ST. FRANCIS HOSPITAL

Wastewater Management Concept

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Contents

1. Introduction

1.1 Background Information

St. Francis Hospital

St. Francis Hospital (SFH) is a church-administered hospital under the ownership of the Anglican Council of Zambia and has been jointly managed with the Catholic Church under the diocese of Chipata and has been in existence for more than 75 years. The hospital serves both out patients and in-patient referrals locally and international (with patients from Malawi and Mozambique being attended to at the hospital). The hospital also houses a recognized nursing and midwifery training school on its premises and also continuously receives nursing students from other training institutions across the province. In 2022, the hospital was awarded Third Level Hospital status (Tertiary/Specialist) by the Zambian Governments Ministry of Health. The serving of many areas henceforth gives the hospital a higher admission and visitation rate than designed hence causing the hospital to be always under an upgrade and expansion program. The growth in the number of serviced people has also entailed for the need of growth of basic needs services. Therefore, between 2013 and 2018, the hospital has seen an upgrade of its water supply facilities with funding from the Scottish charity (Logie Legacy www.logielegacy.com). Currently, the hospital and its surrounding households and institution has eight boreholes with five directly pumping water to a central water storage and reticulation tank which serves the hospital and some housing units partially. The remaining three boreholes pump water to other water storage and supply facilities which serve the housing units and the training center. Connection to the public water supply (Eastern Water & Sanitation Co Ltd) is currently also underway.

The institution through the years has however retained responsibility for its wastewater management facilities thereby having increasingly wastewater management challenges. The hospital relies on septic tanks and soak-away systems which have been implemented across the hospital environment with some septic tanks servicing one or two service wards and centers. The housing units are serviced by individual household septic tanks which are also reported to be constantly collapsing with new ones being constructed.

Realizing the importance and need to address sanitation challenges in the hospital and the need to upgrade sanitation system and services, in 2017, the Logie Legacy', in addition to the ambitious 'Water for Life' project to improve the water supply and distribution network engaged BORDA Zambia to conduct a comprehensive sanitation technical assessment for the hospital and surrounding communities.

The BORDA Zambia technical assessment evaluated the hospitals environment and the state of sanitation facilities and its impact on the hospital environment. Implementation of biological wastewater treatment facilities in the form of Decentralized Wastewater Treatment Systems (DEWATS) including biogas digesters, anaerobic baffled reactors and planted gravel filters as shown in Figure 1; and implementation of various implementation scenarios were proposed which included a clustering of housing blocks according to the geographical terrains as well as having one centralized wastewater treatment facility.

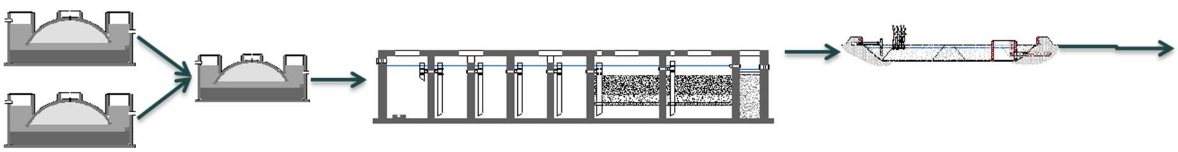

Figure 1: DEWATS system

The proposed treatment scenarios centered on the wastewater flows and the easiness of operations and maintenance and treated wastewater recycling and disposal.

Figure 2: 2018 Proposed hospital system

The proposed treatment technical options and considerations devised were as in Figure 2 with option attributes in Table 1.

Table 1: Treatment system combinations

Design aspect	Option 1: Three separate treatment units A, B & C	Option 2: Two treatment units' A and B&C	Option 3: One Treatment Unit combined
Waste water flow and gradient	A- High flows specially from the hospital B- Low water flows from the household but high-water flows in the morning C- Low as in B	A-High B-Low	C -High flow volumes in one areas but with medium flow rates on a constant rate
intermediate settlers along pipeline	A-3 intermediate settlers two on the households and one near the morgue B-1 to 2 C-non	A-3 intermediate settlers B-1 to 2	A-3 intermediate settlers B-1 to 2

Frequency of blockages	Low	Low	low
Maintenance requirements	Low	medium	medium
Biogas use options	A-Nursing school hostel, hospital lab and incinerator B-Nursing school kitchen C-Two households	A-Nursing school hostel, hospital lab and incinerator B-Nursing school kitchen C-Two households	A-Nursing school hostel, hospital lab and incinerator B-Nursing school kitchen C-Two households
Treated waste water reuse options	A-New vine yard B-New vine yard C-new vineyard	A-New vine yard C-New vine yard	A-New vine yard
Treated waste water disposal	A-Seasonal stream B-New treated waste water flow C-seasonal stream	A-Seasonal stream C-seasonal stream	C-seasonal stream

[1]

Estimated wastewater treatment implementation costs were developed of which the cost depended on the system. However, due to the lack of funding, system implementation did not follow up and due to the time between now (2023) and 2017 and the growth of the institution and services, a need to update the assessment was requested upon. Therefore, a Zambian wastewater and energy expert firm Bio-Carbon Resources Ltd a company incorporated according to the Zambian Laws was engaged.

1.2 Project Objective

The objective of the consultancy was to conduct the technical and social assessment review, recommending the most suitable implementation option and update the treatment facilities to a projected 2030 service population as well as develop implementation related costs.

The aim of the technical assessment review was to help better understand the past and current sanitation problems faced at the Hospital and recommend the best biological treatment practices and approaches to eliminate future challenges.

2 Project Approach and Findings

The assessment was based on and included review of the BORDA Zambia St. Francis Technical assessment report, investigations of the current sanitation and environmental conditions as well as on-site data collection. Current operations and maintenance as well as future requirements of the prevailing sanitation

[1] A-South-Eastern Housing units, B-South-Western Housing Units, C-North-Western Housing Units in the report

facilities and the proposed treatment units and human and material resource availability were analyzed. An understanding of the reviewed assessment and data collected was then used to develop an appropriate water, sanitation and energy concept for the hospital and the surrounding community. Furthermore, an understanding of the hospitals solid waste management approach was followed through from collection to disposal.

2.1 Literature Review

A review of the St. Francis technical and social assessment was conducted. This was done to get an insight of the services that the hospital has offered and the prevailing environment the services have been offered in. The review also showed the previously serviced population. The population was very important as comparing it with the current population helped the future population projection.

