and water supply pipelines and storage areas have been assessed and found to be the most suitable and most reliable for the project. These sites selections were done based on the project topography and environmental concern. The water pipelines were chosen based on the topography and existing settlements patterns and futures plans of the District (settlement sites, residential areas, etc) Other criteria were also taken into consideration during the sites selection and among them include:

Easy access. The sites to be used by the project are composed of water treatment plant, transmission pipes, and water storage facilities. All sites identified are easily accessible and were selected based on the technical requirements in water supply mechanisms and were done to facilitate construction activities including easy accessibility of construction materials and with maximum efforts to avoid environmental pollution and degradation such as creation of new access roads.

Environmental considerations: the selected site for new water treatment plant is located adjacent to the existing Karenge WTP and this was done to avoid scattered infrastructure in the project area The poor distribution of water infrastructure location would cause several environmental issues via access and material transportation. It is important to note that this was done is in compliance with the Ministerial order prevents any activity that may have environment impact in 10 m from the river and 50m from lakes.

Land acquisition and Resettlement:

- **Water Treatment Plant area:**

Major land acquisition will occur at water treatment Plant and at water intake. For pipeline, only easement will be required. In terms of land acquisitions, there was three options:

- Acquire all the land around the WTP and use it for planned and future development
- Acquire all the land needed for phase 1&2 or
- Acquire the land needed for Phase one and acquire the land for phase two later

Initial land demarcation

Figure 26: Alternative land requirement analysis

Source: Feasibility study

Figure 27: Potential impacts of each option in terms of resettlements

Alternative	Physical resettlement	Land acquisition
Initial land demarcation(Red)	15	54
Revised demarcation for phase 1&2(Yellow)	7	28
Land for Phase 1 only (in white)	1	12

- **Water intake**

For intake, there was two option, rehabilitate and expend the intake in the current location. This option is not viable especially given that the area is frequently affected by floods and this situation affect Plant operations. Therefore, it is recommended to relocate the intake outside the flooded area.

Figure 28: Alternatives of water intake location

Source: Feasibility study

- **Pipelines**

For pipeline, there was two options: (i) having new pipeline routes and (ii) having pipeline at the same location as existing one. The second one presents more advantages including minimum impacts on properties as it follows existing roads.

5.4. Conclusion on alternative analysis

The residents of Kigali and Rwamagana district are in need of sustainable and improved clean Water Supply System considering need and increasing clean water demand in the project area. The existing Water Supply system is being deteriorated and sometimes operating below their design capacities despite the efforts being made the country to meet the requirements. Karenge water treatment plant is old and operating beyond its design capacity and considering the new settlements sites that have been developed and increasing the water demand in both Rwamagana and Kigali. ***For these reasons, no project is rejected, as it would maintain the population in poor conditions in terms in terms of water supply and sanitation.***

The alternative that considers relocation of intake, two phases with land acquisition in different period as well as the alignment of pipelines with existing one and along existing roads remain the best option. Though, this option still have some environmental and social impacts on receiving environment and local community. These impacts can be minimised and compensated by implementing appropriate mitigation measures. The EIA team recommends the following.

- Land acquisition should be done in phases starting with phase one and phase two coming when constructions works are about to start,
- The environmental management Plan will be implemented together with construction activities;
- Before construction, land assets valuation should be conducted and compensation provided any land take

CHAPTER VI: PUBLIC CONSULTATION AND STAKEHOLDERS ENGAGEMENT

6.1. Overview

Public consultation and stakeholder engagement is the basis for building strong, constructive, and responsive relationships that are essential for the successful management of a project's environmental and social impacts. Members of the public and stakeholders are supposed to participate and get involved in decision making concerning development projects because they affect them. The role of public consultation and involvement in EIA process is to assure the quality, comprehensiveness and effectiveness of the assessment and ensure that the public views are adequately taken into consideration in decision making process. Stakeholder engagement is an on-going process that involves the following elements; stakeholder analysis and planning, disclosure and dissemination of information, consultation and participation, grievance mechanism and on-going reporting to affected communities.

In our case consultations were held at the project sites with local community, PAPs and local authorities and were as well held at key stakeholders' offices. However, due to restrictions imposed by COVID-19, public gathering were not allowed. Site visits to the project sites, visits to the institutional offices and interview phone calls were the major consultation approaches that were used. This were as well managed while respecting the measures to avoid the spread of covi-19 including social distancing, proper hand washing and use of hand sanitizer and proper wearing of protective musk.

6.2. Purpose

The purposes of conducting the consultation were:

- To inform local community the project implementation and prepare them on potential impacts that could be caused by the project and can affect them.
- To build a trusting relationship with the affected communities and other stakeholders based on a transparent and timely supply of information and open dialogue.
- To ensure effective engagement with local communities and key stakeholders throughout all phases of the project.
- To actively build and maintain productive working relationships, based on principles of transparency, accountability, accuracy, trust, respect and mutual interests with affected communities and other stakeholders.
  To collected relevant and trustable information that shall be based on to formulate project impacts as well their mitigation measures.

6.3. Public participation – methods and process

Due to restrictions imposed by COVID-19, where by public gathering were not allowed one to one interviews with locals while respecting social distancing and phone calls were only the approaches used during the consultations

6.3.1. Consultation with locals and PAPs

During the project consultations, efforts were made to consult with the decision making officials at local level as well as a number of local communities and Project Affected Persons (PAPs). The level of their opinions, thoughts, suggestions and level of project's impacts were assessed and discussed and the feedbacks were of use during the process of conducting this study. Local communities especially nearby residents of the project areas who will be positively or negatively affected by the project implementation were also consulted to give them the opportunity to express their views and concerns about the project implementation.. As part of the process, they were also provided with relevant and sufficient information on the project prior to its start - up.

6.3.2. Consultation with Stakeholders

In addition to the public consultation meeting, the consultant team conducted one to one interviews with different official to discuss the projects and collect their views, concern and recommendations. Consultation conducted also allowed the team to collect different data and information related to the projects like existing laws, standards and policies helped. Visits to stakeholder's offices were organized and conducted. Where visits to offices were not conducted, a guiding questionnaire was sent via e-mails to the respondents who provided the feedbacks using the same method. Phone calls were also done while collecting data and information from key stakeholders. In addition to that the collection of relevant information was also gained via comments that were provided through the client (at inception level). The process of consultation with key

stakeholders is a continuous process throughout the study. Information and data are always being collected during the study period. Key stakeholders and authorities with whom consultations made at the project study areas were:

Table 29: Category of Consulted People

Category	Institution/consulted person	Issue to discuss
WASAC Ltd	Environmental Specialist	Environmental requirement
	Karenge Water Treatment Manager	Land Requirements Issues related to the existing water treatment Plant Environmental and Social issues connected to the new Karenge Water Treatment Plant.
	Karenge water treatment staff and personnel	Water treatment process and requirements Project impacts on social and environment
Feasibility design team	Design team	Project designs and alternatives
Regulatory and standards authorities	Rwanda Environment Management Authority (REMA)	Environmental and social requirements Project's impacts on lake Mugesera and its catchment
	Ministry of Environment	Environment and water quality requirements
	Rwanda Water Board	Water quality, water abstraction permitting Other planned developments within Mugesera lake and its vicinities
	RURA	Water tariffs and water use regulations
	RSB	Drinking water standards
	Rwanda Land use and Management Authority	Land ownership and Resettlement issues
	Rwanda Development Board	EIA process
Rwamagana District	District environmentalist	Project environmental impacts
	Natural resources	Land and water issues and ownership
Karenge Sector	Land manager	Land registration, valuation and ownership transfer Local construction materials availability
	Executive of Sector	Project need assessment Land issues and ownership Wages and manpower sourcing Water availability
Local Community	Water treatment plant Water intake Routes for water pipelines	Project impacts and appreciation Impact mitigation measures Land valuation and compensation issues Grievance mechanism Wages and salaries

Table 30: Outcome of consultation with stakeholders at central and Local Level

Stakeholder	Summary of discussion	Findings
WASAC Ltd	- Existing Karenge WTP working conditions (operation water quality, availability of water, challenges of the plant etc) - Need of having Karenge WTP rehabilitated and extended - Availability of land for extension - Challenges associated to the new Karenge WTP - Labor and work force - Use of chemical and type - Waste generation and type	- There is a need of extending the plant as the plant is old and currently s working under over its working capacity. The land for expansion would be acquired in the neighbouring of the existing Plan through compensation in public interests. Fair compensation will be made. - The work force is available in the project area and willing to support. New jobs will be created and manpower is available in the project area. - Chemicals are used at the plant such as chlorine for the treatment of raw water. Special attention is made to their handling, storage and use in order to avoid any associated impact as to their misuses. - Different types of waste are generated at the plant either solid or liquid. The plant has developed a way of handling the generated waste without causing the environmental pollution.

RWB	- Impact of project implementation of Lake Mugesera - Other planned projects within the Mugesera catchment - Water permitting issues - Water availability/ quantity and quality in lake Mugesera - Other ongoing projects that require the water from Mugesera Lake - Any development Plan within Mugesera Catchment	- Some impacts were discussed including water pollution, siltation, turbidity etc. The proposed mitigation measures were incorporated in this report. - The water abstraction permit has been guaranteed to WASAC ltd for this project. - It is no doubt that other projects development in the catchment will occur. However considering the available water in Mugesera Lake, further studies would be conducted to determine the impacts of those projects on the Mugesera Lake before their approval. - There no current ongoing project within the project area that requires the water from lake Mugesera.
REMA	- Potential source of pollution within Lake Mugesera - Plans for future uses of lake Mugesera - Impacts of project implementation - Any useful information to be used in the ESIA	- Main potential source of water pollution are human activities. However efforts have been made to avoid those pollution through enforcing the implementation of environmental law, water pollution control measures and regular monitoring - Different impacts of project implementation were discussed and incorporated in this report
Sector and District officials	- Impact of project implementation in the project area - Existing other project requiring the water from lake Muhazi - Water tariffs and availability9 Quality and quantity) - Other lake users - Ecosystem Services of lake Mugesera - land availability for project implementation - Challenges and impacts associated to the new Karenge WTP - Labor and work force - Compensation of affected land and private assets	- The project is of high importance since it will contribute to the development of the district in particular the services areas. - Different irrigation projects are being planned on the Lake, however considering the water availability in the region; these would not affect the project implementation. However further studies would be conducted on each project in order to avoid any conflict among Lake Mugesera water users. - Prior to the project implementation fair compensation should be made to the PAPs. - Different project impacts being positive and negative were discussed and incorporated in this report.

6.3.3. Consultation at community level

Despite the fact of conducting the present study during the covid-19 pandemic, local consultations were held with local community in form of discussion and question-answer method. Where possible, the consultation was held in a group of 3 to 5 people while respecting the preventive measures of fighting the spread of Covid- 19. This method has been taken up as an integral part of social and environmental assessment process of the project. Consultation was used as a tool to inform project affected people, beneficiaries and stakeholders about the proposed activities both before and after the development decisions are made. It assisted in identification of the problems associated with the project as well as the needs of the population likely to be impacted. This participatory process helped in reducing the public resistance to change and enabled the participation of the local people in the decision making process.

Initial Public consultation has been conducted in the project areas with the objectives of minimizing probable adverse impacts of the project and to achieve speedy implementation of the project through bringing in awareness among the community on the benefits of the project. Key findings of the consultation

with local community are presented in the table below:

Table 31: Key outcomes of consultation at community level

No	Question/comments	Answers provided by consultant team
Consultative meeting at both Intake and WTP areas		
1	When will the implementation of the project start?	Considering the project need, it is expected to start as soon as the funds are available. Currently the detailed designs are going on and expected to be completed by June. In case everything goes well including tendering process, the project implementation is expected to kick off by October 2014. Local community will be informed about implementation schedules.
2	How are we going to know the value of our properties?	The valuation will be done to allow fair compensation. As per the existing expropriation, valuations of assets will be done by an independent valuer who will be hired by WASAC lad in collaboration with the District. This will be conducted to allow fair compensation and will be done in accordance with the existing laws.
3	What kind of compensation will you give us?	Fair compensation will be provided. Measures to establish the compensation will be based on eligibility criteria and the nature of impact and the compensation may include land for land compensation or monetary compensation. Especially for crops and trees. Further discussion will be made before project implementation.
4	Sometimes the fees paid as compensation is not enough to buy another land. What are you planning to address this issue?	WASAC ltd together with Rwamagana District and Karenge Sector will hire and independent valuer to provide the replacement cost. For the person who disagrees with the value assigned to his/her properties; appealing measures are provided by the expropriation law in Public interests. Prior to the valuation exercise, the law and procedures of appealing to address issues related to compensation will be available to public and explained to the PAPs.
5	Will the project gives us the jobs or it will use machines?	Some activities will require the use of machines, knowledge and expertise to manipulate them. Other works will be performed by people and affected persons will be given priority. However jobs will not be given and limited to the affected people but more personnel will be recruited to work on and for the project. These include manpower, masonry, guards etc.
6	Will be there suspension of existing Karenge WTP to allow the implementation of the New Project? If yes how are we going to survive?	The Implementation of the present project will be implemented while the existing plant is also operational. There will be no suspension of the existing plant. People will be continued to be supplied by the existing Karenge WTP.
7	Is the exact location of the pipelines determined? If yes where will the pipe pass?	The project is under the design stage. The exact location is not yet determined. However efforts are being made to minimize the damages as the pipe will pass in the buffer zones of the existing roads. Where not possible fair compensation will be made to the affected persons.
8	After the pipelines installation will the land used for the pipelines continue to be used by the land owner?	Yes. The land used for pipelines will continue to be used by the land owner. The pipes will be buried in more than 1m depth which cannot handicap the normal users of that land. However some restriction will be made available and people will be regularly sensitized to protect the installed infrastructure. The other land for reservoirs will be taken permanently and fair compensation will be done before project implementation. .
9	Will be there new connections to the water network as a result of project implementation?	For sure. As the project stands to increase the accessibility to clean water new connections will be made even in remote areas of the project to increase water availability.
10	Will be possible to compensate those who till now don't have the land title for their land subject to be affected by the project?	Normally as per the land law, everyone who has land must get a land title. It is better to start the process of getting land titles in order to get compensated in case your land will be affected by the project
11	What will happen for income loss during project implementation for example those having MTN and Tigo kiosks on the buffer zones of the roads where pipelines will pass?	Those willing to work with the project will be given priority during recruitment process. However they can also manage for temporary relocation of those kiosks and reinstall them at their initial places after project implementation.

CHAPTER VII: IMPACTS PREDICTION, ANALYSIS AND MITIGATION MEASURES

The implementation of the project of rehabilitation and expansion of Karenge Water Treatment Plant will have both positive and negative impacts. The environmental impact refers to the changes of existing conditions of any area or environment caused by human activities or any internal or external influence, which may be positive or negative. Project activities that are likely to cause impacts include levelling, soil excavation, site clearing, vegetation cutting, water abstraction and treatment, construction of water pipelines and water storage, water treatments and associated operations.

7.1. Identification and evaluation of potential impacts

7.1.1. Impact identification

In order to identify the potential impacts of the present project, impact matrix was designed and used for the assessment of impacts associated with almost any type of development project. Its main strength is a checklist that incorporates qualitative information on cause-and-effect relationships.

Table 32: Risks/Impacts Matrix associated with rehabilitation and expansion of Karenge WTP

Environmental components			**Physical(Land-Water-Air)**								**Biological**				**Socio-economic**									
			Geology	Soil		Water			Air	Visual	Flora		Fauna		Resettlement						Quality of life			
Project activities			**Geological formation**	**Soil pollution**	**Soil erosion**	**Water Pollution**	**Runoff and infiltration**	**Underground water pollution**	**Air quality**	**Visual impacts**	**Loss of Flora species**	**Flora Succession**	**Loss of Fauna species**	**Disturbance of Fauna Habitat**	**Loss houses and Structure**	**Loss of Crops**	**Loss of private land**	**Loss of public land**	**Loss of income**	**Infrastructure and public utilities**	**Occupational health and safety**	**Employment**	**Skills transfer**	**Injuries and work accident**	**Noise and vibration**
Project Phase	#	Main Activity																						
Design and Planning	1	Preliminary Survey and detailed design of project components													γ	γ				γ	γ	γ	γ	γ	
Construction	2	Excavation and Installation intake pipes	γ	γ	γ	γ	γ	γ	γ		γ		γ	γ		γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
	3	Installation of Intake pumps	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ		γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
	4	Excavation and installation of raw water transmission pipes	γ	γ	γ	γ	γ	γ	γ		γ	γ	γ	γ		γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
	5	Construction of receiving raw water basins	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ		γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
	6	Construction of Coagulation-Flocculation and sedimentation basins	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ		γ	γ	γ	γ	γ	γ	γ
	7	Construction of water reservoirs	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ		γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
	8	Excavation and construction of water transmission pipes	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
	9	Construction of administrative building	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ		γ	γ	γ	γ	γ	γ	γ
	10	Construction of sludge drying beds	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ		γ	γ		γ	γ	γ	γ	γ	γ	γ
	11	Excavation and transport of construction materials			γ				γ											γ	γ	γ	γ	γ	γ
	12	Transportation of other project materials and personnel			γ				γ											γ	γ	γ	γ	γ	γ

Environmental components			Physical(Land-Water-Air)								Biological				Socio-economic										
			Geology	Soil		Water			Air	Visual	Flora		Fauna		Resettlement						Quality of life				
Project activities			**Geological formation**	**Soil pollution**	**Soil erosion**	**Water Pollution**	**Runoff and infiltration**	**Underground water pollution**	**Air quality**	**Visual impacts**	**Loss of Flora species**	**Flora Succession**	**Loss of Fauna species**	**Disturbance of Fauna Habitat**	**Loss houses and Structure**	**Loss of Crops**	**Loss of private land**	**Loss of public land**	**Loss of income**	**Infrastructure and public utilities**	**Occupational health and safety**	**Employment**	**Skills transfer**	**Injuries and work accident**	**Noise and vibration**
Operation phase	13	Raw water treatment process		γ		γ		γ														γ	γ		
	14	Sludge wash out		γ	γ	γ	γ																		
	15	Operation and maintenance works		γ		γ	γ			γ			γ			γ			γ		γ	γ	γ	γ	
Decommissioning	16	Site closure	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ		γ			γ		γ	γ	γ	γ	γ
	17	Decommissioning	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ		γ			γ		γ	γ	γ	γ	γ