2.2 Field Visit

A field visit was conducted to understand the prevailing sanitation conditions and data collection on serviced population, hospital expansions and future plans. The following were the involved activities in the visit:

Stakeholder meeting- A meeting was conducted with Logie Legacy officials and the hospital administrator to discuss the hospitals expansion, challenges and future plans. The meeting was also held to understand the serviced population and services and anticipated solutions required for the project.

Technical meetings, observations and on-site investigations- A hospital facility and sanitation mapping transient walk with the Logie Legacy and hospital technician was held. Site facility investigations were done during the transient walk in the process of collecting various data that gave an overview of the key needs and challenges in the hospital in relation to sanitation. The walk was guided by the technical lead representatives who also pinpointed sanitation related issues for both the households and the hospital environment. The data collected during the transient walk included and was not limited to the following:

Number of sanitation facilities: The number of sanitation facilities were counted and their current usefulness was documented. The facilities recorded included, toilet facilities, hand washing facilities, shower facilities, treatment facilities and disposal units.

Geographical and Topographical data: The geographical and topographical data of the area was collected and assessed. Information such as water resources and waste water facilities, height profiles of points of interest in the hospital area, site access roads, drainages and sizes.

Infrastructure data: Past, current and planned infrastructure development data was gathered. This together with the availability of land for future development was assessed to help in the proper sanitation project.

2.3 Situational Analysis

2.3.1 Hospital Catchment

The hospital catchment can be demarcated into four areas which include the South Eastern households (including hospital lodge the bedsitters lodge), the South-Western housing units (including the nursing school and accommodation, a lecture theatre, administration buildings and hospital canteen), the North-Western housing units and the hospital. The geographical terrain is sloping mostly on the North-Eastern side. Figure shows the area demarcations of the hospital terrain.

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South- Eastern housing units

South-Western housing units

North-Western housing units

Hospital Area

Figure 3: Hospital catchment zones

2.3.2 2023 Serviced Population and 2030 Projected

According to the records provided by the hospital administration, the hospital has 115 houses with two just having been constructed in the past three years signaling an household growth rate of only 1.8%. The hospital in the past five years has seen the construction of two in-patient blocks, one being the Fistula ward and the other being an expansion of the Children's Clinic. It has also seen an increase an expansion of services which include pre-mothers, an Intensive Care Unit an eye ward. Comparing the population of 2017 with the population of the recorded 2022, an average 10% growth rate was recorded across services which were and are being offered by the hospital. In keeping therefore with the patient and infrastructure growth, and the newly awarded Level 3 status, a growth rate of 10% was projected to the population 2030. Table 2 shows the 2017 and 2022 population and the projected 2030 population using the formulae $PY_{22}=PY_{30}* (GR)^{NY}$ where PY is Population year, GY is growth rate and NY is the number of year difference between 2022 and 2030 which was equated to 7 years.

Table 2: St. Francis Hospital 2016,2022 and projected 2030 in-patient population

Ward	Daily No. of Patients 2017	Daily No. of Patients 2023	Total Number of People (Including Bedsitters) 2023	Growth Rate (from 2017)	Projected No.Patients 2030	Projected No. of People (Including Bedsitters) 2030
M'busa	50	62	74	1.04	121	145
St.Monica	27	48	58	1.12	94	112
St.Augustine	28	48	58	1.11	94	112
Mukasa-Female Surgical	38	46	55	1.04	90	108
York (Gynaecology)	50	50	60	1.00	97	117
Kizito- Male Surgical	27	50	60	1.13	97	117
Labour	7	15	18	1.16	29	35
ANC/Antenatal	42	80	96	1.14	156	187
Waiters Lodge	63	150	150	1.19	292	292
SCBU-Low Weight	25	40	48	1.10	78	94
ICU	Nil	8	10	1.10	16	19
Eye	Nil	16	19	1.10	31	37
Kangaroo Mothers	Nil	8	10	1.10	16	19
Pre-Mothers	Nil	10	12	1.10	19	23
Fistula	Nil	40	48	1.10	78	94
Total	**357**	**671**	**775**		**1308**	**1511**

The hospital in 2022 recorded a service attendance of 71,000 out-patients averaging 195 persons a day with an estimated average 2 hours' hospital spending time which is mostly in the morning. Table 3 shows the current and projected 2030 outpatient attendance rates in accordance with provided hospital records data and growth rate.

Table 3 Outpatient attendance

Category	Average daily outpatients attendance 2023	Maximum hourly outpatients per time in 2023	Average daily outpatients attendance 2023	Maximum hourly outpatients per time in 2023
	195	49	256	51

The services in the hospital are offered by 489 general nursing council (GNC) staff, 120 GNC support staff which include and not limited to doctors, visiting specialists, pharmacists, physios, administrators and general workers. Nursing students from other nursing schools as well as three other nursing schools also support service provision. An estimated 20 nursing students offer support on a 24-hour basis. Comparing the service staff of 2016 and the current service providers, a general growth rate of 4% was calculated. The growth rate was used to project the possible service and support staff for 2030 as can be seen in Table 4. The projections were also equated to daily person per day.

Table 4: St. Francis hospital staff and support population

Category	Total number of hospital personnel 2023	Daily average personnel attendance per time 2023	Total number of hospital personnel 2023	Daily average personnel attendance per time 2023
GNC Staff	489	161	643	129
GNC Support	120	40	158	32
Student Nurses	20	13	26	17

2.3.3 Wastewater Production and Management

The average household size in the Hospitals housing units is sized at 5 people with their produced wastewater estimated at 800 liters per day for both black and grey water combined. Wastewater from households is managed by individual household septic tanks and soak pits. Most household septic tanks and soak pits are dilapidated though functional with limited timelines as can be judged by the reported breakdown of two or more systems annually. Figure 4 shows the wastewater challenges found at the households and the hospital and the wastewater production per housing area is shown in Table 5.

Figure 4: Broken down household septic tank (left), Dilapidated hospital sewer facility (Right)

Table 5: wastewater production rates

CURRENT WASTEWATER PRODUCTION IN HOUSING UNITS						
Housing	No. Of Houses	No. of People per House	Faecal generation [g/day]	Urine generation [L/day]	Flush water consumption [L/day}	Waste water production [L/day]
South-Eastern Housing Units	59	5	37,170.00	335.12	16,992.00	17,327.12
South-Western Housing Units	29	5	9,135.00	164.72	8,352.00	8,516.72
North-Western Housing Units	27	5	17,010.00	153.36	7,776.00	7,929.36
Hospital Lodge		15	1,890.00	21.30	864.00	885.30
Nursing College		240	12,600.00	142.00	7,200.00	7,342.00
TOTAL	**115.00**	**230.00**	**77,805.00**	**816.50**	**41,184.00**	**42,000.50**

During the time of the transient investigation, three septic tanks were found totally collapsed and disposing waste into the environment with one septic and soak pit being on the South-Western housing unit and two on the North-Western housing units. Figure 5 and Figure 6 shows the prevailing conditions of the hospital and housing units' wastewater systems.