γ = **potential Risk/negative/positive impacts**

7.1.2. Impact analysis

Impact analysis was done through conducting risk assessment, risk evaluation and risk management (relating directly to applicable mitigation measures to be implemented. the findings are presented in the impact analysis matrix is below

Table 33: Impact analysis matrix of the project

Nature or Status of the Impact: The type of effect the activity would have on the environment	
Status	Description
Positive:	a benefit to the holistic environment
Negative:	a cost to the holistic environment
Neutral:	no cost or benefit
Duration of the Impact: The lifetime of the impact	
Score	Duration	Description
1	Short term	Less than 2 years
2	Short to medium term	2 – 5 years
3	Medium term	6 – 25 years
4	Long term	26 – 45 years
5	Permanent	46 years or more
Extent or Scale of the Impact: The distance from source that impacts may be experienced	
Score	Extent	Description
1	Site specific	Within the site boundary
2	Local	Affects immediate surrounding areas
3	Regional	Extends substantially beyond the site boundary
4	National	Affects country
5	International	Across international borders.
Reversibility of the Impact: To what degree its influence on the relevant environment can be negative.	
Score	Reversibility	Description
1	Completely reversible	Reverses with minimal rehabilitation & negligible residual affects
3	Reversible	Requires mitigation and rehabilitation to ensure reversibility
5	Irreversible	Cannot be rehabilitated completely/rehabilitation is not viable
Intensity or Magnitude of the Impact: Severity of the negative and magnitude of positive impacts	
Score	Severe/beneficial effect	Description
1	Low	Little effect - negligible disturbance/benefit
2	Low to moderate	Effects observable - environmental impacts reversible with time
3	Moderate	Effects observable - impacts reversible with rehabilitation

4	Moderate to high	Extensive effects - irreversible alteration to the environment
5	High	Extensive permanent effects with irreversible alteration

The Probability of the Impact: Describes the likelihood of the impact actually occurring		
Score	Rating	Description
1	Unlikely	Less than 15% sure of an impact occurring
2	Possible	Between 15% and 40% sure of an impact occurring
3	Probable	Between 40% and 60% sure that the impact will occur
4	Highly Probable	Between 60% and 85% sure that the impact will occur
5	Definite	Over 85% sure that the impact will occur
The Consequence (C)		= Magnitude/Intensity (M/I) + Extent (E) + Duration (D) + Reversibility (R).
The Significance (S)		= Consequence (C) x Probability (P)

After assessment of an impact in accordance to the criteria described above, the significance of an impact can be determined. The various ratings as indicated above are accorded to these criteria. These ratings are then used to calculate a significance (S) rating and are formulated by adding the sum of ratings given to the extent (E), duration (D), Reversibility (R) and intensity (I) and then multiplying the sum with the probability (P) of an impact as follows:

Significance (S) = (E+D+R+I) X P

The significance rating is described as follows:

Score out of 100	Significance
1 to 20	Low
21 to 39	Moderate to Low
40 to 60	Moderate
61 to 79	Moderate to high
80 to 100	High

The following table summarizes the evaluation of impacts associated with the proposed project of rehabilitation and extension of Karenge Water treatment Plant and shows identified impacts and their significance during different project phases.

Table 34: Summary of impacts Evaluation

		Positive/ Negative/ Neutral Impact	Magnitude (M/I)	Extent (E)	Duration (D)	Reversibility (R)	Probability (P)	Significance (S)	Mitigation
Project Phases	Main Activity								
Design and Planning	Job Creation		3	1	1	1	3	18	No
	Risk of accidents and diseases contamination		2	1	1	1	2	10	Yes
Construction phase	Job Creation		5	3	3	1	5	60	No
	Loss of land and other structures		5	2	5	5	5	85	Yes
	Loss of houses		3	1	5	5	2	28	Yes
	Loss of income		1	1	2	3	1	7	Yes
	Loss of crops		4	1	4	5	3	42	Yes
	Soil erosion		3	1	2	3	2	18	Yes
	Surface and ground water pollution		1	2	1	5	2	18	Yes
	Dust emission and air pollution		3	1	1	3	2	16	Yes
	Noise pollution		3	2	1	5	2	22	Yes
	Loss of fauna and flora		4	3	3	5	3	45	Yes
	Possible disease contamination between workers		4	1	2	3	3	30	Yes
	Solid waste generation		3	1	3	1	4	32	Yes
	Gender based violence and sexual harassment		2	3	1	5	2	22	Yes

		Positive/ Negative/ Neutral Impact	Magnitude (M/I)	Extent (E)	Duration (D)	Reversibility (R)	Probability (P)	Significance (S)	Mitigation
	Vandalism		2	2	1	5	2	20	Yes
Operation phase	Lake water pollution		4	4	3	5	4	64	Yes
	Generation of sludge		4	2	4	5	5	75	Yes
	Work accidents		2	1	1	3	2	14	Yes
	Possible conflicts with local community		2	2	3	1	3	24	Yes
	Generation of solid wastes		3	1	4	3	3	33	Yes
	Income generation		4	3	3	3	4	52	No
	Job creation		4	3	3	3	3	39	No
	Vandalism		2	1	1	3	2	14	Yes
Decommissioning	Soil contamination		3	2	3	5	3	39	Yes
	Water and air pollution		2	2	1	3	3	24	Yes
	Job Creation		1	3	1	1	2	12	No
	Site restoration and improvement		4	1	4	1	4	40	No
	Water supply availability		5	4	5	5	5	95	No

7.2. Positive Impacts of the project implementation

Different potential positive impacts were identified to be caused by the project implementation and based on the methodology described above; they are discussed in the following paragraphs.

7.2.1. Positive Impact during of the Planning and Design phases

Following the scoping exercise it is noted that there will be no considerable environmental impacts in the preliminary planning and design phases of the project. Among positive impacts of the project during the designing phase include

i. Employment opportunities

During the planning and design period, new jobs will be created in the form of skilled and unskilled labor in the local community to conduct topographical surveys and work force. A majority of unskilled labour will be sourced from the local residents. Indirect employment will be in the form of suppliers and other forms of sub-contracted works that will be required for planning and design of project components.

ii. Skills transfer

In the process of planning and design, the local technical work force will work with the experts in the domain. This process of working together will transfer design and planning tools and other useful guidelines, which are used in similar topographical conditions countrywide.

iii. Increased savings for the local employees

The increase of the project's local work force and employee's revenue will lead to the possibility of savings in local banks and micro-finances.

iv. Gender balance enhancement

It is expected that during the project implementation women will equally benefit as men in terms of employment benefits. In Rwandan culture, it is the responsibility of a woman to collect water and during water shortages, women and girls use most of their time for water. Therefore, the proposed project will be highly beneficial to women and girls.

7.2.2. Positive Impact during Construction phase of the project

i. Employment opportunities

During the construction phase of the present project different people with different skill will be employed and among them including local population within and in the surroundings of the project area. Other people may include experts form different field of water treatment plant constructions. This ensures that they will

economically benefit from the project and as expected, the project will provide up to more than 200 employment opportunities over its entire lifetime. The use of local labourers and skilled workers will improve the skill resource base in Rwanda through the implementation of training and development programmes. These are both positive outcomes of the project and for the local population.

i. Knowledge transfer

Technical and planning skills will also be gained by the Rwandese people that will be employed by the project and this is likely to contribute to the capacity building. Among them include local civil engineers who will be working with other civil experts with different expertise. There will be also the knowledge of technology transfer among project employees.

ii. Gender balance enhancement

It is expected that during the project implementation women will also equally benefit as men in terms of employment benefits. This will contribute to the government vision of fighting against gender inequality and ensuring that women are given equal opportunity in terms of employment.

iii. Increase to public revenue and local socio-economy

It expected that all works related to the project will provide a positive increase to the local and national economy in general This will fully contribute to the increase of human socio-economy benefits within and around the project area. The implementation of the project will also increase revenue and taxes for both the central (Rwanda Revenue Authority) and local authorities. The project will fully participate in increased payments of taxes from suppliers of construction materials and other stuffs required necessary for the project implementation.

iv. Rational exploitation of Rwandan natural resources

The project will contribute to the wise-use of water resources, with among the aims to serve as a model and inspiration for the future attempts for similar projects in region. The project is also committed to ensuring that local companies, local raw materials will be utilized as much as possible for successful completion of the project. It is expected that the demand for the supply and production of local building materials as well as provision of services will contribute to providing a positive increase to various sectors related to the construction industry

v. Increase to public revenue/taxes

The implementation of the project will increase revenue and taxes for both the central and local authorities. The project will fully participate in increased payments of taxes from suppliers of the clean water in its supplied areas.

7.2.3. Positive impacts during the operation phase of the project

i. Access to potable water and reliability of water supply system

The rehabilitation and expansion of Karenge WTP will add more 18.000 m^3/d of water to the existing water supply system within Kigali and Rwamagana District. This will no doubt increasing the number of people with access to clean water and therefore increasing their well being. The implementation of the project will enable greater responsiveness to the demand, increasing also the reliability of the operating system. The reliability of the system will allow adequate planning for water supplies.

ii. Economic Diversification and Improved local socio-economy

It expected that all works related to the project will provide a positive increase to the local and national economy. In general this will contribute to the socio economic benefits within and around the project areas of intervention. The economic expansion will enable alternative businesses and economic activities to develop. Also, increased earnings by staff will most likely be spent locally further supporting already established businesses in the area, as well as potential new businesses that may emerge and connected to the project

iii. Gender balance

It is expected that during the project operation phase women will equally benefit as men in terms of employment benefits. In Rwandan culture, it is the responsibility of a woman to collect water and during water shortages, women and girls use most of their time for water. Therefore, the proposed project will be highly beneficial to women and girls especially in rural areas where water will be then permanently and reliably supplied.

iv. Healthcare for Employees

Employees and their immediate families will be provided with basic healthcare. This will benefit the overall health of the local population. HIV/AIDS information will be dispersed to employees to prevent the spread of the disease amongst the project employees and their families.

v. New jobs creation

As the project will be supply water in different areas ok Rwamagana and Kigali City, new emerging public water kiosks for water vendors may arise from the implementation of the project. This will therefore contribute to the new creation of new jobs in different areas of the project and therefore fighting the unemployment.

vi. Improved health and sanitation

It is with no doubt that the project will significantly contribute to improvement of sanitation within its areas of intervention and therefore improvement of living conditions of Rwanda population.

7.3. Potential adverse impacts and their mitigation measures

The project of rehabilitation and expansion of Karenge WTP is a vital, positive and necessary intervention project. However its implementation has identified some negative impacts as described below. The mitigation measures were also proposed to each impact. .

7.3.1. Negative socio-economic impacts

It is anticipated that the project will have some socio-economic adverse impacts as detailed below:

i. High jobs expectation by local community

During the conduct of the present study, it was noted that local population are expecting more jobs from the project implementation. Indeed, although the project will create employment opportunities, the jobs will be limited and it is therefore important that the procurement processes is clear and fair. It is expected that creation of not enough jobs will create frustration on part of the local people and conflicts can occur or be generated in relation to the project.

✓ **Mitigation measures**

- Recruitment should be done a clear and fair process.
- Establish recruitment committees prior to job commencement
- Local and affected project persons should be prioritized when allocating jobs
- Women should equally benefits from job recruitment

ii. Resettlement implications

The implementation of the present project will require additional land nearby the existing Karenge WTP despite taking into consideration that the project was designed in a way that he project avoids and /or minimise as much as possible the physical resettlement. The land for the plant is currently privately owned and unfortunately five households were identified to be physically resettled throughout the two phases project implementation (one house during phase I and 4 houses during Phase II). Furthermore as discussed above other land will be affected either being private or public. Other residents of the project areas will lose both temporally land while others will lose only crops and trees and other structures such as fences and domestic animal sheds. It was noted that the total of 28 plots will be affected at intake, 32 plots and 5 houses at the water treatment plant. 2 other structures at the pipelines. Easement will also be secured on 2059 plots

✓ **Mitigation measures**

- The project should operate only at the earmarked land and compensation to be done only at the required land by the project
- The land for construction of water storage tanks has to be purchased to land owners in applying market value before construction works.
- Crops and trees to be affected will be also compensated before project implementation.
- All compensations should be done prior to the project implementation and in accordance with the existing law related to the expropriation in public interests.

iii. High expectations of getting great compensation in cases of resettlement

It is highly likely that people who will stand to lose land, infrastructure or business due to the project will have very high expectations of compensation to their loss.

✓ **Mitigation measures**

- Valuation of damaged assets should be done with the certified independent valuer as per the existing regulations and laws. Full replacement cost should be used so as to provide fair compensation
- The compensation should be done in accordance with the existing law related to expropriation in public interests .

iv. Conflicts among workers and the local population in the project area

Though it is anticipated that the project will make an effort to employee local population, projects involving major works include, often, the potential for the occurrence of social conflicts between workers who temporarily settle in the local and community residents. Such behaviours are generally related to socially unacceptable behaviour according to local social standards and can be seen, for example, cases of drunkenness and disregard/lack of respect for local customs. This impact should be considered even though an important part of the manpower to be recruited is locally.

✓ **Mitigation measures**

- Where possible maximum efforts should be made to recruitment of local population who returns to their homes after work.

v. Injuries or fatalities from project activities

The most common injuries or illnesses as a result of manual handling are musculoskeletal disorders in various parts of the body (back, neck, shoulders, or other) and include from sprains and strains to damage to muscles, joints and vessels. Other injuries include cuts, bruises, lacerations and fractures due to unexpected events such as accidents caused by manual handling.

Mitigation measures:

- Health and safety measures should be observed including provision of Personnel Protective Equipment(PPE),
- Provide permanent First aid kit at the work site,
- Occupational Health and Safety(OHS) and,
- Training and health insurance to all workers
- Working conditions should respect the requirement of the Law n° 66/2018 of 30/08/2018 regulating labour in Rwanda.
- Measures are taken to oblige workers to wear safety boots and helmets and to manage waste properly, in order to prevent accidents during the construction work
- The safety and sanitation plan will be prepared and regular safety education will be implemented, in consultation with a district work safety inspector
- Security guards, who are provided with training of health and safety, are assigned and measures are taken such as installation of fence and signboards in order to prevent accidents and troubles involving local residents near the construction site.

vi. Work related Health issues

Health related issues are mainly resulted from emission of dust, noise and vibration which can result in possible respiratory irritation, discomfort, or illness to workers and local communities.

✓ **Mitigation measures**

In addition to the safety measures mentioned above, the following additional measures should be implemented:

- PPE should be provided to workers who are exposed to dust, noise and vibration for a prolonged period.
- watering regularly to suppress excessive dust during construction, use of gas masks and goggles for dusty sections is strongly recommended;
- The contractor together with local authorities is required to enforce acquiring medical insurance “mituelle de sante” for all workers as a means of affordability of treatment.
- The safety and sanitation plan will be prepared planned and regular safety education will be implemented, in consultation with a district work safety inspector.

vii. Possible increases of HIV/AIDS and other communicable diseases such Covid -19

Risk of increase of HIV/AIDS and other Sexually Transmitted Diseases (STD)as well as the increase of Covid-19 due to the increase of people from outside of the project zone may arise. Though there are no workers camp sites planned for this projects Communicable diseases are anticipated among workers.

✓ **Mitigation measures**

- Regular sensitization on ways of HIV/AIDS prevention,
- Regularly washing hands and workers should be sensitized on the importance of proper hygiene is during execution of this project.
- Wearing protective mush should be mandatory and disciplinary measures should be implied.
- The contractor is requested to arrange a health and hygiene training for workers in cooperation with health centre near the construction site, in order to prevent infectious diseases

viii. Project impacts on public utilities/ infrastructures

During construction of the pipelines some social infrastructure like water point, road crossing ring and water supply infrastructure will be affected especially in submerged area. Furthermore, some water pipe and electrical cables were identified in the pipelines areas and are likely to be affected during excavation.

Mitigation measures

- Rehabilitation of affected structures and infrastructures;
- Identification of new water source and construct alternative water spring.

ix. Child labour, forced labour , discrimination and abusive dismissal

The implementation of the present project should be done in compliance with national and international standards in terms of child labour forced labour and discrimination.

Mitigation Measures

- Protect workers' rights and provide contract to each employee
- Establish, maintain, and improve the employee–employer relationship;
- Promote compliance with national legal requirements and provide supplemental due diligence requirements where national laws are silent;
- Comply with international Labour Organization, and the UNICEF Convention on the Rights of the Child, where national laws do not provide equivalent protection;
- Protect the workforce from inequality, social exclusion, child labour, and forced labour

7.3.2. Negative Impact on Physical Environment

The general topography of the project area is relatively flat with no major steps slops to affect the natural surface as well as the water quality of Lake Mugesera. Secondly, the construction activities will contribute to the loss of the topsoil in some areas and combined with soil compaction during site preparation and levelling will result in reduced capacity of the ground to retain water and increase surface water run-off during periods of rainfall. The construction around and within the lake will also cause water and soil pollution from drilling muds, borrow pits and quarries; as well as disturbance/loss of vegetation. The identified physical impacts are described above and their proposed mitigation measures:

i. Changes of landscape - Visual impact

Impacts on the physical environment will consist of landscape transformation causing visual impacts. The construction of the plant and water pipe lines will alter slightly the landscape at their areas of interventions. These impacts will remain during operational phase. Temporary physical impacts will occur during the construction period at places selected to store construction material and pipes and at accommodation places for workers. However, those sites will be decommissioned after the construction phase; the visual impact is restricted to the construction period.

✓ **Mitigation measures**

- to clear only the area demarcated for construction;
- Rehabilitation of construction sites.

ii. Water pollution

The construction works including water pipes laying in Mugesera lakes and its surrounding would change its water quality and this may deteriorate in terms of higher turbidity levels due to increased sediments. Depending on the type of suspended material, this effect will continue over a short period. The

use of machinery in the nearby would also spill away some liquid or solid wastes generated from the construction works which will cause adverse effect on the lake and environment.

✓ **Mitigation measures**

- Before starting to use heavy equipment near the lake, the soils of the lake banks have to be protected with strong materials in order to prevent it from falling into the lake especially during the excavation works
- The construction period should be done during the dry season in order to avoid soil and sediment run off into water bodies;
- After installing pipe sleeves, water pipes are inserted inside them, and aerated light-weight concrete is filled up between the pipe sleeves and water pipes in order to fix the water pipes in concrete.

iii. Soil erosion and contamination

Soil excavation, trenches excavation, construction works and vegetation clearance will expose soils in the project affected areas leaving them vulnerable to erosion by surface run-off or by wind. Other activities exposing soil include the movement of machines, trucking, and to some extent the felling of trees during excavation works. Soil erosion depends not only on soil damage but also soil type, rainfall, and angle and length of slope. Soil erosion is mostly expected at high slops of pipelines and without adequate water management on site, soil erosion will persist and result in loss of soil and sedimentation and affecting the downstream of the project areas. However the impacts of soil erosion are mostly expected to happen during rain seasons.

The contamination of soil may also occur from the spillage of oils and lubricants during construction works and operation activities. Degradation of the surrounding soil will affect flora and fauna and may restrict the future land use.

✓ **Mitigation measure**

- Monitor areas of exposed soil so as to implement sediment dispersal measures as appropriate.
- Only clear areas earmarked for construction.
- Construction of soil erosion barriers

iv. Generation of effluent from washouts

The treatment of surface water for potable supplies involves coagulation, flocculation, sedimentation and filtration processes for removing colloidal as well as suspended solids from raw water. All the processes produce waste/residue known as water treatment sludge (WTS) during the purification of raw water. The sludge produced at Karenge WTP presents different physical and chemical characteristics that may contain fine sand silica, ferric oxide and lime and others based on the chemicals used. The direct disposal of the produced sludge into the environment is not an environment friendly disposal option as this is currently being done at the plant

According to the information collected during the survey, the discharged waste water after back washing is mostly causing conflicts to the local population downstream the plant as mostly during the dry season. This is remarkable on site as the local population have created bypass to the existing waste water chancel in order to convey the water into their filed and be used for irrigation purposes.

✓ **Mitigation measures**

- Use the underground pipes to convey waste water in their final destination via the rehabilitation of the old existing waste water open channels.
- With local authorities it is required to enforce the mechanism of waste water management at the through emphasis on the proper management of their final destination.
- In case the waste water has to be used for irrigation, together with the local authorities WASAC should establish the local committees that are in charge of proper distribution to the neighbouring agriculture field.
- There is a need to develop suitable sludge management strategies for sustainable development.
- The sustainable and profitable disposal through recycling and reuse is recommended such as bricks making and be used as fertilizers or as a substitute to building materials. Recycling the sludge in building and construction industry could be a safe disposal option.
- WASAC ltd is recommended to develop proper sludge management at Karenge WTP and for proper environmental management.

v. Dust releases and air pollution

Exposed surface with loosened topsoil will increase dust raised in the area especially during initial levelling and preparation required under each phase of the project. Dust will also be raised by haulage vehicles delivering materials to and from the site as access roads are not paved. The dust raised during construction can pose a nuisance to workers although the impact of this is considered relatively small and localized. Dust raised by construction activities can also pose a nuisance to adjacent settlements especially under dry and windy conditions. The impact of this affecting some parts of the settlements around the construction sites is potentially significant although intermittent. It can be anticipated that a certain amount of air borne particulate matter (dust) will be generated by earth moving activities during construction phase of water treatment plant and water reservoirs. This situation will be worse during the dry season and during the afternoons when the winds are most prevalent. Air borne particulates may pose a hazard to residents in the vicinity or downwind of the construction site that suffer from upper respiratory tract problems.

✓ **Mitigation**

- Access roads and exposed ground should be regularly wetted in a manner that effectively keeps down the dust.
- Exposed construction sites will be fenced with wind brokers to avoid dust emissions to neighbouring areas
- Workers on the site should be issued with dust masks during dry and windy conditions.
- Most of the emissions are expected to come from vehicles, tractors and machines to be used. The contractor will be required to present technical control certificate for all vehicles, machines and trucks. Those certificates are issued by National police and are issued only when the vehicle emission is below the maximum permissible limit.
- A regular monitoring on ambient air will be conducted to check the level of air pollution. In the case the level exceeds the minimum permissible air pollution level, the developer will be required to reduce his emissions

vi. Impacts on Noise and Vibrations

Noise will be caused by construction traffic transporting construction materials/workers to and from the site and from the construction site. These would be also generated by the operation of heavy machines, heavy trucks, right of way preparation, soil stripping, trenching, pipe stringing, welding and laying and backfilling activities. However, the impacts are limited as the construction works will be for a short periods and only to be done during normal working hours.

Mitigation measures include the:

- limitation of heavy works in daytime 7am to 5pm;
- Provision of PPE to workers;
- If necessary, local residents should be given notice of intended noisy activities so as to reduce degree of annoyances.
- Workers operating equipment that generates noise should be equipped with noise protection gear.
- A regular monitoring of noise will be conducted as to check the compliance of noise pollution with permissible level.
- As most of the expected noise is from vehicles, truck and machines, the contractor will be requested to use equipment in good condition and certificate of technical control will be required
- Equipment with heavy noise and vibration will be restricted on normal working hours, from 7am to5 pm,
- Facing sites should be mandatory to limit noise emitted.

vii. Generation of Solid Waste

Solid waste generated during site preparation and construction work would include several types of solids wastes including off cut vegetation, typical construction waste, soil, metals, and papers. These wastes would negatively impact the site and surrounding environment if not properly managed and disposed of at an approved dumpsite.

✓ **Mitigation-**

- Workers on site will be clearly briefed on proper solid waste disposal.
- Onsite temporally waste deposit area should be clearly designated and marked.
- A site waste management plan should be prepared by the contractor prior to commencement of construction works. This should include designation of appropriate waste storage areas, collection and removal schedule, identification of approved disposal site, and a system for supervision and monitoring.

- Waste recycling is also an option whereby construction recycled soil and concrete debris can be used as road bed materials in different areas of the project intervention.

viii. Impacts on Quarries and burrow pits

It is anticipated that the project will need construction material such as sand and stones. Therefore, it is appropriate to give consideration to the environmental implications in selection of quarry sources since poorly run operations create dust problems, contribute noise pollution, Occupational health and safety of their employees, or environmental degradation in general.

✓ **Mitigation measure**

- To ensure adequate mitigation of potential adverse impacts, only licensed quarrying operations are to be used for material sources. Efforts should be made to use material commonly found along the roadway as a construction material.
- Burrow pits areas shall preferably be selected from high land and/or waste land. Although locations of the borrow areas are negotiated between contractor and landowners. The excavation and restoration of the burrow areas and their surroundings, in an environmentally sound manner to the satisfaction of the Supervising Engineer, is required before final acceptance and payment under the terms of the contract.
- All borrow pits areas will be properly dressed maintaining drainage to outwards. The side slopes shall be provided with surfing. Topsoil from the opening of burrow pits from agriculture land shall be saved and reused in re-vegetating the pits to the satisfaction of the Engineer/land owner. Additional borrow pits will not be opened without the restoration of those areas no longer in use.

ix. Contamination of soil and water bodies due to oil spillage

During the construction activities it is expected that machinery shall be including trucks, bulldozer and other equipment that require re-fuelling, maintenance works and repair works, which in effect result in oil spillage. At point sources, contamination of soils and run-off ending in the receiving bodies could cause water quality degradation, if no mitigation measures are implemented. This impact can be considered of low magnitude, duration and spatial extent since it shall only be experienced during the early construction phases.

✓ **Mitigation Measures**

- Re-fuelling, oil change, maintenance works, repair works shall be allocated at a restricted area and far from water body and marshland and preferably positioned in an area that have no adverse effects if degraded.
- The area allocated for fuels shall need to have a cemented floor and a sand stock for use in the absorption of spilled oil.
- Water quality will be regularly monitored so as to compare the baseline and monitoring results. If during monitoring process water is contaminated, then additional measures will be taken.

7.3.3. Impact on Biological Environment

i. Loss of Flora and Fauna

Some crops and trees established in the project area will have to be destroyed and removed especially where the pipelines and water supply infrastructures will constructed. It is also important to note that there is no surveyed plant or animal species of special conservation purpose that will be affected by plant/reservoir construction.

✓ **Mitigation**

- Compensation of trees and land to be affected should be done prior to the project implementation.
- The site clearance should be only done on an area demarcated for construction activities.
- The rehabilitation and re-planting of affected trees is recommended after project construction works

ii. Disturbance of Ecosystems habitats

The clearing of vegetation during water source excavation and water transmission works will no doubt result in the complete loss of associated ecological habitats and their fauna within the project area. Noise, vibrations, and intrusive activities related to construction works will tend to scare away some animals species remaining on the site after vegetation clearance.

✓ **Mitigation**

- Clearing and construction activity should be restricted within the area of the project development.

Table 35: Summary of impacts significance before and after consideration of mitigation measures

Impacts	Positive impact	With No mitigation measures	With mitigation measures		
Positive impacts			**High**	**Medium**	**Low**
Employment opportunity and income generation	+				
Skills transfer	+				
Increased saving for local employee	+				
Gender balance enhancement	+				
Increased public revenue and local socioeconomic	+				
Rational exploitation of Rwandan natural resources	+				
Access to potable water and reliability of water supply system	+				
Economic diversification and improved local socio economy	+				
Gender balance	+				
Improved health and sanitation	+				
Improved living condition due to availability of clean water	+				
Negative impacts					
High job expectations by local community		-			-
Resettlement implications		---		--	
High expectations of getting great compensation		---		--	
Conflicts among workers and local population		--			-
Injuries or fatality of workers		---		--	
Possible increase of HIV and other communicable diseases.		--			-
Child labor and forced labor		--			-
Change of landscapes		-			-
Mugesera lake Water pollution		---		--	
Soil erosion and contamination		---		--	
Generation of effluent from washouts		---		--	
Dust release and nuisance		--			-
Noise and vibrations		-			-
Solid waste generation		-			-
Disturbance of ecosystem habitat		--			-
Water use conflicts		--			-
Lake buffer encroachment		---		--	
		---		--	

+	Positive environmental and Social Impacts
-	Low significance
--	Medium significance
---	High significance impacts

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CHAPTER VIII: ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN

In this EIA report, the Environmental Management and Monitoring Plan is divided into two parts. The first is the **Environmental Management Plan** and other is the **Environmental Monitoring Plan.** The Environmental Management Plan explain the proposed mitigation measures into actions and provides management measures to be undertaken during the construction and operational phases of the project. The Environmental Monitoring Plan details monitoring activities and measures to be undertaken during construction and operation. The estimated costs for implementation of the mitigation measures are just indicative. Appropriate bills of quantities should clearly give actual figures. In any case the consultant used informed judgment to come up with these figures. However, it is mandatory that WASAC Ltd designate an environmental and social officer who will make day-to-day follow up of proper implementation of proposed mitigation measures (e.g. supervision and liaising with stakeholders). The EPC contractor has also mandate to have an Environmental, Social. Health and Safety manager on the implementation team to follow up the implementation this EMP.

8.1. Environmental Management plan

The EMP is presented in the table below and provides the activity that leads to the adverse impact, the anticipated impact, the proposed mitigation measures, the implementation schedules and the responsibility.

8.1.1. Environmental management plan for the construction phase

Table 36: Environmental management plan for the construction phase

Activity	Adverse Impacts	Proposed Mitigation measures	Responsible	Monitoring	Budget (USD)
Land acquisition	**Loss of land, Houses crops and trees**	**Valuation and compensation al all assets prior construction**	**WASAC LTD**	**WASAC Ltd and district**	45,000(phase 1) 120,000(Phase 2)
Site installation and Site clearing	Soil erosion and compaction	- All earthworks for site preparation and levelling have to be carried out during the dry season Storm water drainage system has to be installed on sites susceptible to erosion. . - Soil erosion barriers have to be installed on site. Restrict clearing works to only project sites and at the minimum possible - To only use appropriate machinery at each type of activity in order to minimize the risks; - Remove and stockpile topsoil, sub-soils and any parent material separately.	Contractor	WASAC Ltd/ REMA	1,000
	Loss of biodiversity	- Plantation of trees after construction works. - Stabilize soil with grasses and trees - Stabilize borrow pit with grasses and trees. - In areas of dense vegetation cover, like manmade forestry, the removal of vegetation must be restricted to the minimum necessary width	Contractor	WASAC Ltd/Local Authorities/, District	4,000
	Soil cover loss	- Create contour drains during Construction works - Use of the excavated soil to refill borrow pits	Contractor	WASAC ltd/ REMA	2,000
	Conflict on land acquisition and Loss of crops and trees	- Fair compensation of land from owners before project activities and implementation. - Involve and work with district/ Sectors authorities to better solve any conflict that may rise - Fair compensation of affected crops, trees and other assets before project implementation works	Property Valuer WASAC Ltd / District	MINECOFIN WASAC Ltd / District	Under expropriation budget
	Changes of landscape - Visual impact	- Rehabilitate working area with trees and grasses	Contractor	WASAC Ltd /REMA	3,000
Construction works of intake WTP, pipelines and water reservoirs	Potential soil erosion	- Only clear areas earmarked for construction works. - Constructions of water ways with check dams as to reduce sediment	Contractor	WASAC Ltd Local authorities	5,000

Activity	Adverse Impacts	Proposed Mitigation measures	Responsible	Monitoring	Budget (USD)
Land acquisition	**Loss of land, Houses crops and trees**	**Valuation and compensation al all assets prior construction**	**WASAC LTD**	**WASAC Ltd and district**	45,000(phase 1) 120,000(Phase 2)
	Water pollution (Lake water and other surface and underground water)	- Avoid at the maximum the use of polluting machinery. - On site adequate sanitary facilities have to be provided - Staff to be regularly trained and sensitized on appropriate waste management. - All unused materials to be properly handled - Consider measures to prevent pollution of ground water while designing the sludge storage site; - Storage site shall follow the appropriate regulation of Waste Management - Regular monitoring of water pollution sources	Contractor	WASAC ltd/ REMA/ RWB	Under operation budget
	Disturbance and mortality of terrestrial fauna	- Restrict construction activities do the daylight; - Inspect the area to be cleared for any terrestrial fauna before bush clearing and digging; - Protect any trench left overnight with a net fence to block fauna from being trapped inside; - Capture and release fauna away from the direct influence zone (including species trapped in the trenches);	Contractor	WASAC Ltd/ REMA	No budget required
	Injuries and accidents on site	- Provision of Personnel Protective Equipment to all staff - Sensitization of workers on safety measures - Provide first aid kit on the site - The safety and sanitation plan is formulated and safety trainings are provided for workers - Ensure all employees have health insurance;	Contractor	WASAC Ltd/ Local authorities	5,000
	Air and noise pollution	- Construction activities shall be restricted to normal working hours (7h00-17h00) to prevent noise for neighbours at night - The machinery and automobiles to be used on site should have certification of good working conditions from "National Automobile inspection centre" in order to reduce noise or exhaust fumes emissions. - Ensure routine maintenance, repair of trucks and machines. - Spray water when deemed necessary in order to reduce the dust. - Regularly watering when clearing land to reduce the dust - Construction sites to be fenced by dust barriers and suppressors. - Provision of protective equipment to all workers. The contractor to inform the general public any activity that shall emit noise prior to execution in order to minimize the impacts (e.g. blasting activities and operation of heavy machinery and construction traffic).	contractor	WASAC Ltd/ REMA	2,500
Purchase of construction materials as stones, gravel and sand	Land degradation	- Purchase of all raw materials and construction materials has to be done from approved quarries and gravel pits. - Backfilling borrow pits after excavation and rehabilitating with vegetation.	Contractor	WASAC Ltd/ local authorities/ REMA	No budget required

Activity	Adverse Impacts	Proposed Mitigation measures	Responsible	Monitoring	Budget (USD)
Land acquisition	**Loss of land, Houses crops and trees**	**Valuation and compensation al all assets prior construction**	**WASAC LTD**	**WASAC Ltd and district**	45,000(phase 1) 120,000(Phase 2)
Construction of reservoirs	Fugitive dust generated during excavation works	- Wetting the surface during construction - Top soil to be stored separately from subsoil. - After completion of works, the top soil has to be spread over those areas which can be partially restored in order to facilitate natural regeneration of those areas. - Compaction of soil to be minimized by careful stockpiling and separation of top and sub-soils.	Contractor	WASAC Ltd/ REMA/ Local authorities	
	Nuisance of noise from construction activities	- The Contractor shall restrict any of his operations, which result in undue noise disturbance between 7h00 am and 5h00 pm hour (e.g. blasting activities and operation of heavy machinery and construction traffic) - Restrict construction and operation of heavy machines to daylight; - Ensure noise emissions are kept within the Rwanda standards; - Reduce needed truck movements by careful planning of needs of delivery of construction materials. - Regular and effective equipment maintenance in order to ensure all machinery is in good working order and use does not generate excess noise.	Contractor	WASAC Ltd/ Local authorities	No budget required
Construction of water reservoirs and water pipelines	Disturbance of natural soil structure, mixing of layers	- Top soil to be stored separately from subsoil. - After completion of works, the top soil has to be spread over those areas which can be partially restored in order to facilitate natural regeneration of those areas. Compaction of soil to be minimized by careful stockpiling and separation of top and sub-soils.	Contractor	WASAC Ltd	1,000
Construction of water sources	Pollution of surface and ground water	- Provide onsite protective equipment's - Staff to be regularly trained and sensitized on appropriate waste management. - On site adequate sanitary facilities have to be provided - All unused materials to be properly handled - Regular monitoring by the professional in the domain.	Contractor	WASAC Ltd/ REMA	under construction budget
	Sediment load	- Proper handling and management of generated of waste on site. - All excavated material to be carefully re-used, replaced and/or planted up with grass and other indigenous seedlings.	Contractor	WASAC Ltd/ RWB/ REMA	Construction budget
Levelling of Reservoir Sites and excavation of trenches for water pipelines,	Land degradation	- All earthworks for site preparation and levelling shall be carried out in a proper designated manner and have to be done by the qualified engineers. - Wastes produced have to be disposed of in a designated area.	Contractor	WASAC Ltd Local authorities	No budget required
Excavation and alignment of pipes	Disturbance of traffic	- Provide appropriate equipment and manpower in order to complete the work in short time especially for the section that cross the roads - Appoint staff in charge of traffic management - Use of appropriate traffic sign post - Rehabilitation of affected section - Excavation and backfilling of the affected section during evening hours where there is no heavy traffic	Contractor	WASAC Ltd	Construction budget
	Accident and injuries	- Provision of Personal Protective Equipment - Provide first aid kit on site - Training of workers on safety measures	Contractor	WASAC Ltd/ District	500