The institution spends an approximate 30,000 ZMW ($1500) dollars in building a new system every time one fails.

Wastewater from the hospital is also managed also managed by septic tanks that have been implemented either in the hospital grounds or channeled to systems either out of the hospital walls on the Northern end of the hospitals.

Figure 5: Overloaded hospital wastewater septic tank (left), Broken down hospital septic tank disposing untreated wastewater into the open environment (Right)

Grey water mostly is disposed in septic tanks in the hospital environment whilst black water systems mostly in dilapidated states are on the periphery of the hospital building boundaries spilling untreated wastewater unsafely into their surroundings.
With the estimated sanitation wastewater production parameters as shown in Table 6, the estimated wastewater production rates for the hospital and the average waste mass is shown in Table 7.

Table 6: In-patient wastewater production rates (C.Rose, 2015)

Inpatient Data Parameters	
Flush water for toilets [L]	**9**
Median urine generation [L/cap/day]	**1.42**
Average urinating rate per person/day	**8**
Median fecal wet generation [g/cap/day]	**126**
Stools per day per person	**2**

Table 7: Hospital population figures

Ward	Projected No. Patients 2030	Projected No. of People (Including Bedsitters) 2030	Fecal generation [g/day]	Urine generation [L/day]	Flush water consumption [L/day]	Waste water production [L/day]	Waste water production [m3/day]	Total Waste Mass per Day (Kg)
M'busa	121	145	18268	206	5219	5425	5.43	5444
St. Monica	94	112	14143	159	4041	4200	4.20	4214
St. Augustine	94	112	14143	159	4041	4200	4.20	4214
Mukasa-Female Surgical	90	108	13554	153	3872	4025	4.03	4039
York (Gynaecology)	97	117	14732	166	4209	4375	4.38	4390
Kizito- Male Surgical	97	117	14732	166	4209	4375	4.38	4390
Labour	29	35	4420	50	1263	1313	1.31	1317
ANC/Antenatal	156	187	23572	266	6735	7000	7.00	7024
Waiters Lodge	292	292	36831	415	10523	10938	10.94	10975
SCBU-Low Weight	78	94	11786	133	3367	3500	3.50	3512
ICU	16	19	2357	27	673	700	0.70	702
Eye	31	37	4714	53	1347	1400	1.40	1405
Kangaroo Mothers	16	19	2357	27	673	700	0.70	702
Pre-Mothers	19	23	2946	33	842	875	0.88	878
Fistula	78	94	11786	133	3367	3500	3.50	3512
Total	**1308**	**1511**	**190341**	**2145**	**54383**	**56528**	**56.5**	**56719**

2.3.4 Solid Waste and its management

The hospital also generates solid waste in the form of clinical and biological waste as well as general solid waste. The generated waste is disposed through incineration which is partially done in a newly constructed incinerator which has also been reported to be badly constructed and in a dug out open pit. Some of the solid waste is weekly collected and taken to a landfill by a contracted solid waste management company.

During the time of the site transient walk, huge volumes of solid waste were found unmanaged in the hospital collection and disposal points.

3 Recommended Management Concepts and Related Costs

3.1 Recommended Wastewater Management Approaches

With review of the St. Francis Technical Assessment developed by BORDA Zambia in 2018 and the technical requirements, the site assessment of 2023 and parameters favourable for design, implementation and sustainable operations and maintenance according to assessed capacity, skills and location attributes in the hospital as shown in Table 8, implementation of nature based biological wastewater treatment system in the form of DEWATS (See appendix 1) is recommended for wastewater management.

Table 8: Design Technical requirements

No.	Requirement	Site Qualities
1	Durability	Less human/machine traffic
2	Topographic position	Easy flow of waste water
3	Easily accessible	Ergonomic treatment position/ For different waste water flows
4	Reuse position	Waste water reuse position
		Biogas Reuse position
5	Low maintenance	Minimal number of pipes, fittings, valves etc.
		Less blockages
6	Safety	Less human contact
7	Stability	Less likely to be disturbed by machine movement

The recommended approach involves constructing one treatment facility for the South-Eastern Housing unit and the hospital wastewater and another unit for the South-Western and North-Western housing unit's wastewater according to the block clusters shown in Figure 6.

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Cluster 1 Wastewater management Unit boundary

Cluster 2 Wastewater management Unit Boundary

Main wastewater sewer lines (into which subsidiary lines can be connected)

Wastewater Treatment System

Figure 6: Recommended wastewater management system

3.2 Qualities of the Recommended plant locations

3.2.1 Cluster 1 Treatment Unit: Hospital and South-Eastern Housing Units

The treatment unit will receive wastewater from the hospital ablution block from both the Eastern side and the Western side as well as wastewater from the South-Eastern housing units. The volume of wastewater to be treated per day include 73.4m3 from the hospital as shown in Table 9 and 17.3 cubic meters from the South –Eastern housing units. Therefore, the total volume of wastewater to be treated is 90.7m3 per day.

Table 9: Hospital Housing units wastewater production rates

Wastewater Production in the Hospital			
Total Waste Production	**East Side**	**West Side**	**North Side**
Total Number of People	863.4	719.2	51.2
Fecal generation [kg/day]	108.8	90.6	6.5
Urine generation [L/day]	1226.1	1021.3	72.7
Flush water consumption [L/day]	32182.4	25892.2	1843.0
Grey Water [L/day]		11177.0	
Total Wastewater production [m3/day]	33.4	38.1	1.9

The treatment approach includes installation of three biogas digesters with two being intermediate settlers and one being a final settler; installation of a 90m3 ABR and planted gravel filter including a subsurface wastewater polishing and disposal field in the process of creating a vineyard wetland.