Activity	Adverse Impacts	Proposed Mitigation measures	Responsible	Monitoring	Budget (USD)
Land acquisition	**Loss of land, Houses crops and trees**	**Valuation and compensation al all assets prior construction**	**WASAC LTD**	**WASAC Ltd and district**	45,000(phase 1) 120,000(Phase 2)
	Overall environmental management	- Avail an Environmental and Social Manager at the site to oversee environmental management, social concerns, environmental training, and the implementation of environmental policies; - Appoint ESHS Manager in EPC contractor team to assist with sampling, monitoring and daily environmental compliance; - Provide environmental training to all employees.	Contractor	WASAC Ltd/	3,000
Overall construction works	Influx of job seekers	- Disclosure the exact number of jobs available for the project; the applicable period and the remuneration to be allocated for each type of work before project implementation - Involve local leaders in recruitment process; - Recruitment should consider both male and female. - Local residents and PAPs to be prioritized in the recruitment process.	Contractor	WASAC Ltd/Local authorities	No budget required
	Child labour, forced labour and discrimination	- Protect workers' rights; - Establish, maintain, and improve the employee–employer relationship; - Promote compliance with national legal requirements and provide supplemental due diligence requirements where national laws are silent; - Comply with international Labour Organization, and the UNICEF Convention on the Rights of the Child, where national laws do not provide equivalent protection; - Protect the workforce from inequality, social exclusion, child labour, and forced labour;	Contractor	WASAC Ltd/	No budget required
	High expectations of getting great compensation in cases of resettlement	- Expropriation and compensation mechanisms should be implemented in all justifiable cases. - Full involve the PAPs in all steps required for the fair compensation as stipulated in the expropriation laws and regulations. - Establish and make operational conflicts resolutions committees.	Contractor WASAC Ltd Local Authorities	WASAC Ltd/ Local authorities/ District	No budget required
	Impacts on public utilities electrical lines passing nearby the project sites	- Rehabilitation of affected structures and infrastructures as soon as possible; - Identification of potential impacts that may occur during construction works and identify mitigation measures. - Inform local residents ahead of time any expected impact on public utilities (such as power cuts etc) .	Contractor	WASAC Ltd/ REG/ RURA/RTDA Local authorities	No budget required

Activity	Adverse Impacts	Proposed Mitigation measures	Responsible	Monitoring	Budget (USD)
Land acquisition	**Loss of land, Houses crops and trees**	**Valuation and compensation al all assets prior construction**	**WASAC LTD**	**WASAC Ltd and district**	45,000(phase 1) 120,000(Phase 2)
	Risk of increase of HIV/AIDS and other Sexually Transmitted Diseases and increasing of COVID- 19 Contamination	- Providing surveillance and active screening and treatment of workers - Regular check up of workers on site - Providing health and hygiene training - Preventing illness among workers in local communities - Providing health services - Use of Personal Protective Equipment - Enforce the health measures established by competent authorities to fight such diseases (wear of protective musk, regular hand washing, keeping distance among workers etc).	Contractor	WASAC Ltd Local authorities Health Organs	5,000
	Gender based violence and sexual Exploitation and Abuse(GBV/SEA	- Preparation and implementation workers Code of conduct - Conduct GBV/SEA awareness	Contractor	WASAC Ltd/ District	1,000
	Disturbance and mortality of terrestrial fauna	- Restrict construction activities do the daylight; - Inspect the area to be cleared for any terrestrial fauna before bush clearing and digging; - Protect any trench left overnight with a net fence to block fauna from being trapped inside; - Capture and release fauna away from the direct influence zone (including species trapped in the trenches);	Contractor	WASAC Ltd/ REMA/ RWB	
		-			199,000

8.1.2. Environmental Management Plan for the Operation Phase

During the operation phase of the present project, it is not expected to have many negative impacts. The table below summarize the Key impact and proposed mitigation measures that were identified.

Table 37: Environmental Management Plan for operational phase

Activity	Adverse Impacts	Proposed Mitigation measures	Responsible	Monitoring	Budget (USD)
Water treatment process	Generation of sludge at WTP	- Conduct the chemical analysis of the produced sludge before being discharged. - Dedicated treatment area be provided and regular and be monitored as appropriate - These quantities are not large and in diluted form and can be used as fertilizers and be used in crop irrigation downstream the plant. - Establish waste water (from the plant) users committees to the locals of down Karenge Water Treatment Plant.	Contractor	WASAC Ltd REMA/ RWB/ Local authority	5,000
Use of chemicals during treatment process such as chlorine.	Ground water and surface water pollution resulting from poor handling and management	- Provide safe storage facilities according to health and safety regulations. - Waste to be properly stored in designated areas as provided by the manufactures. - Liquid fuel storage and dispensing to be done far from water bodies. - All hazardous wastes and material with hazardous wastes shall be stored on site in an approved manner, and be removed at regular intervals to offsite waste disposal facilities designed to handle such hazardous waste as required by law - The use of PPEs should be mandatory during the use of chemicals	Contractor WASAC Ltd	WASAC Ltd REMA	under operation budget

Activity	Adverse Impacts	Proposed Mitigation measures	Responsible	Monitoring	Budget (USD)
Sanitary	Poor management of the project infrastructures	- Proper management of water source, pipes and reservoirs. - Regular maintenance of the infrastructures.	Contractor	WASAC Ltd	Under operation budget
Water supply	Loss of water due to break of pipe or , water storages	- Regular monitoring of the infrastructures. - Establish information gathering mechanism from local residents in order to be informed on the break that may occur in the system. - Repair the damages as soon as possible.	Contractor	WASAC Ltd Local residents	The budget depend on required repairing works
	Vandalism of equipment	- Provision of guards at sensitive area such as intake and WTP. - Sensitize local population on the importance of public utilities.	Contractor	WASAC Ltd/ Local authorities	2,000
		-			7,000

8.2. Environmental Monitoring

In this section, a monitoring plan is proposed indicating measurements of parameters, responsibility and cost estimates of outcomes of the proposed mitigation measures. However, a general monitoring plan should be implemented on site. The monitoring plan stands to facilitate and ensure the follow-up of the implementation of the proposed mitigation measures and helps to anticipate possible environmental hazards and/or detect unpredicted impacts over time. The monitoring tools include:

- Visual observations;
- Selection of environmental parameters/indicators at specific locations;
- Sampling and testing of these parameters.

Environmental monitoring programs for this project should be implemented to address all activities that have been identified to have potentially significant impacts on the environment, during normal operations and upset conditions. Environmental monitoring activities should be based on direct or indirect indicators of emissions, effluents and resource use. Monitoring frequency should be sufficient to provide representative data for the parameter being monitored.

- **Water Quality Monitoring**

Construction and operation phases of this kind of project are often a source of significant surface and groundwater pollution if not managed and sited properly. It is no doubt that Mugesera Lake will be polluted by the project activities especially during construction works. Therefore that WASAC Ltd should undertake monitoring of the water quality of Lake Mugesera prior to project activities and conduct regular monitoring of its quality during construction works in order to avoid severe pollution of the lake. The key parameters to be monitored includes: Temperature PH, turbidity and TSS.

- **Temperature**

The variation of temperature of surface water affects physical, chemical and biological processes in water bodies and therefore the concentration of many variables. As water temperature increases, the rate of chemical reactions generally increases together with the evaporation and volatilization of substances from the water. Increased temperature also decreases the solubility of gases in water, such as O_2, CO_2, which in return may affect chemical reactions of the general conditions of the lake.

- **The potential of hydrogen (pH)**

The Potential of Hydrogen is an important variable in water quality assessment as it influences many biological and chemical processes within a water body. It is used to specify the acidity or basicity of the lake.

- **Turbidity**

The turbidity of water is due to the presence of thin suspended matters such as gray, colorants, organic matters, and planktons etc. When it is less the water treatment is efficacious during purification and is analysed on field using turbid meter.

- **TSS**

Total suspended solids (TSS) are the dry-weight of suspended particles that are not dissolved, in a sample of water. The more total suspended solids in the water, the darker it seems and the higher the turbidity. The turbidity therefore varies seasonally according to biological activity in the water and surface run-off carrying soil particles.

- **Soil erosion monitoring**

The project is not likely to have major impact on soil quality according to the general topography of the project sites. However some soil erosion may be anticipated on some areas when excavation works are not well controlled. Therefore a regular monitoring is required. Soil stability, riverbank protection, soil stockpiling and step soil protection should be monitored on regular basis.

- **Fair compensation monitoring**

The compensation of project affected persons shall e made after property valuation. Individual payment will be made at property owner's account. The District and WASAC ltd should ensure that fair compensation was done and in accordance with the laws and regulation related to expropriation in public interests.

- **Noise and vibration level monitoring**

Periodic sampling of equipment and generally around the project site should be undertaken. Noise level monitoring could be supplemented by consulting with Project Affected People to identify the level of monitoring and impact of noise that shall be regenerated by the project activities.

- **Monitoring of Accidents/incidence**

The contractor and WASAC Ltd must make sure that appropriate signs are posted at appropriate locations/positions to minimise/eliminate risk of accidents. In addition, health inspectors should make sure that:

- Measures to create awareness regarding sexually transmitted diseases, primarily HIV/AIDS, and other diseases are taken;
- Preventive measures to reduce and combat the transmission of COVID- 19 are put in place and followed.
- All workers on site are insured with "*Mutuelle de Santé"* of over health insurances.

The following parameters could be used as indicators:

- Accident reports: records on actual accidents associated with the project.
- Number of workers with health insurances.
- Number of periodic awareness conducted and connected to the project activities.

- **Monitoring of Social impacts**

The monitoring of the social impacts of the project is based on the experience of the communities and households. Through survey and/or focus-group information gathering techniques the following impacts should be monitored with the help of local authorities and households.

- Employment and procurement: impact on the community of the jobs offered and material bought locally by the project
- Quality of life: impact of noise, vibration, dust, etc. related to the project on the daily life of households.

- **Community relationship**:

Impact of arrival of workers in the community on relationships in the community and with the workers. Number of workers should be recorded by sex/origin and age.

Table 38: Environmental and Monitoring Plan

Environmental concern/ impact	Monitoring item/ Indicator	Parameter to be monitored	Location	Frequency	Responsible	Budget (USD)
Pre-construction and site mobilization phase						
Land compensation and payment of other assets to be damaged by the project	Compensation for land and other assets including houses , crops and tress	Number of houses to be compensated Area of land compensated Number of PAPs with consent forms of damaged assets	Project area	Once before construction	WASAC Ltd/ MINECOFIN/ District	Expropriation budget
	Complaints resolutions	Number of the complains received/ Log book of the complains	Project area	At each time when deemed necessary	Districts/GRM Committees/ WASAC / MINECOFIN	Expropriation budget
High number of job seekers	Number of job seekers on site	Number of PAPs who receive support such as priority in employment	Project area	Once before project implementation	Contractor/ local authorities	No cost required

Environmental concern/ impact	Monitoring item/ Indicator	Parameter to be monitored	Location	Frequency	Responsible	Budget (USD)
Air pollution	Equipment's and machinery used by the projects Dust emissions	Quality of air at the project area	Project sites	As appropriate	Contractor/ WASAC ltd/ REMA	Included in project budget
Water pollution	Mugesera lake water quality	Temperature, pH, TSS, Turbidity, soil erosion	At the intake and WTP	Daily	WASAC Ltd/ REMA/ RWB	Under operation Budget of the plant
Noise and vibrations	Noise and vibrations	Noise level	At project sites	When deemed necessary	Contractor	1000
Construction phase						
Accident and incident	Complaints (in general such as noise, traffic jam, and accidents)	Records of complaints Number of accidents occurred	Project areas	Daily	Contractor WASAC Ltd Local authorities	Operational Cost
Air Pollution	Equipment and automobiles in good working conditions	Routine inspection and maintenance of machinery and other equipments	Project sites	Daily	Contractor	No budget required for monitoring
	Dust emitted and particulate matter in the air Level of dust in the ambient air (observation)	Level of dust emitted in the atmosphere Records on water spray during sun seasons.	Project sites	Daily	Contractor	2,000
	Electrical installations, Fire extinguishers, water tanks	Number of fire extinguishers and water tanks Records of inspection	Construction sites	Monthly	Contractor	Under construction budget
Water pollution	Mugesera lake water quality	Temperature, pH, TSS, Turbidity	At the intake and WTP	Daily	WASAC Ltd	Under operation Budget of the plant
Noise and vibrations	Restriction of noise/vibration emitting activities to working hours.	Level noise emitted Level of vibration	Construction sites	At the time of earth works or concrete vibrations.	Contractor/ WASAC Ltd	Cost of a sound meter level is about 350 US$. Vibration meter 500US$
Soil pollution	Established measures for prevention of oil and other liquids contamination	Adequate and proper storage of liquid	At Karenge WTP site	daily	WASAC Ltd/ Contractor	Operational Cost
Soil erosion	Measures established to prevent soil erosion especially on Mugesera banks and at other steep slope along the pipeline route	Adequate soil erosion preventive measures.	At Intake. WTP and on steep slope subject to soil erosion in the project sites	When necessary	Contractor/ WASAC Ltd REMA	Operational Cost
Solid waste generation	Management of excavated soil Management of concrete debris and others generated solid wastes on site	Quantity of generated solid wastes Waste management mechanism	Construction sites	Daily	Contractor/ WASAC ltd	Operational Cost
Ecosystem degradation	Reforestation to offset lost grasses and trees Management of top soil	Number of planted hectares (ha) Number of trees planted	Construction sites	Every quarter of a year	Communities/ Districts/ Contractor	2,000
Work conditions	Occupational Safety and Health plan	Availability of OHS Plan	Construction sites	Daily (	Contractor/ WASAC Ltd	Operational Cost
	Meetings and trainings	Number of meetings and trainings				

Environmental concern/ impact	Monitoring item/ Indicator	Parameter to be monitored	Location	Frequency	Responsible	Budget (USD)
	Safety gear for workers	Number of workers with safety gears				
	Noise and vibrations	(from noise and vibrations)				
	Occurrence of accidents and injuries	Records of accident and injuries	Project area			
Accident/ Traffic congestions	Traffic management Plan and traffic signage	Availability of Transport Management Plan Number of traffic signage	Project areas	Monthly	Contractor/	Operational Cost
HIV; Covid -19 and other diseases	Health and sanitation for labour workers	Number of trainings awareness Availability of sanitation facilities and other diseases preventives measures	Project sites	Daily	Contractor/ WASAC Ltd Local authorities	5,000
Child and forced labour	Minimum working age and working condition	Employment record by age and working conditions	Project sites	Monthly	Contractor /Local authorities	No budget required
Operation phase						
Mugesera water level decreases	Water abstraction	Water level indications within the lake	Intake	Daily	WASAC ltd/ RWB	3,000
Conflict between local down users of waste water from the WTP	Number of conflicts related to water usage	Conflict resolutions/ complaints received	Down Karenge WTP	Quarterly	WASAC. Ltd/ Local authorities/ local residents	Operational budget
Water pollution	Mugesera lake water quality	Temperature, pH, TSS, Turbidity	At the intake and WTP	Daily	WASAC Ltd	Under operation Budget of the plant
Modification of flows and quality for downstream usage	Water quantity and quantity	Flow rate, Q (m^3/s) Quality parameters	Project developer	Monthly	WASAC ltd/ RWB/ REMA	2,000
	Total cost for monitoring					**15,800**

8.3. EMP implementation arrangements

8.3.1. Overall implementation responsibility

The overall responsibility of implementation of this ESMP is under Contractor and WASAC ltd. WASAC headquarters together with WASAC Karenge branch will designate a staff to act as Environmental and Social Safety Officer for the project implementation. The mandate of the assigned staff would be to follow up on regular the environmental and social issues related to the project. He/she will have an oversight of environmental aspects of the construction contracts, including the enforcement of all monitoring provisions, the locations of construction and labour camps, etc. The Contractor could also have an Environmental Health and Safety Manger (ESHS) and Social management officer to oversee the implementation of project during construction. The main duties of the designated Environmental officers will include but not limited to:

- Review designs and ensure they adhere to the environmental and social specifications and the requirements of the Environmental Management Plan (EMP).
- Co-ordination with government departments on environmental and social issues and obtaining the necessary clearances from the regulatory authorities.
- Collection and dissemination of relevant environmental documents including amendments to environmental protection acts issued by REMA.
- Monitoring the environmental aspects especially during construction phase to ensure that the environmental requirements of the contract and the mitigation measures proposed in the ESMP are implemented.

8.3.2. Environmental and social training

The training program will cover measurement techniques in the field, tools for the prediction of pollutants, conservation of water bodies including marshy lands, etc. Rwanda Environmental Management Authority, Rwanda Bureau of Standards and Rwanda Development Board may be consulted for such training. The need for additional and specialised training will be examined and appropriate training will be undertaken as required. Training of personnel to be deployed on the proposed project during construction and operation, with regard to environmental requirements should be the integral part of the planning. In addition all employees will be trained on safety, methods of disaster prevention, action required in case of emergency, fire protection, environmental risk analysis etc. Capacity to quantitatively monitor water sediments or turbidity (by suitable portable test equipment) and noise is always advantageous, but monitoring will primarily involve ensuring that actions taken are in accordance with contract and specification clauses, and specified mitigation measures. Training will be provided to the Contractor personnel to ensure the project is implemented in compliance with this EIA/EMP provision.

8.3.3. Monitoring and reporting procedures

The WASAC designated ESHS officer will visually assess contractor's practices and, if high pollutant levels are suspected instruct the contractor to make corrections. Photographic records will be established to provide useful environmental monitoring tools. A full record will be kept as part of normal contract monitoring. All applicable regulations need to be enforced by the Project Manager and designated ESHS manager. Under the environment law , water quality discharge standards, air pollution emission standards and noise standards have been established. It is a legal obligation of the Contractor that any discharges from the work sites meet these standards. Steps will be taken by the Project Manager and designated ESHS manager to ensure that regular monitoring of water quality parameters such as pH, suspended solids, turbidity, oil and grease be carried out as provided in the contract. Regular monitoring of noise and dust will also be carried out as provided in the environmental monitoring program especially on working sites with machinery uses.

8.3.4. Record keeping

Monitoring forms should be devised for documentation, analysis and record of parameter. The form should focus attention on environmental issues and provide feedback for the future stages of the work. Mitigation and enhancement measures adopted in final design will be explicitly under the Bill of Quantities (BOQ) so that performance and completion is readily documented. Daily project diaries would record environmental problems (injuries, spills, dust, noise, etc.) as well as safety incidents and will be retained as part of accepted modern contract management and summarized in Quarterly Environmental Reports.

8.3.5. EMP Implementation schedule

The most important aspects of the implementation is the appointment of the Environmental Officer at WASAC level and at Contractor level to oversee the implementation of the environmental mitigation measures incorporated in the design and contract specifications. Most of the planned mitigation measure will be implemented along with project activities and is provided in Environmental Management Plan and Environmental Monitoring Plan.

8.4. Scope of Land Acquisition and Resettlement Management

At this stage of project preparation, there is no Resettlement Plan prepared. However, it was noted the implementation of the project requires land for infrastructure sitting especially the water treatment Plant, and water reservoir and wellfield. Some of the land is government owned land/ public land and others are privately owned. Therefore, a Resettlement Plan including a census survey of all affected land and properties needs to be conducted prior to the project implementation and documented in an Abbreviated Resettlement Action Plan (ARAP). This section describes key requirement and processes for the preparation of the A-RAP.

8.4.1. Objective and purpose

The Resettlement Plan is a prerequisite to determine the level of those who will be ne negatively impacted by the project implementation and resettled to pave the way the project activities. Therefore a cut of date will be determined by WASAC Ltd in collaboration with District and local authorities. This will be done with the aim of areas not to carry out any development activities within the project sites. The residents nearby the project sites are also informed about the cut-off date and commencement of the census survey and that any construction, crops planting or structure expansion or improvement on their assets and people coming into the area after the cut-off date are not eligible for compensation or assistance. This would take emphasis especially at the location of the pipelines considering that there was no household or other structures that was identified to be affected by the project implementation at the WTP except land and trees/ crops.

8.4.2. Eligibility criteria and entitlement matrix

This section sets out eligibility criteria, which are necessary to determine who will be eligible for resettlement and benefits, and to discourage inflow of ineligible people.

- ✓ **Principles**

The involuntary taking of land resulting in relocation or loss of shelter; and loss of assets or access to assets or loss of source of income or means of livelihood, whether or not the PAPs must move to another location or not. Meaningful consultations with the affected persons, local authorities and community leaders will therefore allow for establishment of criteria by which displaced persons will be deemed eligible for compensation and other resettlement assistance. Affected people eligible for compensation and resettlement in three groups as shown below.

a) Those who have formal rights to land including customary/communal land, traditional and religious rights recognized under Rwandan Law.
b) Those who do not have formal legal rights to land at the time the census begins but have a claim to such land or assets provided that such claims are recognized under the laws of Rwanda or become recognized through a process identified in the resettlement plan.
c) Those who have no recognizable legal right or claim to the land they are occupying, using or getting their livelihood from before the cut of date.

- ✓ **Entitlement Matrix**

PAPs entitlement matrix is provided in Table 3 below it provides an indication of resettlement and compensation measures to restore livelihoods impacted by the loss of land, crops and other structures. It is important to pay special consideration to vulnerable people, for instance, giving them high priority to be employed as project labours.

Based on the laws of Rwanda, JICA guidelines, and World Bank Safeguards Policies, compensation and assistance by the project, entitlements, and compensation calculation methods are summarized in the matrix below.

Table 39: Compensation entitlement matrix

Type of Loss	Entitled Person	Type of Impact	Compensation/Entitlement/ benefits	Responsible Organization
Land (Agricultural/ residential)	Title holder	**No displacement:** Less than 20% of land holding affected, the remaining land remains economically viable	Cash compensation for affected land equivalent to full replacement cost	WASAC Ltd / MINECOFIN
		Displacement: More than 20% of land holding lost or less than 20% of land holding lost but remaining land not economically viable	Cash compensation for affected land equivalent to full replacement cost	
	Rental/ lease holder	**No displacement:** Land used for residence partially affected, limited loss, and the remaining land remains viable for present use	Cash compensation equivalent to 10% of lease/ rental fee for the remaining period of rental/ lease agreement (written or verbal)	WASAC Ltd /MINECOFIN
Buildings and other structures	Owner	**Displacement:** Entire structure affected or structure partially affected but the remaining structure is not suitable for continued use	Cash compensation of full replacement cost for entire structure and other fixed assets without depreciation, or alternative structure of equal or better size and quality in an available location which is acceptable to the PAP. Right to salvage materials without deduction from compensation.	WASAC Ltd /MINECOFIN
Standing crops	1. Land owners 2. Crop Owner	Crops affected by land acquisition or temporary acquisition or easement	Cash compensation equivalent to market value/ full replacement cost for the mature and harvested crop. For crop owners with lease title: Cash compensation for the harvest of the affected land equivalent to existing market value (full replacement cost)	WASAC Ltd /MINECOFIN

Type of Loss	Entitled Person	Type of Impact	Compensation/Entitlement/ benefits	Responsible Organization
			of the crop for the remaining period of tenancy/ lease agreement, whichever is greater	
Trees	1. Land owners 2. Tree Owner	Trees lost	Cash compensation based on type, age and productive value of affected trees.	WASAC Ltd /MINECOFIN
Temporary Acquisition	1. Owner 2. Tenant/ occupant	Temporary acquisition	Cash compensation for any assets affected (e.g. boundary wall demolished, trees removed)	WASAC Ltd /MINECOFIN

8.4.3. Cut-off date, assets inventory and valuation methods

a) Cut-off date

Compensation eligibility will be limited by a cut-off date which should be date of commencement of the census survey of PAPs. The precise cut-off date will be publicly announced by the local leaders in advance and the census of PAPs and assets inventory will commence immediately following this announcement.

b) Assets inventory and valuation methods

This section describes the methods to be used in valuing assets that will be eligible for compensation consistent with either Rwandan laws or policies or IFAD. Law No.17/2010 of 2010 establishes and organizes the Real Property Valuation Profession in Rwanda. It provides the registration of land valuers in Rwanda and conditions for registration. The law also allows the Government to conduct valuation when mandated by their government institutions. Articles 27, 29, 30 and 31 of the law deal with valuation methods and stipulate that the price for the real property shall be close or equal to the market value. Land values could also be compared country wide. Where comparable prices are not available to determine the value of improved land, the replacement cost approach shall be used to determine the value of improvements to land by taking real property as a reference. The law also allows the use of international methods not covered by the law after approval of the Institute of Valuers.

c) Valuation methods

Valuation methods recognized under valuation law in Rwanda include:

- **Use of Standard Valuation Tables**

The implementation of the proposed project will be done in all 30 districts and it is anticipated that a relatively large number of small-scale asset valuations will need to be carried out during the course of the project. It would therefore be cumbersome and inefficient to deploy an individual valuation expert in each and every case. Therefore, it is recommended that the independent value is hired to provide the list of properties value and this list will be used by district to calculate the compensation package for affected people when the need arises. The compensation rates / valuation tables would be developed using legally acceptable valuation procedures accepted by both the Government of Rwanda and World Bank for purposes of fairness and consistency. The approach will consider replacement costs and types and levels of compensation under the Rwanda law. Valuation of lost assets will be made at their replacement cost.

- **Comparison of Land/Property Values Countrywide**

In case there are no compensation rates, the Valuer shall compare prices by referring to the prices recently assigned to a real property that is similar or comparable to the real property subject to valuation. Where comparable prices are not available for land in a particular area, the Valuer may use comparable prices of similarly classified land from other areas of the country

- **Replacement Cost Approach**

The replacement cost approach is based on the premise that the costs of replacing productive assets is based on damages caused by project operations. These costs are taken as a minimum estimate of the value of measures that will reduce the damage or improve on on-site management practices and thereby prevent damage. The approach involves direct replacement of expropriated assets and covers an amount that is sufficient for asset replacement, moving expenses and other transaction costs.

- **Gross Current Replacement Cost**

Gross Current Replacement Cost (GCRC) is defined as the estimated cost of erecting a new building having the same gross external area as that of the existing one, with the same site works and services and on a similar piece of land.

- **Other methods**

Rates from Contractors*:* When rate schedules do not exist or are out of date, recent quotations by contractors for similar types of construction in the vicinity of the project can be used for calculating replacement costs. In projects offering the options of cash compensation or alternative accommodation, the construction cost estimates for alternative accommodation could be used for calculating cash compensation payable.

It is recommended that the replacement Cost is used as valuation methods and results can be used to prepare standardised valuation tables. This is because the Replacement cost valuation methods is recommended by ESS5 and recognised by valuation law in Rwanda. Standardized table will easy the valuation process given that small scare valuation site are scattered in different places.

8.4.4. Calculation of compensation by assets

The following methods of calculation should be adopted for the preparation of the aforementioned standardized asset valuation tables and/or the application of specific case by case valuations in the case of projects that have significant impacts.

(i) Compensation for Land

Compensation for land is aimed at providing a farmer whose land is acquired and used for project purposes, with compensation for land labour and crop loss. For this reason, and for transparency, land is defined as an area or homestead (i) in cultivation, (ii) being prepared for cultivation, or (iii) cultivated during the last agricultural season. This definition recognizes the farmer's labour as the biggest investment he/she makes in producing a crop which is higher than all other inputs such as seed and fertilizer. As a result, compensation relating to land will cover the market price of labour invested as well as the market price of the crop lost.

(ii) Land Measurement

For purposes of measuring land, the unit of measurement would be that which is used and understood by the affected farmers and if a traditional unit of measure exists in the rural areas, that unit should be used. If a traditional unit of measurement does not exist in a particular area, then it is recommended that land should be measured in meters or any other internationally accepted unit of measurement. However, in such an event, the unit that is being used must be explained to the affected farmers/users and must somehow be related to easily recognizable land features that the communities are familiar with, such as using location of trees, stumps, etc as immovable pegs. The most important concern of this exercise is to ensure that the affected person is able to verify using his/her own standards/units of measurement, the size of land that is being lost. This will ensure transparency in the system and will thus avoid subsequent accusations of wrong measurements or miscalculation of areas. A farmer should know how much land he/she is losing, in terms of size and the replacement land must be at least of that same size and comparable value as land lost.

(iii) Calculation of Crops Compensation Rate

The current prices for cash crops will be determined and all crops will be valued using a single rate considering the crop at mature age. This rate incorporates the value of crops and the value of the labour invested in preparing new land. Determining compensation using a single rate creates transparency because anyone can measure the area of land for which compensation is due and multiply that by a single rate known to all. This approach also allows assignment of values to previous year's land (land in which a farmer has already invested labour) and land that have been planted but crops have not germinated. Further, it avoids contention over crop density and quality of mixed cropping.

The value of the labour invested in preparing agricultural land will be compensated at the average wage in the community for the same period of time. The rate used for land compensation should be updated to reflect values at the time compensation is paid. Table 5 below, derives a total value for a one-hectare land from the value of the crops on the land and the value of labour invested in preparing a replacement land.

Figure 29: Example of method to be used to determine a monetary compensation rate for land*

Item Compensated	Basis of Value	Rwandese Francs/ha
	Average of the highest 2020 official and market survey land prices per ha of staple food crops (maize, rice etc.), plus cash crops (e.g. sugar cane, corn).	

	Labour costs of preparing a replacement land.	
Total	Replacement value of crops plus labour.	

(Rwandan Francs payments will be revised to reflect crop values and labour rates in effect at the time of compensation). This example assumes a one-hectare land. Crop values will be determined on:

- A combination of staple foods and cash crops. The 80/20 ratio of land that a farmer typically has in food crops and cash crops is used to determine the chances s/he would lose food crop rather than a cash crop income.
- The value of stable crops to be taken as the highest market price (over 3 years) reached during the year, in recognition of the following factors:
- Although most farmers grow staple crops mainly for home consumption, they always have the option of selling these crops to take advantage of the market.
- Farmers most often purchase cereals when they have run out, during drought when prices are high. Compensating at a lower value might put the individual or household at risk.
- On average, the highest price of stable food yields a high per hectare value reimburses for the vegetables and other foods that are commonly inter-cropped with staples, but are almost impossible to measure for compensation.
- The labour cost for preparing replacement land is calculated on what it would cost a farmer to create a replacement land. This value is found by adding together the average costs of clearing, ploughing, sowing, weeding twice, and harvesting the crop.

(iv) Compensation for vegetable gardens

Until a replacement garden starts to bear, the family displaced (economically or physically), will have to purchase vegetables in the market for daily use. The replacement costs therefore, will be calculated based on the average amount that an average town dweller spends on buying these items for one year from the local market.

(v) Compensation for horticultural, floricultural and fruit trees

Banana and Mango trees are featured here below as two examples of the set of primary fruit trees that are likely to be found in project targeted area and are estimated to account for a significant amount of all fruit bearing trees. They are primarily important as a source of:

- Subsistence food for families
- Cash produce that contribute to the export economy
- Petty market income in some areas, and
- Shade (in the case of mango trees).

For banana trees, they have a relatively much shorter productive life, normally, than mango trees. For species, banana trees will not bear fruit more than once. Therefore, compensation for banana trees would be compensated at the full market rates for bananas harvested in that year and for another year. The second year payment is for the replacement cost of planting a new tree, looking after it and harvesting it which could all be done in one year. Therefore, the farmer should have restored his pre-project position by the end of the second year. This example of bananas is an example for trees/plants that have a relatively short life.

As defined in this policy, individuals will be compensated for wild trees which are located in their land. Wild productive trees belong to the community when they occur in the bush as opposed to fallow land. These trees will be compensated for under the umbrella of the community compensation.

8.4.5. Asset inventory, PAPs identification and compensation

(i) Assets inventory and PAPS

In order to prepare for compensation and other resettlement benefits, it is imperative that a comprehensive asset and affected persons inventory in the designated areas for the different project components is done. The inventory will specify the different assets, properties affected in each plot of land and their owners. The Land Valuation Bureau which is the entity responsible for undertaking valuation of assets will be responsible for the valuation exercise and will therefore provide independent valuation experts. The valuation document will indicate when the affected person will be notified, and that the inventory will not be official until a second signed copy, verified by project supervisory staff, is returned to the affected person. At this time, a copy of the grievance procedure will also be given to the affected person as stated in the grievance redress mechanism. The valuation experts will work hand in hand with the local leaders of the area.

(ii) Forms of Compensation

Individual and household compensation will be made in cash, in kind, and/or through assistance. The type of compensation will be an individual choice although every effort will be made to instil the importance and preference of accepting in kind compensation if the loss amounts to more than 20% of the total loss of subsistence assets. Compensation payments raises issues regarding inflation, security and timing that must be considered. One purpose of providing in-kind compensation is to reduce inflationary pressure on the cost of goods and services. Local inflation may still occur and thus market prices will be monitored within the time period that compensation is being made to allow for adjustments in compensation values. The issue of security, especially for people who will be receiving cash compensation payments should to be addressed by the local administration. The RPF has provided an entitlement matrix that shows type of compensation for each category.

(iii) Procedures for delivery of compensation

It is recommended that compensation be made through reputable local banks. This will ensure security of the PAPs money especially for those receiving large sums. Forms acknowledging receipt of the compensation packages shall be signed by each PAP.

8.4.6. Implementation and monitoring framework

✓ WASAC LTD

WASAC will be reversible for the preparation of abbreviated RAP, its implementation and monitoring.. The social safeguard Specialists of WASAC will be the focal point RAPs implementation and will liaise with other stakeholders to executive RAP. The Specialist will ensure that the procedures and requirements of the Rwandan laws and donor environmental and Social Polices are complied with. A key role will be to implement the RAP and other resettlement-related activities and to ensure that all procedures have been adhered to and that there is consistency in approach between sub-projects activities. It will also undertake the main monitoring and evaluation role of resettlement activities during and post implementation.

✓ Rwanda Land Use and Management Authority(RLMUA)

RLMUA through its department of Land administration and Mapping is the organ responsible for overall management and coordination of all activities related to land administration, land use planning and management in Rwanda. The role of RLMUA in RAP process will be to advise on matters related to land ownership and expropriation. District land bureau in close collaboration with project staff will check and approve surveys, various maps and approve land surveys carried out during the RAP exercise.

✓ Rwanda Environment Management Authority(REMA)

REMA was established in 2004 to act as the implementation organ of environment-related policy and laws in Rwanda. REMA is also tasked to coordinate different environmental protection activities undertaken by environmental promotion agencies; to promote the integration of environmental issues in development policies, projects, plans and programmes; to coordinate implementation of Government policies and decisions taken by the Board of Directors and ensure the integration of environmental issues in national plan among concerned departments and institutions within the Government; to advise the Government with regard to the legislation and other measures relating to environmental management or implementation of conventions, treaties and international agreements relevant to the field of environment as and when necessary; to make proposals to the Government in the field of environmental policies and strategies; etc. In Regards to the implementation of this ARAP, REMA will ensure that all policies and regulations related to resettlement are observed and advise on the better way to implement RAPs. This will be done together with environmental monitoring.

✓ Kicukiro District

As indicated in section 3.6, the Land Office is a district based institution authorized by law to manage land. The DLBs will be responsible for ensuring activities undertaken comply with the National and District level Land Use Master Plans. They will assess the validity of land tenure rights of affected persons and eventually provide the land use permit for the new activity proposed by the sub- project. In addition they will be responsible for ensuring effective grievance mechanisms are in place. They will also be used in the design of the RAP as much as possible in order to ensure that community buy in is present at an early stage hence reducing disputed or grievances. Their activities will be monitored by the District authority.