The proposed site is favorable due to the following aspects:

- It's a lower point of the recommended cluster hence it is able to receive wastewater from both sides of the hospital efficiently
- It will be easy to tap wastewater from the existing hospital sewer line
- The site already has a wastewater treatment facility hence it is already a wastewater disposal area
- The site has enough land to implement various wastewater treatment facilities
- The site can have a creation of a safe treated wastewater wetland which can be sustainably used to create a fruit tree vineyard which can supplement the hospitals fruit nutrient requirements
- The site is in vicinity of a waste incinerator hence gas fuels from primary treatment facilities can be used to supplement incinerator fuels
- The site is easily accessible for utilization of a biological waste disposal
  The projected

Grey water systems in the hospitals will be left as functional

3.2.2 Cluster 2 Treatment Unit: South-Western and North-Western housing

Cluster 2 wastewater treatment unit will treat wastewater from the housing units on the Western side of the hospital which also includes the nursing school and the hospital canteen. The volume of wastewater to be treated by the system is assumed to be 23.7m3 with 15.8m3 coming from the nursing school and South-Western housing units and 7.3m3 contributed by the North-Western housing units. The system would see the implementation of new sewer system as the old one is rapidly breaking down, one intermediate settler trapping wastewater at the pipe end of the South-Western units and a final biogas settler, ABR and PGF at the proposed treatment unit. The treated wastewater would be disposed in fields channeling into a seasonal stream.

Positive attributes for the location include:

- The site topography can conveniently receive wastewater from the housing units through natural gravitated flow
- The site is far off accessible from the public hence treated wastewater can be safely disposed off
- The site sewer route can be easily installed along existing household wastewater treatment facilities
- Some households can benefit from wastewater treatment by-products for their energy needs
- The treated wastewater would be easily disposed far off into a seasonal stream converting it into a perennial stream

3.3 Solid Waste Management Concept

Solid waste produced in the hospital has the ability to be managed within the hospital facilities. The produced solid waste can be managed at two facilities depending on the type accordingly;

Paper and Plastic: The two types of solid waste can be incinerated in the incinerator with the use of biogas produced from the treatment of wastewater. The two facilities were found in non-operating condition which however will be explored for rectification during project implementation.

Biological Solid Waste: All the biological solid waste can be fed into the main wastewater treatment biogas digester where it can be decomposed to produce biogas and sludge except for waste with a high bone mass which will be considered for incineration and the ash disposed into an ash pit. The biogas can be used to fuel the solid waste incinerator. Therefore, ash pits will be constructed which will be sealed and decommissioned after filling up. This will be done together with ash from other wastes such as paper and plastic.

3.4 System Cost

The related investment cost for the implementation of wastewater systems at St. Francis Hospital Includes the decommissioning of existing old septic tanks and installing new wastewater conveyance networks especially on the hospital periphery where most septic tanks and plumbing installations are broken.

Tentative implementation costs for inclusive of management costs for cluster 1 and Cluster 2 systems are detailed in Table 10 and 11 respectively.

Table 10: Estimated Cluster 1 wastewater treatment system implementation costs

CLUSTER 1 Wastewater Treatment Solution					
ITEM	DESCRIPTION	UNIT	QUANTITY	RATE (ZMW)	TOTAL (ZMW)
1	Household Intermediate Biogas Settler	M3	20	2500	50000
2	Hospital Western Side Biogas Settler	M3	20	2500	50,000
3	Main Biogas Settler	M3	50	2500	125000
4	Main Anaerobic Baffled Reactor	M3	180	1000	180000
5	Planted Gravel Filter	M2	400	250	200000
6	Installation of sewer line	m	2000	150	300000
7	Sewer manhole installation	Nr	20	2000	40,000
8	Sewer Inspection Chambers	Nr	55	1000	55,000
9	Clinic Solid Waste Treatment unit	M3	40	3500	140000
10	Incinerator maintenance	Nr	2	20000	40000
11	Incinerator ash Pit	Nr	2	15,000	30000
12	Biogas Connections/ auxiliaries	Item	1	20000	20000
	Total				**1,230,000**
	Design and Construction supervision	Mandays	40	5000	**200,000**
	Administrative Costs	%		12.5%	153750
	Contingency	%		10%	123000
	Grand Total				**1,706,750**

Table 11: Estimated Cluster 2 wastewater treatment system implementation costs

CLUSTER 2 Wastewater Treatment Solution					
ITEM	DESCRIPTION	UNIT	QUANTITY	RATE (ZMW)	TOTAL (ZMW)
1	Household Intermediate Biogas Settler	M3	20	2500	50000
3	Main Biogas Settler	M3	20	2500	50000
4	Main Anaerobic Baffled Reactor	M3	40	1500	60000
5	Planted Gravel Filter	M2	80	250	20000
6	Installation of sewer line	m	4000	150	600000
7	Sewer manhole installation	Nr	20	2000	40,000
8	Sewer Inspection Chambers	Nr	60	1000	60,000
9	Biogas Connections /auxiliaries	Item	1	15000	15000
	Total				**895,000**
	Design and Construction supervision	Mandays	30	5000	**150,000**
	Administrative Costs	%		12.5%	111,875
	Contingency	%		10%	89,500
	Grand Total				**1,246,375**

The estimated total implementation cost for the project is **2,953,125 ZMW**.

3.5 Systems O&M

3.5.1 Operational tasks

The designed treatment facilities for St. Francis Hospital requires essential and unsophisticated execution of O&M tasks for successful system implementation that should be carried out on a daily/weekly basis. O&M responsibilities for O&M personnel need to be defined, shared and taken up accordingly by the existing operations and maintenance team. The identified operational tasks include tasks directly related to the systems operations (e.g. gas use, manhole cleaning, planted gravel filter cleaning, etc.). Lack of execution of these minute operational tasks can lead to a drop in the treatment efficiencies of the systems which might further lead to unacceptance by the community.

3.5.2 Maintenance tasks

The identified system maintenance crucial for long-term system functioning requires operations such as cleaning of surrounding, desludging and backwashing of treatment facilities and repair of system failures.

Proper preventive maintenance measures minimize reactive maintenance which might be detrimental to the system. Preventive maintenance tasks need to be carried out periodically depending on system requirements (e.g. daily, weekly, monthly, yearly). Lack of execution of maintenance tasks might lead to excessive repair and replacement costs and can lead to system breakdowns that might further lead to a non-conducive environment and abandonment of the system.

3.5.3 O&M costs

Operational costs

The identified costs after system implementation mostly only involves salaries for caretakers and as tasks will not be changed but lessened, O&M costs of sanitation facilities remain the same.

Maintenance costs

As the designed system does not involve intricate parts, the maintenance costs only involve periodical (depending on system setup, execution of O&M tasks and incidents of vandalism) non-replacement of expendable parts.

Periodical system maintenance such as treatment system de-sludging and backwashing of treatment facilities.