The District Land Offices will play a major role in RAP implementation by:

- Issue construction permits and monitor compliance with construction plans
- Monitor and approve activities pertaining to valuation of land and other immovable property;
- Demarcate and approve land cadastral;

- Establishing project level Resettlement and Compensation Committees at Sector/ Cell level;
- Clarifying the policies and operational guidelines of these Resettlement and Compensation
- Committees;
- Review and approve valuation report done by independent Valuer and ensure that are in compliance with valuation, expropriation and land laws.
- Coordinating and supervising implementation by Resettlement and Compensation Committees

✓ **District resettlement committee**

The Kicukiro district will work closely with WASAC in the implementation of the A-RAP. A team that includes a civil Engineer, District Land Bureau officer, Social Safeguards specialist(provided by designated SPIU), executive secretaries of Kicukiro sector affected sectors and PAPs representatives will be responsible for resettlement and ensure that the A-RAP is properly applied across all relevant subprojects. Its initial role will be to undertake screening and assessment of potential subprojects. The team will be supported by the project Social Safeguards team based at project headquarters.

✓ **Resettlement Committees at site level**

Based on Rwanda's decentralization governance and project nature, the responsibility for the development and implementation of the RAPs will be at district and site level. Once resettlement requirements, affected assets and affected persons has been identified via the census process, District Land Bureau representatives will be responsible for electing members of a sub-project Resettlement and Compensation Committee. This committee will be constituted for the sole purpose of RAP implementation arrangements, and will operate at District level and site level. It is proposed to be coordinated by the District Land Bureau, due to the executive powers of the DLB.

This committee will plan for, coordinate and monitor resettlement, compensation and relocation activities, as well as supervise compensation payments to the recipient PAPs. A large part of their responsibility will be consultation with potential PAPs.

It is recommended to have site resettlement committee at each block and the Site Resettlement and Compensation Committee would comprise the following:

- Representative from Sectors preferably the land manager
- Representative of four cells that are affected
- Representative from the District Development Committee;
- Representative from any other key sector office involved in the resettlement process;
- Key stakeholder's representative from the implementing organization;
- Two representatives of PAP by cells (equal gender representation); and

The Resettlement and Compensation Committee would have responsibility for:

- Verifying PAPs
- Validate inventories of PAPs and affected assets;
- Allocate land, where required, to permanently PAPs;
- Monitor the disbursement of funds;
- Guide and monitor the implementation of relocation;
- Coordinate activities between the various organizations involved in relocation;
- Facilitate conflict resolution and addressing grievances; and
- Provide support and assistance to vulnerable groups including widows, orphans, and the old persons among others).

This committee should meet on a regular basis (as determined by the needs of the project) to ensure that resettlement activities are appropriately designed and executed. It is recommended that a representative be elected to act as the District Project Coordination officer who would act as the key contact with PAPs and therefore facilitate implementation of consultation, public participation and grievance mechanisms.

✓ **Mediators/Abunzi**

At the Cell, there are in place mediators (Abunzi) whose work is to hear disputes, especially land disputes. The Abunzi, or mediation committees, have mandatory jurisdiction over land disputes involving amounts less than three million RwF, which means over most land disputes. The Abunzi also have mandatory jurisdiction over succession and boundary disputes involving less than three million Rwanda Francs. The Abunzi will be

used in the sub project as the first stop for resolving disputes and grievances following land acquisition. They will be involved in the compensation process from the beginning to the end. They will also be used in the design of the RAPs as much as possible in order to ensure that community buy in is present at an early stage hence reducing disputed or grievances.

- ✓ **Project Affected Persons**

This group of people will also help identify community projects that will lead to the uplifting of the lives as well as share in project. PAPs will also participate in planning and implementing resettlement programs.

Table 40: Summary of Institutional Responsibilities RAP implementation

Institutions	Responsibilities
WASAC LTD	- Collation of information regarding Masaka project , including ARAP documentation. - Review and approval of Resettlement related documentation from all subprojects(screening forms, A-RAP reports etc) to ensure consistency and compliance with regulations; - Overall monitoring and evaluation of resettlement implementation (i.e., annual audits and review of sub-project level monitoring undertaken by District authorities), ensuring that ARAPs are implemented in accordance with regulations - Initiate the resettlement process identify resettlement and compensation requirements
	- Preparation and signature of Compensation Grant agreement with the District - To establish Resettlement and Compensation Committee in consultation with District Land Bureau - Have a representation in sub-project Resettlement and Compensation Committee - Provision of capacity building and technical support relating to resettlement and compensation activities; - Ensure funds allocated appropriately, according to RAP.
RLMUA	- To advise on matters related to land ownership and expropriation Exercise. - To participate in verification of land ownership and land titles
District	- Verify land owners from records of land register - Issue construction permits and monitor compliance with construction plans - Monitor and approve activities pertaining to valuation of land and other immovable property - Approve land expropriated land surveys - Work in collaboration with the Sub- Project Resettlement and - Compensation Committees to ensure that 'fair and just' compensation is reached in accordance with the law and the requirements of this RAP. - To identify resettlement site in any physical resettlement is required - To coordinate the land for land compensation and land retributions
District Resettlement Committee	- Verifying PAPs - Validate inventories of PAPs and affected assets; - Allocate land, where required, to permanently affected households - Facilitate conflict resolution and addressing grievances - Guide and monitor the implementation of relocation
Site resettlement Committee	- Help in creating awareness on expropriation process - Monitor the implementation of community resettlement work closely with environment protection committees to monitor the use of marshlands and reserved areas; - Conflicts resolution - Help in land demarcation confirm holders of land rights during land resettlement process, help in the resettling of the displaced in the community, participate in the identification of community settlement sites, identify and list escheat land, and serve as witnesses in compensation and resettlement
Mediators/ Abunzi	- Resolving disputes - Provide grievances mechanism following land acquisition. - Help in designing resettlement programs at the community level to ensure community buy in.
Project Affected Persons	- Be present when the land survey and inventory is being carried out - Provides all required information in regards to resettlement activities - Participate in compensation and livelihood activities

8.4.7. Grievance Redress Mechanism

The District of Rwamagana is an acknowledged institution for which the PAPs have been made aware of as avenues for expressing discontent and disapproval to the resettlement and compensation process. Article 26 of the Expropriation Law of 2015 provides complaints procedures for individuals dissatisfied with the value of their compensation. The Law stipulates that dissatisfied persons have a period of 30 days after project approval decision has been taken to appeal (Article 19).

Grievance procedures are required to ensure that PAPs are able to lodge complaints or concerns, without cost, and with the assurance of a timely and satisfactory resolution of the issue. The procedures also ensure that the

entitlements are effectively transferred to the intended beneficiaries. Stakeholders will be informed of the intention to implement the grievance mechanism, and the procedure will be communicated at the time that the RAPs are finalized. Grievances may arise from members of communities who are dissatisfied with eligibility criteria use, community planning and resettlement measures, actual implementation or compensation.

- ✓ **GRM process**

The overall process of grievance is as follows:

- During the initial stages of the valuation process, the affected persons will be given copies of grievance procedures as a guide on how to handle the grievances.
- The process of grievance redress will start with registration of the grievances to be addressed for reference, and to enable progress updates of the cases.
- The project will use a local mechanism, which includes resettlement committees, peers and local leaders of the affected people. These will ensure equity across cases, eliminate nuisance claims and satisfy legitimate claimants at low cost.
- The response time will depend on the issue to be addressed but it should be addressed with efficiency.
- Compensation will be paid to individual PAPs only after a written consent of the PAPs, including both husband and wife.

- ✓ **GRM procedures**

The aggrieved person should file his/ her grievance, relating to any issue associated with the resettlement process or compensation, in writing to the subproject Resettlement and Compensation Committee. The grievance note should be signed and dated by the aggrieved person.

The WASAC social safeguards officer and the Resettlement and Compensation Committee will consult to determine the validity of claims. If valid, the Committee will notify the complainant and s/he will be assisted. The Resettlement and Compensation Committee will respond within 14 days during which time any meetings and discussions to be held with the aggrieved person will be conducted. If the grievance relates to valuation of assets, a second or even a third valuation will be undertaken, until it is accepted by both parties. These should be undertaken by separate independent valuers than the person who carried out the initial valuation.

If the aggrieved person does not receive a response or is not satisfied with the outcome within the agreed time, s/he may lodge his/her grievance to the relevant Municipal Administration such as the District Land Bureau, also mandated to help resolve such matters. If requested, or deemed necessary by the subproject Committee, the District Project Coordination officer will assist the aggrieved person in this matter.

The relevant Local Administration will then attempt to resolve the problem (through dialogue and negotiation) within 30 days of the complaint being lodged. If no agreement is reached at this stage, then the complaint is dealt with through the local courts (Abunzi) where possible. Where matters cannot be resolved through local routes, the grievance will be referred to higher authorities at the national level. The Resettlement and Compensation Committee will provide assistance at all stages to the aggrieved person to facilitate resolution of their complaint and ensure that the matter is addressed in the optimal way possible.

If administrative ways of grievance redress is not enough to address the complaint, then the agrieveted person may refer to judicial system. Based on the nature of complaints, the process will start from mediators for asses below 3 million Rwandan francs and if the value is more than three million, the process will start from intermediate courts , High court and to supreme court.

- ✓ **Grievance Log**

The District land Bureau will ensure that each complaint has an individual reference number, and is appropriately tracked and recorded actions are completed. The log will contain record of the person responsible for an individual complaint, and records dates for the following events:

- Date the complaint was reported;
- Date the Grievance Log was added onto the project database;
- Date information on proposed corrective action sent to complainant (if appropriate);
- The date the complaint was closed out; and
- Date response was sent to complainant.
- The District Project Coordination officer will be responsible for:
- Providing the sub-project Resettlement and Compensation Committee with a weekly report detailing the number and status of complaints;

- Any outstanding issues to be addressed; and
- Monthly reports, including analysis of the type of complaints, levels of complaints, actions to reduce complaints and initiator of such action.

8.4.8. Monitoring

The objective of the monitoring and evaluation process will be to determine whether PAPs have been paid in full and before implementation of the subproject, and people who were affected by the subproject have been affected in such a way that they are now living a higher standard than before, living at the same standard as before, or they are they are actually poorer than before. The arrangements for monitoring the resettlement and compensation activities will fit into the overall monitoring program of the entire project, which will fall under the overall responsibility of WASAC.

✓ Monitoring Indicators

A number of indicators would be used in order to determine the status of affected people (land being used compared to before, standard of house compared to before, level of participation in project activities compared to before, how many kids in school compared to before, health standards, etc). Therefore, the resettlement and compensation plans will set two major socio-economic goals by which to evaluate its success: Affected individuals, households, and communities are able to maintain their pre-project standard of living, and even improve on it; and the local communities remain supportive of the project.

In terms of the resettlement process, the following indicators could be used to understand the success of the measures identified and the working of the relevant parties in implementation the RAP:

- Percentage of individuals selecting cash or a combination of cash and in-kind compensation;
- The number of contentious cases as a percentage of the total cases;
- The number of grievances and time and quality of resolution;
- Number of impacted locals employed by the civil works contractors; and
- General relations between the project and the local communities.

These will be determined through the following activities:

- Questionnaire data will be entered into a database for comparative analysis at all levels of local government;
- Each individual will have a compensation dossier recording his or her initial situation, all subsequent project use of assets/improvements, and compensation agreed upon and received.
- The District authorities will maintain a complete database on every individual impacted by the sub-project land use requirements including relocation/resettlement and compensation, land impacts or damages; and WASAC should prepare Resettlement Completion Reports for each RAP, in addition to other regular monitoring reports.
- Resettlement and Compensation Committee will facilitate coordination of information collation activities (such as surveys, supervising documentation) in accordance with procedures put in place.
- WASC will provide training, technical support and funds to ensure that this happens. In order to assess whether these goals are met, the resettlement and compensation plans will indicate parameters to be monitored, institute monitoring milestones and provide resources necessary to carry out the monitoring activities.

✓ Monitoring of RAP Implementation

Local Government Authorities from district level will assist in compiling basic information from the project, and convey this information to the SPIU, on a quarterly basis. They will compile the following statistics:-

- Number of households and individuals physically or economically displaced by each sub-project;
- Length of time from sub-project identification to payment of compensation to PAPs;
- Timing of compensation in relation to commencement of physical works;
- Amount of compensation paid to each PAP household (if in cash), or the nature of compensation (if in kind);
- Number of people raising grievances in relation to project; and
- Number of unresolved grievances.

Table 41: Sample Format for Monitoring

Work	Planned in total	Progress in quantity	Progress in percentage
Announcement to the affected people			
Cost estimation for resettlement			
Consultation meeting			
Revise of the resettlement plan and signing based on the feedback at the consultation meeting			
Compensation in cash			
Compensation by land			
Social supports such as job training			
Number of unresolved grievances.			

WASAC will scrutinize these statistics in order to determine whether the resettlement planning arrangements as set out in this RAP are being adhered to. The project team will alert WASC, if there appears to be any discrepancies. WASC will directly monitor compensation and loss of wages. Financial records will be maintained by the district land bureau to permit calculation of the final cost of resettlement and compensation per individual or household. The indicators that will be used to monitor implementation of the RAP include.

- Outstanding compensation contracts not completed before next agricultural season
- Projects unable to settle compensation after two years
- Grievances recognized as legitimate out of all complaints lodged

Financial records will be maintained by Project team to permit calculation of the final cost of resettlement and compensation per individual or household.

- ✓ **Storage of PAPS details**

Each PAP household will be provided with a signed report recording his or her initial situation, all subsequent project use of assets and compensation agreed upon and received. At the same time, before compensation all household heads representing the PAPs will be required to provide passport size photographs. The Local Authority and project management team will maintain a complete database on every individual impacted by the project land use requirements including relocation, resettlement and compensation, land impacts or damages.

Each recipient of compensation will have a record containing individual bio-data, number of household dependents and amount of land available to the individual or household when the report is opened. Additional information to be acquired for individuals eligible for resettlement and/or compensation include the level of income and of production, inventory of material assets and improvements in land and debts. Each time land is used by a sub-project; the report will be updated to determine if the individual or household is being affected to the point of economic non-viability and eligibility for compensation or its alternatives.

- ✓ **Socio-economic Monitoring**

The purpose of socio-economic monitoring is to ensure that PAPs are compensated and recovering on time. During implementation of each subproject A-RAP, an assessment will be undertaken on payment of compensation, restoration of income delivery of resettlement objectives. Monitoring of living standards will continue following resettlement.

A number of indicators will be used to determine the status of affected people and appropriate parameters and verifiable indicators will be used to Measure the resettlement and compensation plans performance. For this sub-project with adverse social impacts, a monitoring and evaluation plan of the mitigation measures will be established. As part of the preparation of each RAP, a household survey will be conducted of all PAPs, prior to physical or economic displacement, and this will provide baseline data against which to monitor the performance of the ARAP.

8.4.9. A-RAP Preparation and Implementation Schedule and next steps

Responsible organizations and the schedule for the ARAP preparation and implementation are shown in the table below. This schedule is applicable to the PAPs who are eligible for compensation and available and posses all the required documents including land titles.. For those who are absent or not meet the requirements, the processes to be taken are the same but the timing when each process happens may differ, depending on the PAPs.

Table 42: ARAP implementation schedule and next steps

Process	Responsible Organization	2023						
		Jun	Jul	Aug	Sept	Oct	Nov	Dec
Recruitment of Assets Valuer	WASAC Ltd							
ARAP Preparation	WASAC Ltd	X	X	X				
Preparation of compensation forms	WASAC Ltd, Property valuer, Sector/Cell leaders, District One Stop Center			X	X			
Approval of compensation forms	WASAC Ltd Social Safeguard Specialist				X			
Financial arrangement in WASAC ltd	WASAC Ltd Social Safeguard Specialist, Finance Department			X	X	X		
Submission of compensation payment order to MINECOFIN	WASAC Ltd Finance Department					X	X	X
Payment order to the Bank	MINECOFIN					X	X	X
Compensation Payment	Banks of PAPs					X	X	X

CHAPTER IX: CONCLUSIONS AND RECOMMENDATIONS

9.1. Conclusions

The conduct of the study in all steps has identified a number of issues pertaining to the proposed project of rehabilitation and extension of Karenge water treatment Plant. The pertaining impacts have been assessed and described in details to gain an adequate understanding of possible socio and environmental effects of the proposed project in all its implementation phases. The analysis of impacts was done in order to formulate mitigation measures in response to negative aspects which have raised. The Environmental Management Plan (EMP) provides a way forward for implementation of the identified mitigation measures. The EMP should be implemented as a requirement for a positive Record of Decision (by the appropriate authorities.

The estimated costs for implementation of the mitigation measures are just indicative. Appropriate bills of quantities should clearly give the actual figures. In any case the consultant has used judgment and cost for similar project to come up with these figures. The Environmental Monitoring Plan provides parameters to be monitored and responsibility. While the consultant is aware that each monitoring aspect need to have a separate budget.

The consultant is recommending that the Project Developer/WASAC Ltd assigns Social and Environmental officer to undertake the monitoring of the mitigation measures for the project through its existence. This way the proponent will achieve sustainable project implementation at reduced cost for undertaking the monitoring. The figures given are considered to be absolute maximum such monitoring could cost. However, regular internal monitoring shall be carried out by the project supporter.

Based on the study components and findings, the Consultant is of the opinion that most of the potential environmental impacts identified can be mitigated while applying the proposed measures. The proposed environmental management plan and environmental monitoring plan if implemented will protect the integrity of the environment.

Taking into the considerations of the nature and location of this project and its needs, the conclusion is that the potential impacts associated with the proposed project are of a nature and extent that can be refused, reduced, limited and eliminated by the application of appropriate proposed mitigation measures.

9.2. Recommendations

In addition to the Environmental and social Management plan and the proposed mitigation measures the ESIA team came up with the following recommendations:

1. Before the implementation of the project WASAC shall discuss with land owners and compensate all persons to be affected by permanent infrastructure. An easement agreement should be also negotiated for water supply pipelines
2. The guaranteed water abstraction quantity of 48.000 m^3/day should be respected and considering the lack of scientific evidence and enough data on water quantity of Lake Mugesera, the consultant is recommending that sustainable water supply withdrawal should be further studied considering the water balance of the Mugesera Lake in regards to other similar projects requiring the water from the same lake.
3. An abbreviated Resettlement Plan should be prepared and valuation of affected assets should be conducted prior to the project approval processes and funds allocated for timely compensated.
4. Fair compensation of all assets to be affected by the project should be done prior to the project activities and this with involvement of Local authorities.
5. Affected people and local communities should be given priority when allocating for jobs
6. All on sites works (construction of temporary offices, temporary storages facilities, cement and mortar mixing etc) should be done beyond the buffer zone of Lake Mugesera (50 m) to avoid and minimize the Lake pollution.
7. Regular monitoring of a joint team made of WASAC, REMA, RWB, Rwamagana District etc should be regularly conducted to assess the implementation of the EMP , ;
8. Where possible local community should be connected to the nearby passing water network so as to take advantages of this project.
9. Land acquisition should be done in phases and start with the land required for phase one. This is to avoid holding the land for long time before using it and allow local community to use the land.

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Annex 1: List of contacted people

A. Government Institutions

Names	Institution	Contact
SHUMUSHO Marcellin	WASAC Ltd/ Karenge WTP	0788848479
Vital MUNYANDINDA	RWB/	0788225918
RWAKAYIGAMBA	Rwamagana District	0788454412
Jacques NSENGIYUMVA	REMA	0786624431
Simeon NTUYE	RDB	0788353048
BAVUGE Alvin Bernardin	Expert in Environmental & Climate Change/REMA/LDCF II	0788413796
MUDENGE Jean Paul	Rwamagana District Environmental Officer	0788642401
KWIZERA Alphonse	Forestry and Natural Resources Officer	0783085175

B. Local residents

No	Names	Institutions	Contact
1	NSANZUMUHIRE Ildeponse	Local Resident/ PAP	0726760912
2	UWISHEMA Hervin	Local Resident/ PAP	0724927262
3	NYIRABAMENYI Modesta	Local Resident/ PAP	0727241355
4	UWOSHEJE Julien	Community member	782223434
5	NYIRAMANA Vestine	Community member	783030965
6	MUJAWAYEZU Rachel	Community member	782924452
7	MUNYANKUYU Theogene	Community member	787377282
8	KAGAJU Evelyne	Community member	723620676
9	MUREKATETE Anastasie	Community member	728978284
10	UWISENGEYE Ernestine	Community member	725011810
11	UWIRAGIYE Bernard	Community member	784942576
12	MANIZABAYO Antoine	Community member	786800963
13	AKAYEZU Esperance	Community member	785966400
14	KURADUSENGE John	Community member	783091880
15	KABANDA Antoine	Community member	781155999
16	MUKASHYAKA Mediatrice	Community member	724444291

17	MUKAKABERA Clementine	Community member	782223434
18	NYIRAMANA Gaudence	Community member	724444291
19	NDABAMENYE Sylivain	Community member	
20	NYIRANIZEYIMANA Priscilla	Community member	787612636
21	KARAMUKA Anathole	Community member	727487804
22	MUKANDINDA Virginie	Community member	728092646
23	NTIYAHABOSE J. de Dieu	Community member	728086276
24	NDAGIJIMANA Eric	Community member	789276444
24	MUTEKANO Abraham	Community member	724124843

Annex 2: Land affected by Karenge water treatment Plant and forwarding infrastructures

- **Households to be affected by Reservoirs**

No	Reservoir	District	Sector	Cell	Village	UPI	Owner Name	Ownership	Area(m^2)
1	Muyumbu_Kanyinya(KN)	Rwamagana	Muyumbu	Ntebe	Kabagabo	5/01/10/04/3366	Nkurunziza Marie Rose	Private	4203
2	Bihembe_High(BH)	Rwamagana	Nyakaliro	Rwimbogo	Kimicanga	5/01/12/05/1266	MININFRA	Government	4279
3	Gasutamo (GS)	Rwamagana	Gahengeri	Kibare	Iramiro	5/01/02/04/572		Government	
4	Gahengeri_Mont_Rugarama (GG)	Rwamagana	Gahengeri	Runyinya	Gacunshu	5/01/02/07/1216		Government	
5	Bihembe_Low(BL)	Rwamagana	Nyakaliro	Rwimbogo	Kimicanga	5/01/12/05/1106	Captaine Franco	Private	587
6	Gahenger_Karutimbo_PS	Rwamagana	Gahengeri	Kibare	Karutimbo	5/01/02/04/102	Kamana Ezechiel	Private	5627
7	Nyabubare (NB)	Rwamagana	Karenge	Nyabubare	Feri	5/01/04/06/475	MININFRA		3015
8	Ryabahesha (RY)	Rwamagana	Muyumbu	Akinyambo	Ryabaheshwa	5/01/10/01/1442	Nyirangendo Veronique	Private	14389
9	Nyakaliro(NL)	Rwamagana	Nyakaliro	Gishore	Rusagara	5/01/12/03/4394	Rukemanganizi Bernard	Private	784
10	Muyumbu_Murehe	Rwamagana	Muyumbu	Murehe	Miyove	5/01/10/03/4759	Tugirinshuti Jean Claude	Private	1165
11	Cyimo Masaka Middle (CY)	Kicukiro	Masaka	Cyimo	Cyimo	1/03/08/02/1563	Ntihinyurwa Thadee	Private	85559
12	Maison des Jeunes Kabuga (RU)	Gasabo	Rusororo	Nyagahinga	Gisharara	1/02/14/07/401	Centre de Jeune Kabuga	Private	5699
13	Kabuga2 (KB2)	Gasabo	Rusororo	Kabuga II	Ruhangare			Government	
14	Nzige_Akanzu(NZ)	Rwamagana	Nzige	Akanzu	Akanzu			Government	

- **Households to be affected by Karenge Intake**

No	District	Sector	Cell	Village	UPI	Owner Name	Owner ID	Area(m^2)
1	Rwamagana	Karenge	Byimana	Rukori	5/01/04/02/478			
2	Rwamagana	Karenge	Byimana	Rukori	5/01/04/02/483	MANIRAHO VENANTIE	Private	207
3	Rwamagana	Karenge	Byimana	Rukori	5/01/04/02/482			
4	Rwamagana	Karenge	Byimana	Rukori	5/01/04/02/476	MININFRA	Government	3153
5	Rwamagana	Karenge	Byimana	Rukori	5/01/04/02/485	udahemuka alphonse	Private	5922
6	Rwamagana	Karenge	Byimana	Rukori	5/01/04/02/484	MUDAHUNGA JEAN BAPTISTE	Private	10353
7	Rwamagana	Karenge	Byimana	Rukori	5/01/04/02/466	MUKANDUTIYE SUSAN	Private	5985
8	Rwamagana	Karenge	Byimana	Rukori	5/01/04/02/465	BYUKUSENGE JEAN DE DIEU	Private	1341
9	Rwamagana	Karenge	Byimana	Rukori	5/01/04/02/464	UWIMBABAZI GERARD	Private	1295
10	Rwamagana	Karenge	Byimana	Rukori	470	RWAKANA HERMOGENE	Private	3778
11	Rwamagana	Karenge	Byimana	Rukori	5/01/04/02/470	NYIRAHAGUMIMANA SPECIOSE	Private	1086
12	Rwamagana	Karenge	Byimana	Rukori	5/01/04/02/481		Government	
13	Rwamagana	Karenge	Byimana	Rukori	5/01/04/02/471	GAKOSI FAUSTIN	Private	1862
14	Rwamagana	Karenge	Byimana	Rukori	5/01/04/02/462		Government	
15	Rwamagana	Karenge	Kabasore	Migamba	5/01/04/03/2490	MUSABYEMARIYA VALENTINE	Private	2712
16	Rwamagana	Karenge	Byimana	Rukori	5/01/04/02/468	MUKANOHERI FLORENCE	Private	3391
17	Rwamagana	Karenge	Byimana	Migamba	5/01/04/02/2106		Government	
18	Rwamagana	Karenge	Byimana	Rukori	5/01/04/02/480	NTAWIBYARA SILAS	Private	6980
19	Rwamagana	Karenge	Byimana	Rukori	5/01/04/02/474	AYINKAMIYE FLORENCE	Private	2231
20	Rwamagana	Karenge	Byimana	Rukori	5/01/04/02/460	RUGANINTWARI PIERRE CELESTIN	Private	4463
21	Rwamagana	Karenge	Byimana	Rukori	5/01/04/02/477	MUJAWAYEZU BERNADETTE	Private	1247
22	Rwamagana	Karenge	Kabasore	Migamba	5/01/04/03/1057	MUDAHUNGA JEAN BAPTISTE	Private	2917
23	Rwamagana	Karenge	Kabasore	Migamba	5/01/04/03/2632	IYIKIRENGA JEAN	Private	738
24	Rwamagana	Karenge	Byimana	Rukori	5/01/04/02/463	MUKANDUTIYE SUSAN	Private	5127
25	Rwamagana	Karenge	Byimana	Rukori	5/01/04/02/469	HAVUGIMANA LAURENT	Private	3645
26	Rwamagana	Karenge	Byimana	Rukori	5/01/04/02/479	MATEMANE MAHIRWE ANTOINE	Private	1955
27	Rwamagana	Karenge	Kabasore	Migamba	5/01/04/03/1056	TURIKUNKIKO ILDEPHONSE	Private	1859
28	Rwamagana	Karenge	Byimana	Rukori	5/01/04/02/467	UWIZEYIMANA STRATON	Private	6105

Household to be affected by Karenge WTP Phase1

No	District	Sector	Cell	Village	UPI	Owner Name	Ownership	Area(m^2)	House
1	Rwamagana	Karenge	Byimana	Byimana	5/01/04/02/1564	GASIMBA CELESTIN	Private	1511	
2	Rwamagana	Karenge	Karenge	Bwiza	5/01/04/05/627	MININFRA	Government	19417	]
3	Rwamagana	Karenge	Byimana	Byimana	5/01/04/02/1831	MPATSWENUMUGABO STEVEN	Private	291	

4	Rwamagana	Karenge	Byimana	Byimana	5/01/04/02/1569		Private		
5	Rwamagana	Karenge	Byimana	Byimana	5/01/04/02/1562	MANIRAFASHA CASSIEN	Private	424	
6	Rwamagana	Karenge	Byimana	Byimana	5/01/04/02/1830	MUKAREBURA EPIPHANIE	Private	252	
7	Rwamagana	Karenge	Byimana	Byimana	5/01/04/02/1568	UZIGAMYUKWEMERA MARIE VIANNEY	Private	1900	
8	Rwamagana	Karenge	Byimana	Byimana	5/01/04/02/1546	NYIRANDORIMANA CLEMENTINE	Private	695	
9	Rwamagana	Karenge	Karenge	Bwiza	5/01/04/05/637	NSANZUMUHIRE ILDEPHONSE	Private	11866	Yes
10	Rwamagana	Karenge	Byimana	Byimana	5/01/04/02/1561	NYIRANDORIMANA CLEMENTINE	Private	601	
11	Rwamagana	Karenge	Byimana	Byimana	5/01/04/02/1832		Private		
12	Rwamagana	Karenge	Byimana	Bwiza	5/01/04/02/1574		Private		

- **Households to be affected by Karenge WTP Phase 2**

No	District	Sector	Cell	Village	UPI	Owner Name	Owner ID	Area(m^2)	House
1	Rwamagana	Karenge	Byimana	Byimana	5/01/04/02/1560	NYIRANIZEYIMANA FLORENCE	Private	174	
2	Rwamagana	Karenge	Byimana	Byimana	5/01/04/02/1570	UZIGAMYUKWEMERA MARIE VIANNEY	Private	476	
3	Rwamagana	Karenge	Byimana	Byimana	5/01/04/02/1576	BANZINIBENSHI OLIVIER	Private	356	
4	Rwamagana	Karenge	Byimana	Byimana	5/01/04/02/1550	GIRIMBABAZI JOSELINE	Private	424	
5	Rwamagana	Karenge	Byimana	Byimana	5/01/04/02/1559	BAZIRE THADEE	Private	468	
6	Rwamagana	Karenge	Byimana	Byimana	5/01/04/02/1575		Private		
7	Rwamagana	Karenge	Byimana	Byimana	5/01/04/02/1548	MANIRAFASHA CASSIEN	Private	706	
8	Rwamagana	Karenge	Byimana	Byimana	5/01/04/02/1547	BAZIRE THADEE	Private	1728	
9	Rwamagana	Karenge	Byimana	Byimana	5/01/04/02/1828	NZABANTERURA SYLIVESTRE	Private	435	
10	Rwamagana	Karenge	Byimana	Byimana	5/01/04/02/1829	NZABANTERURA SYLIVESTRE	Private	289	
11	Rwamagana	Karenge	Karenge	Bwiza	5/01/04/05/640	BAVURIKI SIMON	Private	4293	
12	Rwamagana	Karenge	Byimana	Byimana	5/01/04/02/1567	HAKIZABERA JEAN PIERRE	Private	240	
13	Rwamagana	Karenge	Byimana	Byimana	5/01/04/02/2290				
14	Rwamagana	Karenge	Byimana	Byimana	5/01/04/02/1826	MPATSWENUMUGABO STEVEN	Private	356	
15	Rwamagana	Karenge	Karenge	Bwiza	5/01/04/05/638	MUSAFIRI JEAN MARIE VIANNEY	Private	699	Yes
16	Rwamagana	Karenge	Byimana	Byimana	5/01/04/02/1558	NDAGIJIMANA EPITAS	Private	3176	
17	Rwamagana	Karenge	Karenge	Bwiza	5/01/04/05/639	BAVURIKI SIMON	Private	8368	
18	Rwamagana	Karenge	Byimana	Byimana	5/01/04/02/1549	HITIMANA JEAN BOSCO	Private	572	
19	Rwamagana	Karenge	Byimana	Byimana	5/01/04/02/1529	BAHANGIJAMBO VENANT	Private	9530	
20	Rwamagana	Karenge	Byimana	Byimana	5/01/04/02/2291				Yes
21	Rwamagana	Karenge	Karenge	Bwiza	5/01/04/05/637	NSANZUMUHIRE ILDEPHONSE	Private	11866	Yes
22	Rwamagana	Karenge	Byimana	Byimana	5/01/04/02/1564	GASIMBA CELESTIN	Private	1511	yes
23	Rwamagana	Karenge	Byimana	Byimana	5/01/04/02/1830	MUKAREBURA EPIPHANIE	Private	252	yes
24	Rwamagana	Karenge	Byimana	Byimana	5/01/04/02/1831	MPATSWENUMUGABO STEVEN	Private	291	
25	Rwamagana	Karenge	Byimana	Byimana	5/01/04/02/1561	NYIRANDORIMANA CLEMENTINE	Private	601	
26	Rwamagana	Karenge	Byimana	Byimana	5/01/04/02/1569				
27	Rwamagana	Karenge	Byimana	Bwiza	5/01/04/02/1574				

RDB | RWANDA DEVELOPMENT BOARD

This is to certify that the Environmental Impact Statement (EIS) was received from

Project title:

Project objective:

To enhance stability of water supply and to catch up growth of water demand, for developing and maintaining water supply facilities in Kigali City, thereby contributing to provide access to safe water and stable economic growth in Rwanda.

Location: District(s) , Sector(s), Cell(s).

The EIS has been submitted in accordance with the Laws and Regulations relating to the requirements & procedures for Environmental Impact Assessment in Rwanda and has been reviewed and found to have sufficient and relevant mitigation measures to the identified likely impacts of the project on the environment.

It was therefore approved subject to fulfilment of the conditions attached to this certificate.

Clare AKAMANZI

Chief Executive Officer

Fred KAREMERA

Copies to: MININFRA, REMA, Eastern Province,Rwamagana District

RDB | RWANDA DEVELOPMENT BOARD

EIA CERTIFICATE CONDITIONS OF APPROVAL

Conditions of approval for the **Rehabilitation and Expansion of Karenge WTP, Transmission & Distribution Facilities in Rwamagana District of Eastern Province.** In addition to the implementation of mitigation measures outlined in the EIA report, this certificate of approval is granted under condition that the developer shall comply with the conditions given herein:

General conditions

- This certificate of approval is valid for a period of 3 years before the commencement of the project. Application for its renewal shall be examined by RDB. Otherwise, it is valid during the whole lifecycle of this project unless henceforth revoked or suspended;
- Any change in the project designs shall be notified to RDB for further environmental considerations, and adjustment of this certificate of approval;
- Ensure that the EMP is implemented as prescribed in the EIR and ensure that records are kept for future monitoring or environmental audits.
- Ensure that any other undesirable environmental impacts arising from implanting this project but no foreseen by the time of undertaking the EIA are mitigated.
- Obtain all necessary approvals from all other relevant institutions as required by the law;
- Ensure that this certificate is clearly displayed and is available at all times at the project site during project development;
- Fulfill other environmental conditions and requirements as may be prescribed from time to time by the environmental authority or any other lead agency;
- Carry out regular environmental monitoring and audits. Audit reports shall be submitted to the Authority;

Specific conditions

- Make sure that all works related to site clearing are done in the prescribed site area and are supervised all the time by the project manager or resident engineer;
- The assessment of the values of goods to be expropriated should be based on the laws and regulations relating to expropriation in the public interest and should take into account the leap in prices on the market;
- Funds for the expropriations and the payment of the aforesaid indemnifications should be mobilized before the starting of works;
- Compensation for any affected crops/properties during implementation of the project should be effected;
- The implementation and future rehabilitation/maintenance plan shall be put into place to minimize conflict of interest to the concerned parties' i.e. local authorities and the

population. Responsibilities for all parties concerned should be clearly stipulated for smooth and regular monitoring and maintenance of water schemes;

- ☞ The public should be sensitized on the objectives and benefits of the project to the community for their big contribution towards implementation and maintenance of the project during its lifespan
- ☞ The contractor will apply and observe construction good practices and provide personal protective equipment to the workers to reduce accidents during the works. A first aid kit should be made available on site, transport means ready for any injured to the nearest clinic;
- ☞ The EIR is thus approved subject to the fulfillment of the conditions described above.