3.6 Implementation Recommendations and Costs

The implementation can be phased into four phases according to resource availability which include:

1. Phase 1: Installation of Cluster One’s Hospital Wastewater Treatment Unit
2. Phase 2: Installation of Cluster One’s 1500 meters’ Household Wastewater Sewer Connections
3. Phase 3: Installation of Cluster Two’s Household Wastewater treatment unit
4. Phase 4: Installation of Cluster Two’s Sewer Connections

3.6.1 Phase 1: Installation of Cluster One’s Hospital Wastewater Treatment Unit

Phase one of the project is aimed at the construction on the main hospital wastewater treatment facilities and part of its sewer connection only including the implementation of surgical biological waste treatment facilities. The hospital wastewater treatment facility includes a biogas settler, anaerobic baffled reactor, a block lined planted gravel filter and wastewater disposal subsurface drains. Under this phase shall also be implemented an intermediate biogas settler on the western side of the hospital which shall pre-treat wastewater on the sewerline on the western side and create a solid free sewer flow to the mainline treatment facilities. Gas connections from the biogas systems shall be interconnected for use at the incinerator and also for cooking at the waiting mothers shelter.

The project related cost for phase 1 of the project is estimated at 1,229,225 ZMW. The breakdown of the costs is as shown in Table 12

Table 12: Phase 1- Implementation costs for the hospital wastewater treatment system

Phase 1: Hospital Wastewater Treatment System Only					
ITEM	**DESCRIPTION**	**UNIT**	**QUANTITY**	**RATE (ZMW)**	**TOTAL (ZMW)**
2	Hospital Western Side Biogas Settler	M3	20	2,500	50,000
3	Main Biogas Settler	M3	50	2,500	125,000
4	Main Anaerobic Baffled Reactor	M3	180	1,000	180,000
5	Planted Gravel Filter	M2	400	250	200,000
6	Installation of new hospital sewer line	m	500	150	75,000
7	Sewer manhole installation	Nr	8	2,000	16,000
8	Sewer Inspection Chambers	Nr	5	1,000	5,000
9	Clinic Solid Waste Treatment unit	M3	40	3,500	140,000
10	Incinerator maintenance	Nr	2	20,000	40,000
11	Incinerator ash Pit	Nr	2	15,000	30,000
12	Biogas Connections/ auxiliaries	Item	1	20,000	20,000
	Total				**881,000**
	Design and Construction supervision	Mandays	30	5,000	**150,000**
	Administrative Costs	%		12.5%	110,125
	Contingency	%		10%	88,100
	Grand Total				**1,229,225**

3.6.2 Phase 2: Implementation of Cluster One's Household's 1500 Meters' Wastewater Sewer Connections

Phase two of the project shall be aimed at the installation and rehabilitation of the hospital's Cluster one households Blackwater system for connection to the hospital wastewater treatment facilities. The phase shall also be aimed at rehabilitation works for the hospital's main sewer lines which runs on either side of the hospital. Hospital plumbing rectifications where the system is dilapidated shall also be done under this phase. Decommission of broken down septic tanks and landscaping their location points shall also be part of the works under phase 2. The project related costs for the works are as highlighted in Table 13.

Table 13: Phase 2-Implementation costs of Cluster one's household sewer connections

Cluster 1's Household Units Wastewater Treatment Sewer Connections					
ITEM	DESCRIPTION	UNIT	QUANTITY	RATE (ZMW)	TOTAL (ZMW)
1	Household Intermediate Biogas Settler	M3	20	2500	50,000
6	Installation of sewer line	m	1500	150	225,000
7	Sewer manhole installation	Nr	12	2000	24,000
8	Sewer Inspection Chambers	Nr	50	1000	50,000
	Total				**349,000**
	Design and Construction supervision	Man-days	10	5000	**50,000**
	Administrative Costs	%		12.5%	43,625
	Contingency	%		10%	34,900
	Grand Total				**477,525**

3.6.3 Phase 3: Installation of Cluster Two's Household Wastewater Treatment Unit and Housing Units Intermediate Settler

The third phase of the project shall include construction of the South-Western and North-Western housing unit's wastewater treatment facility as well as construction of all the housing unit's intermediate biogas settlers only. The treatment system for the housing unit shall include a biogas digester for primary settlement of the wastewater, an anaerobic baffled reactor and a planted gravel filter. The treated wastewater can be disposed into a natural wetland before it reaches the seasonal stream thereby affording more treatment.

The Phase will also realize the construction of a household's intermediate settler for cluster two. The related costs for the phase is in Table 14.

Table 14: Phase 3-Cluster two wastewater treatment system implementation costs

Cluster Two's Wastewater Treatment System					
ITEM	DESCRIPTION	UNIT	QUANTITY	RATE (ZMW)	TOTAL (ZMW)
1	Household Intermediate Biogas Settlers	M3	20	2500	50,000
2	Main Biogas Settler	M3	20	2500	50,000
3	Main Anaerobic Baffled Reactor	M3	40	1500	60,000
4	Planted Gravel Filter	M2	80	250	20,000
5	Installation of sewer line	m	1000	150	150000
6	Sewer manhole installation	Nr	5	2000	10,000
7	Sewer Inspection Chambers	Nr	20	1000	20,000
8	Biogas Connections /auxiliaries	Item	1	15000	15,000
	Total				**375,000**
	Design and Construction supervision	Man-days	20	5000	**100,000**
	Administrative Costs	%		12.5%	46,875
	Contingency	%		10%	37,500
	Grand Total				**559,375**

3.6.4 Phase 4: Installation of Cluster two's household sewer connections

The last phase of the project is the phased implementation of cluster two's household wastewater network and the related collection and conveyance manholes. Phase four offers the affordability of doing the project at once or a gradual increment depending on the availability of resources for the household connections. The phase is projected to cost approximately 687,000 ZMW as shown in Table 15.

Table 15: Phase 4- Cluster two's sewer connections implementation costs

Cluster 2 Wastewater Connections					
ITEM	DESCRIPTION	UNIT	QUANTITY	RATE (ZMW)	TOTAL (ZMW)
1	Installation of sewer line	m	3000	150	450,000
2	Sewer manhole installation	Nr	15	2000	30,000
3	Sewer Inspection Chambers	Nr	40	1000	40,000
	Total				**520,000**
	Design and Construction supervision	Man-days	10	5000	**50,000**
	Administrative Costs	%		12.5%	65,000
	Contingency	%		10%	52,000
	Grand Total				**687,000**

4 Next Steps

The following are the recommended progressive steps and their related service deliverables for the implementation of the St. Francis Hospital sanitation system Tables 16 to Table 18.