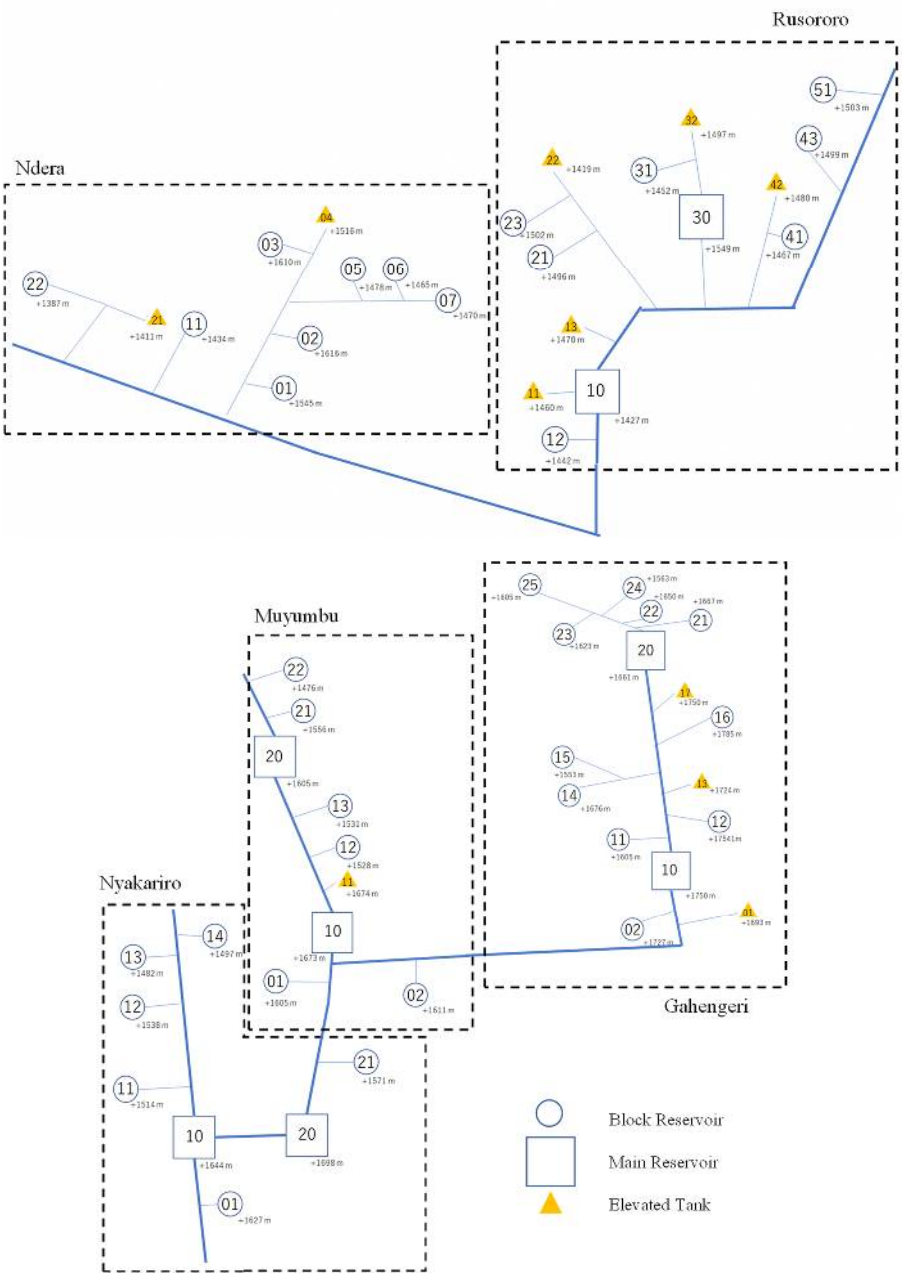
Signed by

Clare AKAMANZI
Chief Executive Officer
Rwanda Development Board

Eng. Alfred D. BYIGERO
Chief Executive Officer
WASAC Ltd

APPENDIX F：Distribution Systems Plan

Distribution System Plan



Source: JST

Figure A - 1 Distribution Block in Rusororo, Ndera, Gahengeri, Muyumbu and Nyakariro

Table A - 1 Table Estimated Water Demand/Area (m^3/day/km^2) for Each Sector

Sector	Area (m2)	Area of Development Zone (km2)	Urban Ratio	Ratio of Development Zone in Sector	Water Demand in 2030 (m3/day)	Water Demand/ Area (m3/day/km2)	
					Yearly Average	Urban	Rural
Ndera	50.37	21.2	90%	42%	15566	656	56
Rusororo	52.22	20.3	78%	39%	17496	676	119
Gahengeri	63.01	11.0	47%	17%	3632	156	37
Muyumbu	50.30	8.2	47%	16%	3710	212	47
Nyakariro	50.03	6.5	47%	13%	4103	295	50

Table A - 2 Zoning Plan in Ndera and Rusororo

Sector	Block	Zoning Plan										
		C1	C3	C4	I1	I2	R1	R1A	R1B	R2	R3	R5
Ndera	NDE01		3%	8%			9%	20%		16%	16%	27%
	NDE02	8%	3%	8%				0%		3%	23%	54%
	NDE03											100%
	NDE04							100%				
	NDE05	0%	13%					28%			7%	52%
	NDE06							16%				84%
	NDE07							17%				83%
	NDE11		3%				19%			14%	20%	44%
	NDE21				14%	86%						
	NDE22				24%	10%	20%			9%		37%
	NDE99	1%			10%				19%			70%
Rusororo	RUS10	2%	3%		6%			31%			15%	43%
	RUS11	1%						99%				0%
	RUS12	7%						58%				35%
	RUS13		0%		52%	33%					15%	
	RUS21		5%				5%				26%	63%
	RUS22						100%					
	RUS23						25%					75%
	RUS30											100%
	RUS31										27%	73%
	RUS32											100%
	RUS41				48%							52%
	RUS42				44%							56%
	RUS43				100%							
	RUS51								100%			
Total		1%	2%	1%	10%	5%	6%	13%	3%	3%	9%	47%

Note: C, I and R represent Commercial Zone, Industrial Zone and Residential Zone respectively.

Table A - 3 Developing Area in Gahengeri, Muyumbu and Nyakariro

Sector	Developing Area	Major Land-use Purposes	Area for Development Zone, ha	Corresponding Block
Gahengeri	Akamasasa	Residential	55.98	GAH22, GAH25
	Byimana	Residential	66.35	GAH21
	Gacunshu	Residential	36.88	GAH20, GAH24
	Gasutamo	Residential	65.81	GAH01, GAH10
	Gatenderi	Residential	23.87	GAH17
	Kabeza	Residential	79.46	GAH10, GAH11, GAH12,
	Karutimbo	Residential	134.09	GAH01, GAH02, GAH10
	Kinteko	Residential	79.63	GAH02, GAH10, GAH11
	Kiruruma	Residential	57.85	GAH11, GAH15
	Mataba	Residential	36.87	GAH14
	Rubonobono	Residential	62.04	GAH20
	Ruhita	Residential	61.66	GAH16
	Ryamuzuka	Residential	52.50	GAH20, GAH22
	Ryasenteteri	Residential	64.16	GAH23
Muyumbu	Kanyinya	Residential	150.36	MUY12, MUY13, MUY20
	Murehe	Residential, Industrial	238.22	MUY10, MUY11
	Nyanza	Residential	47.26	MUY02, MUY10
	Samuramba	Residential, Health-care center	135.21	MUY10, MUY20, MUY21
	Yeruzarem	Residential	49.34	MUY01, MUY10
	Gatare	Residential	83.11	MUY01
Nyakariro	Gatare_Nyakariro	Residential	83.11	NYA11
	Busimbuzi	Residential	111.67	NYA10, NYA12
	Butare	Residential	105.49	NYA10, NYA21, MUY10
	Kimicanga	Residential	41.45	NYA20
	Munini	Residential, Health-care center	81.27	NYA12
	Okamu	Residential	105.48	NYA12, NYA13

Table A - 4 Water Demand for each Block and the Size of Block Reservoir

Sector	Block			Reservoir		
	ID	Area (m2)	Water Demand (m3/day)	Type	Size (m3)	Elevation (m)
Gahengeri	GAH01	0.8	96	ET	50	1693
	GAH02	3.5	339	BR	50	1727
	GAH10	2.0	210	MR	100	1750
	GAH11	1.3	148	BR	50	1605
	GAH12	0.6	83	BR	50	1741
	GAH13	1.9	251	ET	50	1724
	GAH14	1.5	148	BR	50	1676
	GAH15	4.4	379	BR	50	1553
	GAH16	0.9	125	BR	50	1785
	GAH17	3.3	314	ET	50	1750
	GAH20	4.5	399	MR	250	1661
	GAH21	1.9	203	BR	50	1667
	GAH22	3.0	271	BR	50	1650
	GAH23	2.6	242	BR	50	1623
	GAH24	0.7	83	BR	50	1563
	GAH25	0.6	82	BR	50	1605
Muyumbu	MUY01	6.6	808	BR	250	1611
	MUY02	2.3	271	BR	50	1673
	MUY10	9.8	1263	MR	500	1674
	MUY11	0.4	71	ET	50	1528
	MUY12	2.5	389	BR	50	1531
	MUY13	2.8	285	BR	50	1605
	MUY20	5.9	715	MR	250	1556
	MUY21	6.9	649	BR	100	1476
Nyakariro	NYA01	3.4	336	BR	50	1644
	NYA10	6.4	1060	MR	500	1514
	NYA11	4.3	778	BR	100	1538
	NYA12	7.0	880	BR	250	1482
	NYA13	2.3	436	BR	100	1497
	NYA14	5.7	572	BR	100	1698
	NYA20	2.3	328	MR	250	1571
	NYA21	2.4	274	BR	50	1572
Rusororo	RUS10	8.3	4781	MR	2000	1427
	RUS11	1.1	613	ET	100	1460
	RUS12	3.0	1159	BR	250	1442
	RUS13	1.1	652	ET	100	1470
	RUS21	3.0	1713	BR	250	1496
	RUS22	0.8	492	ET	100	1419
	RUS23	1.4	844	BR	250	1502
	RUS30	0.5	245	MR	100	1549
	RUS31	1.9	987	BR	250	1452
	RUS32	1.7	941	ET	250	1497
	RUS41	0.8	410	BR	100	1467
	RUS42	2.3	1414	ET	250	1480
	RUS43	1.3	789	BR	100	1499
	RUS51	1.5	635	BR	100	1503
Ndera	NDE01	3.2	1744	BR	250	1545
	NDE02	3.2	1808	BR	250	1616
	NDE03	0.6	352	BR	50	1610
	NDE04	0.9	535	ET	100	1516
	NDE05	2.3	1111	BR	250	1478
	NDE06	1.2	665	BR	100	1465
	NDE07	2.0	1037	BR	250	1470
	NDE11	5.5	2692	BR	500	1434
	NDE21	2.6	1373	ET	250	1411
	NDE22	2.5	1195	BR	250	1387

APPENDIX G：Comparison of LV and MV Motors

Appendix G. Comparison of Medium Voltage and Low Voltage Motors for the Pumps

			CASE 1 Motor Voltage: 6kV			CASE 2 Motor Voltage: 400V		
Characteristics			- Difficult to maintain electrical equipment - Fewer motors compared to low voltage			- Easy to maintenance of electrical equipment - Many moters compared to high Voltage		
Initial Cost	Intake pump Station	Pump	Double suciton volute pump 300mm/200mm x 12m3/min x 115.6m x 4 nuits	22473000*4=	89,892,000 [JPY]	Double suciton volute pump 300mm/200mm x 6.08m3/min x 115.6m x 7 units	13335000*7=	93,345,000 [JPY]
		Motor	340kW			160kW		
		Control Panel	VCS + Soft Sterter	60424000*1=	60,424,000 [JPY]	Soft Starter	136703000*1=	136,703,000 [JPY]
		Transformer Incoming Panel	VCB 15kV 600A			VCB 7.2kV 600A		
		Transformer	15kV/6kV 1600kVA x 1			15kV/400V, 1600kVA x 1		
		Transformer Secondary Panel	LV Feeder			LV Feeder		
		Cable	6/10kV Cu/XLPE/PVC(4x16sq)x50m	1700*50*4=	340,000 [JPY]	0.6/1kV Cu/XLPE/PVC(3x120sq)x50m	5600*50*7=	1,960,000 [JPY]
	BL Transmission pump Station	Pump	Double suciton volute pump 300mm/250mm x 11.1m3/min x 214.7m x 4 units	27513750*4=	110,055,000 [JPY]	Double suciton volute pump 300mm/250mm x 6.66m3/min x 214.7m x 6 units	24415000*6=	146,490,000 [JPY]
		Motor	575kW			345kW		
		Control Panel	VCS + Soft Sterter	70930000*1=	70,930,000 [JPY]	Soft Starter	176896000*1=	176,896,000 [JPY]
		Transformer Incoming Panel	VCB 15kV 600A			VCB 7.2kV 600A		
		Transformer	15kV/6kV 2500kVA x 1			15kV/400V･200V, 2500kVA x 1		
		Transformer Secondary Panel	LV Feeder			LV Feeder		
		Cable	6/10kV Cu/XLPE/PVC(4x16sq)x50m	1700*50*4=	340,000 [JPY]	0.6/1kV Cu/XLPE/PVC(3x120sq)x50m	5600*30*6=	1,008,000 [JPY]
	BH Transmission pump Station	Pump	Double suciton volute pump 300mm/200mm x 8.3m3/min x 59.8m x 2 units	17754000*2=	35,508,000 [JPY]	Double suciton volute pump 300mm/200mm x 8.3m3/min x 59.8m x 2 units	10033000*2=	20,066,000 [JPY]
		Motor	120kW			120kW		
		Control Panel	VCS + Soft Sterter	47642000*1=	47,642,000 [JPY]	Soft Starter	48914500*1=	48,914,500 [JPY]
		Transformer Incoming Panel	VCB 15kV 600A			VCB 7.2kV 600A		
		Transformer	15kV/6kV 630kVA x 1			15kV/400V･200V, 630kVA x 1		
		Transformer Secondary Panel	LV Feeder			LV Feeder		
		Cable	6/10kV Cu/XLPE/PVC(4x16sq)x50m	1700*50*2=	102,000 [JPY]	0.6/1kV Cu/XLPE/PVC(3x120sq)x50m	5600*30*2=	336,000 [JPY]
		TOTAL [JPY] (1)			**415,233,000 [JPY]**			**625,718,500 [JPY]**
		TOTAL [US$] (1)			**3,774,000 [US$]**			**5,688,000 [US$]**
					100[%]			**150[%]**
Operating Loss	Intake pump Station	Motor Loss	efficiency = 95.1 %	321,930 [kWh/Year]=	5,372,552 [JPY/Year]	efficiency = 95.6 %	578,160 [kWh/Year]=	9,648,664 [JPY/Year]
		Soft Starter Loss	4%	262,800 [kWh/Year]=	4,385,757 [JPY/Year]	4%	525,600 [kWh/Year]=	8,771,513 [JPY/Year]
		Transformer Loss	load loss = 9,346[W] no load loss=2,930[W]	78,064 [kWh/Year]=	1,302,777 [JPY/Year]	load loss = 11,700[W] no load loss=2,200[W]	169,734 [kWh/Year]=	2,832,618 [JPY/Year]
		Cable Loss	1.47 [Ohm/km]	1,941 [kWh/Year]=	32,393 [JPY/Year]	0.20 [Ohm/km]	47,784 [kWh/Year]=	797,450 [JPY/Year]
	BL Transmission pump Station	Motor Loss	efficiency = 96.2 %	249,660 [kWh/Year]=	4,166,469 [JPY/Year]	efficiency = 95.9 %	448,950 [kWh/Year]=	7,492,334 [JPY/Year]
		Soft Starter Loss	4%	262,800 [kWh/Year]=	4,385,757 [JPY/Year]	4%	438,000 [kWh/Year]=	7,309,594 [JPY/Year]
		Transformer Loss	load loss = 13,450[W] no load loss=3,425[W]	105,409 [kWh/Year]=	1,759,126 [JPY/Year]	load loss = 17,100[W] no load loss=3,100[W]	246,051 [kWh/Year]=	4,106,240 [JPY/Year]
		Cable Loss	1.47 [Ohm/km]	1,941 [kWh/Year]=	32,393 [JPY/Year]	0.20 [Ohm/km]	39,820 [kWh/Year]=	664,542 [JPY/Year]
	BH Transmission pump Station	Motor Loss	efficiency = 94.2 %	127,020 [kWh/Year]=	2,119,782 [JPY/Year]	efficiency = 94.6 %	118,260 [kWh/Year]=	1,973,590 [JPY/Year]
		Soft Starter Loss	4%	87,600 [kWh/Year]=	1,461,919 [JPY/Year]	4%	87,600 [kWh/Year]=	1,461,919 [JPY/Year]
		Transformer Loss	load loss = 4,922[W] no load loss=2,396[W]	48,584 [kWh/Year]=	810,798 [JPY/Year]	load loss = 6,390[W] no load loss=1,100[W]	90,922 [kWh/Year]=	1,517,358 [JPY/Year]
		Cable Loss	1.47 [Ohm/km]	647 [kWh/Year]=	10,798 [JPY/Year]	0.20 [Ohm/km]	7,964 [kWh/Year]=	132,908 [JPY/Year]
		ANNUAL LOSS [JPY]			25,840,518 [JPY/Year]			22,050,245 [JPY/Year]
		ANNUAL LOSS [US$]			234,000 [US$/Year]			200,000 [US$/Year]
		15YEARS LOSS [JPY] (2)			**387,607,774 [JPY]**			**330,753,681 [JPY]**
		15YEARS LOSS [US$] (2)			**3,523,000 [US$]**			**3,006,000 [US$]**
Initial Cost + Operating Loss (1) + (2)					**802,840,774 [JPY]**			**956,472,181 [JPY]**
					7,298,000 [US$]			**8,695,000 [US$]**
					100[%]			**119[%]**

1US$= 110 JPY = 980 FRw

1kWh= 149 FRw = 16.689 JPY

APPENDIX H：Financial and Economic Evaluation

APPENDIX H FINANCIAL AND ECONOMIC EVALUATION

This Page is closed due to the confidentiality.

APPENDIX I : Calculation and Unit Rates for Cost Estimate

APPENDIX I Calculation and Unit Rates for Cost Estimate

This Page is closed due to the confidentiality.