4.1 Detailed Systems Designs

Table 16: Implementation step 1

Pos.	**Service**	**Deliverable**
1	Detailed engineering of the hospital wastewater treatment modules (civil and structure details)	Detailed design documents including process design and construction and structure engineering drawings for wastewater treatment facilities
2	Detailed construction quantification	Bill of quantities for wastewater treatment facilities
3	Preparation of construction bidding documents	Compiled construction bidding documents
4	Development of O&M measures considering the proposed and designed facilities. Areas of activities that will be covered: routine operations, routine maintenance, system malfunction & troubleshooting.	Wastewater treatment facilities operations and maintenance documents

4.2 Phased system Construction

Table 17: Implementation step 2

Pos.	**Service**	**Deliverable**
1	Construction supervision of wastewater treatment infrastructure	Construction supervision checklist and timesheets according to construction phase and contract

4.3 System O&M Training

Table 18: Implementation step 3

Pos.	**Service**	**Deliverable**
1	Operations and maintenance training of St. Francis Hospital maintenance staff on the operations and maintenance of constructed waste facilities	Trained staff list on operations and maintenance of wastewater treatment facilities

The phased approach for the implementation of the St. Francis wastewater management concept presents an opportunity for implementing the project according to available funds and according to sanitation needs so far ranked in order of the phase presentation order.

Each phase to be implemented has been presented with its design and supervision costs as well as required operations and maintenance training for system operators and caretakers for it to sustainably contribute to safe sanitation for the hospital environment and surrounding areas.

APPENDICES

APPENDIX 1: DEWATS Approach-TREATMENT SYSTEM DESIGN

Review of available treatment technologies

Different technologies are applied in biological waste water treatment solutions. The applied technologies depend on the treatment objectives and the end use. The three types of applied technologies are 'established', 'transferring' and 'innovative' technologies. Established technologies are technologies that have been in use for a very long time and they have been developed on a higher level due to operations and maintenance experience. Transferring technologies are technologies that have been developed for other waste but are being adapted for waste water. Operations and maintenance have to be redefined for transferring technologies as the characteristics and parameters are different from the waste developed for. Innovative technologies are technologies that are still under research and scaling up.

Technologies to be applied should depend on the treatment objectives which could be solid liquid separation, sludge stabilization, nutrient management and pathogen inactivation. Established waste water technologies for waste water include settling thickening tanks, planted drying beds, and unplanted drying beds and composting. Transferring waste water technologies include anaerobic biogas digesters, anaerobic baffled reactors, incineration, lime treatment and composting. Innovative technologies include pyrolysis, pelletizing, fly larvae composting and ammonia treatment.

Preliminary Treatment

Preliminary treatment facilities could be defined as technologies that are applied at the receiving station. Waste water preliminary treatment is done in the process of screening inorganic waste oils that comes with the sludge.

Grease trap

Waste water from kitchens, bathrooms and laundry rooms sometimes contains oils and greases. The oils and fats contain elements which hinder biological treatment of waste water. Grease traps can be in form of small chambered manholes or primary settlers. Grease traps can also be incorporated in treatment units by the use of T-joints when connecting one facility to the other.

Primary Treatment

Dewatering (liquid-solid separation) is one of the most important treatment processes in waste water treatment of which gravity is probably the most commonly employed method of liquid – solid separation. Gravity can achieve the separation of suspended particles and unbound water. Particles that are heavier than water settle out under quiescent conditions at rates based on size of particles, suspended solids concentration, and flocculation. The four types of settling mechanisms include discrete particle, flocculent, hindered, and compression.

Discrete particle settling occurs in lower concentration waste streams when particles settle out individually without reacting with other particles. Flocculent settling occurs when particles join together and merge, increasing their mass and settling velocity. This is important for smaller particles that are held together through Van der Waals force, resulting in increased settling velocities.

Biogas Digester/Settlers

The biogas digester is designed as a split globe, made by bricks and built into the ground. Its primary function is to separate the solid and liquid forms of the incoming wastewater as well as to biologically digest the organic solids. The digestion process takes place without oxygen input, under anaerobic conditions, and creates biogas which can be used for cooking, lighting and heating. Biogas digesters are constructed most of the time exclusively using brick-work and built in sizes of minimum 6 m^3 to up to 200 m^3 due to the dome structure. Biogas digesters have been implemented in FS projects where gas trapping and use is of interest.

Biogas digesters are efficient in solid stabilisation and achieve a COD treatment efficiency of over 70%. The sludge entering the treatment facility should be sand free as it complicates the maintenance of the facility. Periodic removal of stabilised sludge should also be ensured so that a compact layer of sludge difficult to remove does not develop at the bottom.

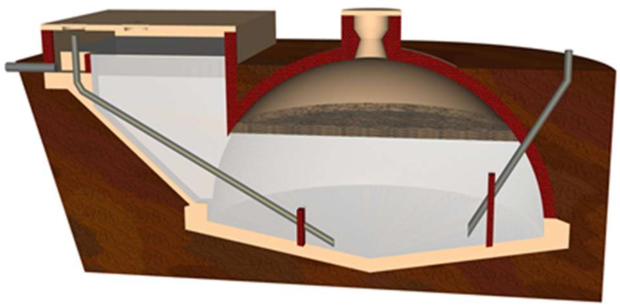

Figure 0-1: Biogas digester (Courtesy of BORDA)

The settler separates scum and large particles which can settle to the bottom, while protecting the post-connected treatment stages. The settler will be fed with wastewater pumped up through the lift station. It pre-treats dissolved and particulate wastewater components through sedimentation and bio-degradation. Utilizing a hydraulic retention time of 1.5 – 2 hours, referring to the peak-flow, up to 30 – 40% of the organic load measured as COD is removed.

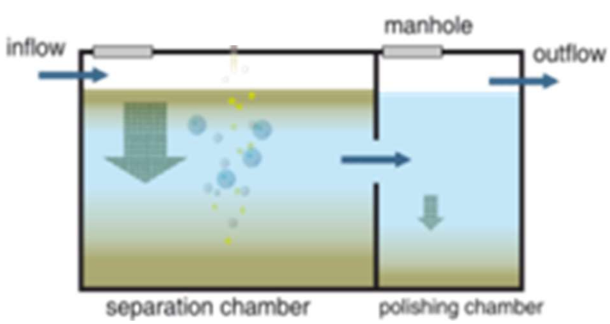

Figure 0-2: Primary settler (Courtesy of BORDA)

Secondary Treatment

Secondary treatment facilities treat the effluent from primary treatment units in the treatment of solids and COD and pathogens. The most commonly used secondary treatment units for waste water treatment include, Anaerobic Baffled Reactors (ABR's), Anaerobic Filters (AF's) and sludge drying beds.

Anaerobic Baffled Reactor (ABR)

The ABR serves as the core secondary treatment stage of anaerobic treatment. Up to 60% of the organic load (measured in BOD and COD) coming from the settler can be eliminated through sedimentation and bio-degradation. The up and down flow characteristics of this plug-flow reactor establishes an environment whereby the dissolved and particulate organic matter comes into contact and is biodegraded by the microorganisms forming an activated sludge layer on the bottom of each reactor chamber. This process takes place without aeration and mixing under anaerobic condition and therefore does not require external energy. Distributing the inflow over the entire width of the ABR and maintaining a maximum flow velocity of 0.5-1 m/h are crucial hydraulic design and operation requirements.

In order to avoid storm water intrusion, the ABR should be raised at least 1 m above ground level. This provides additional slope to discharge the ABR effluent into the polishing pond/wetland by gravity flow.

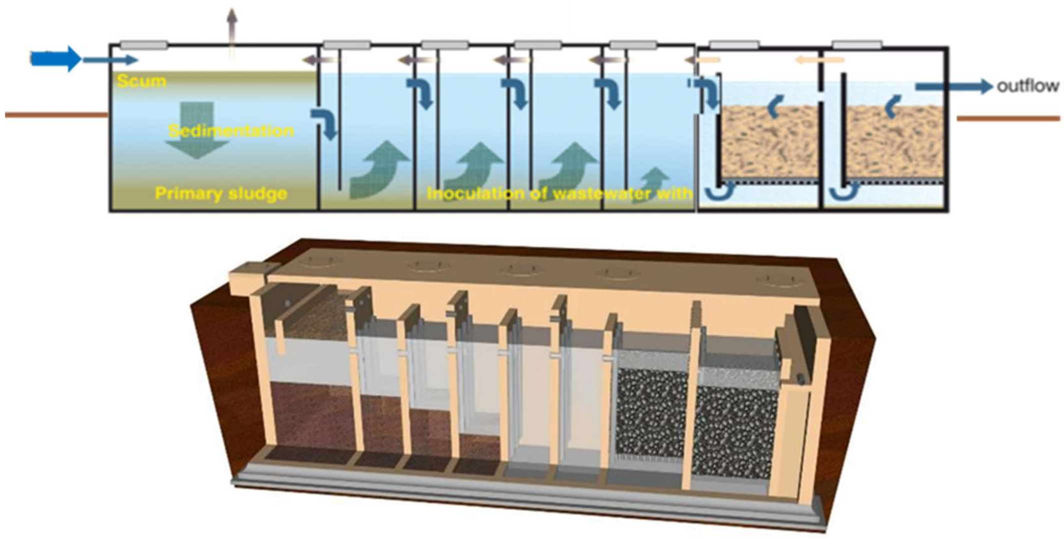

Figure 0-3: Anaerobic baffle reactor (Courtesy of BORDA)

Planted Gravel Filter (PGF)

Planted Gravel Filter is a constructed wetland which is the pre-treatment and water distribution stage of the tertiary treatment of Unit III. Its core function within the DEWATS Cluster concept is to distribute the effluent equally and create natural aeration before the treated effluent enters polishing pond. It is suitable for wastewater with a low percentage of suspended solids which have been removed through previous primary and secondary treatment. It also serves a treatment function depending on the size and design parameters, primarily through biological conversion, physical filtration and chemical absorption. The PGF is made of planted filter bodies consisting of graded gravel. The bottom slope is 1% and the flow direction is mainly horizontal. The main plants used in this filter bed are Canas indica, Reed juncus, Papyrus, Phragmites and Arunda donax. The plant selection is mainly based on their ability to grow on wastewater and have their roots go deep and spread wide. Plants transport oxygen via their roots into the ground. However, in the present DEWATS design the use of plants is only to act as catalysts rather than actually be a treatment medium. BOD reduction rate is between 75 - 90% and pathogen removal is over 95%

depending on the systems size and design. The operation and maintenance of the system are simple. The spatial requirements for construction are compensated through landscaping.

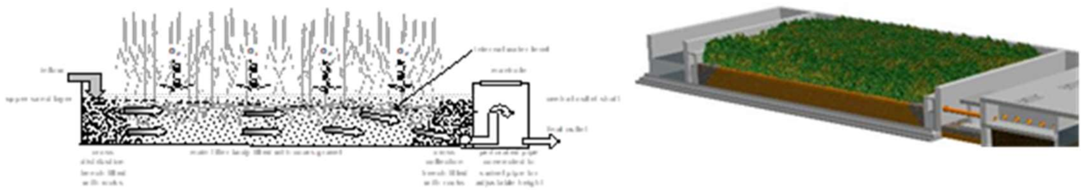

Figure 0-4: Planted gravel bed (Courtesy of BORDA)

Advanced Secondary Treatment

Advanced secondary treatment facilities polish off the treated waste water in readiness for reuse or disposal. Advanced treatment units treat waste water by the use of ultra-violet rays, plants and gravity. These include polishing ponds,

Polishing Pond

The polishing pond is the tertiary treatment stage primarily designed to eliminate up to 80-90% of the nutrients (measured as total nitrogen and phosphorous) and up to 99% of the pathogens in the treated effluent from the secondary treatment stage.

Determining the most appropriate tertiary treatment stages involves comparing compact treatment systems requiring energy vs. spatially larger areas utilizing natural treatment i.e. polishing ponds. In many contexts, it is recommended to utilize existing ponds/wetlands and to engineer and operate them as polishing ponds as the tertiary wastewater treatment stage. This serves a dual purpose of protecting these important wetland ecosystems and provides positive overall impacts on water resource management as well as giving them a control function within sustainable urban drainage systems.

Design recommendations for these ponds state that the effluent of the AF should be distributed in a small constructed wetland zone prior to the actual wetland, to ensure equal distribution and natural aeration before entering the pond. The ponds need to provide a minimum hydraulic retention time of 10 days, referring to a daily and maximum wastewater inflow volume, or to a dilution ratio of 1:10.

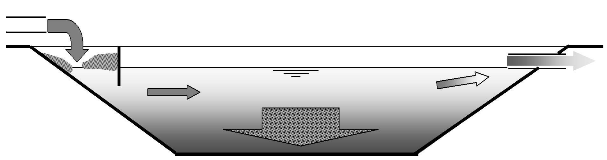

Figure 0-5: Polishing pond (Courtesy of BORDA)

Vertical Sand Filter

The vertical sand filter has a treatment efficiency between 90-99% by vertically directing the effluent through course sand which promotes the dissolution of oxygen into the water. Vertical sand filters treat waste water in terms of Cod but also help in the removal of nutrients from the effluent.

However, the facilities require batch feeding intervals which means mechanisms need to be implemented to ensure proper operations.

Figure 0-6: Vertical sand filter

Vortex

The vortex is the unit which uses the principle of the tornado in increasing dissolved oxygen content in the waste water before reuse or disposal. The unit works with low energy input and can perfectly fit where a planted gravel nor vertical sand filter cannot fit. The vortex can be incorporated in the polishing pond hence increasing the treatment efficiencies of the waste water

However, operation of the vortex requires the flow of water at high pressure to the tubes hence a pressurising mechanism is required in order to create the swirl in the tube.

Figure 0-7: Vortex

By Product reuse

Waste water treatment products range from biogas, sludge used as soil conditioner and effluent water. Waste water products have economic value and the use of the products ensures sustainability of the waste water operation.

Biogas

Depending on the type of primary treatment applied, biogas can be recovered as a by-product for reuse if a biogas digester is used as treatment module. The biogas can be used as a fuel for heating purposes depending on the amount of biogas produced and captured in the dome. The volume of biogas produced will depend on the volume of sludge fed into the treatment facilities and the properties of the sludge such as BOD concentrations, PH and temperature.

Treated sludge as soil conditioner

Sludge from the treatment units can be used as soil conditioner for use in gardens, grass lawns and farms as it has high nutrient concentrations. The sludge can be processed by crushing big sludge pieces into small ones and packaged for selling

Treated sludge as biofuel

Sludge collected from waste water facilities can be used as a fuel in combustion plants due to its combustible properties. The calorific value of the sludge will depend on the sand and grit content as well as the moisture percentage.

Treated effluent water

Treated effluent water is the water that has been treated by the treatment modules. Treated waste water can be disposed or reused depending on the treatment levels. The water can be used for road construction, forest irrigation and some sub-surface irrigation.

Expert CV

The St. Francis Hospital Sanitation Concept has been developed by Eng. Aubrey Simwambi; An engineer with over 10 years' experience in the design, construction and operations and maintenance of decentralized wastewater treatment systems and energy systems. His expertise is focused on designing sustainable and environmental resilient systems which include community based sanitation, school based sanitation, hospital based sanitation and energy recovery from waste projects

Aubrey Simwambi – Curriculum Vitae

Sanitation Specialist and Renewable Energy Expert

Position Title and No.	Onsite Sanitation Specialist and Renewable Energy Expert
Name of Expert	Aubrey Simwambi
Current Employer/Position	BORDA Zambia/ Senior Engineer Africa Focal Point Engineer
Date of Birth	16th June, 1984
Country of Citizenship/ Residence	Zambia / Zambia

Education:

Institution [Date]	Degree(s)/ Diploma(s)
University of Zambia, November 2015 - December 2018	Master of Engineering in Energy Engineering Specialisation: Energy recovery from human waste
German WASH Network, October 2021	Trainer of Trainers Certificate: Sanitation in Emergencies
German WASH Network, February-March 2020	Trainers Certificate: WASH in Emergencies
Centre for advanced Sanitation Solutions (CASS) India, July 2019	Certificate: Advanced Training for Design engineers on Faecal sludge management
World Health Organisation / GIZ CFS-April 2019	Training on WHO Guidelines on Sanitation and Health and Sanitation Safety Planning (SSP) for City Wide Sanitation Implementation
African Water Association/Bill and Melinda Gates Foundation, September 2017	Training on Faecal Sludge Treatment Technologies
Hydroaid-Water for Development Training Institute, February – July 2016	Technical Course in Wastewater Treatment and Management of Urban Solid Waste
Online and contact training from Cap-Net, ANSI and GWP, Oct 2020 & Nov 2020	Certificate in ISO 30500 and ISO 24521: International Non-sewered Sanitation Standards

Online Course from Hydroaid-Water for Development Training Institute, Italy, Feb 2016 to July 2016	Technical course for Wastewater Treatment and Management of Urban Solid Waste
University of Zambia, April 2007-March 2013	Bachelor of Engineering in Mechanical Engineering Specialization: Production Engineering
Lusaka Business and Technical College, February 2005 - December 2006	Craft Certificate in Mechanical Machining

Employment record relevant to the assignment:

Period	Employer & your title/ position. Contact info for references	Country	Summary of activities performed relevant to the assignment
1. 09/2021 to 12/2022	Client: GIZ RWSII Position: Expert 2 For References: Doreen Mbalo Reform of the Water Sector Phase II (RWS II) in Zambia Head of Program doreen.mbalo@giz.de +260777062603	Zambia	**Support the data collection on water and sanitation for the implementation of the ECAM Tool in six (6) selected Commercial Utilities in Zambia** **Southern, Luapula, Lusaka, Lukanga, Nkana and Mulonga Water and Sanitation Company)** (i) Carry out a data needs and data management assessment of the CUs based on the provided data requirements needed for the energy efficiency, GHG and SFD tools. (ii) Assess the availability, status, functionality and frequency of calibration of wastewater flow measuring equipment in six CUs. (iii) Assess knowledge and skills of Laboratory staff in the 6 CUs to undertake key wastewater and faecal sludge2 quality tests (iv) Support the 6 selected CUs in producing SFDs. (v) Support the 6 CUs in producing GHG emission baselines. (vi) Compile key recommendations on wastewater flow measurements, sampling sites and analysis of COD and BOD, energy efficiency and reduction of GHG emissions by the selected CUs. (vii) Compile recommendations on energy efficiency and reduction of GHG emissions in general (concrete) national recommendations. **(viii)** Facilitation of workshops with key water supply, wastewater management and GHG emissions monitoring and reporting stakeholders on the possible integration of energy efficiency and GHG emission reporting guidelines into annual CUs performance reports
2. since 09/2017	Client: Lusaka Water and Sewerage Company Ltd (LWSC) Position: Design Engineer For reference: Stefan Doerner, Country Director, Zambia	Zambia	**Lusaka Sanitation Program (LSP)** **Detailed Design, Procurement and Supervision of Sewerage Works under AfDB and WB Component of the Lusaka Sanitation Program – Financed by AfDB and WB** (i) Study of existing FSM technologies and sludge reuse options across the globe, evaluation of operations and maintenance challenges of existing faecal sludge treatment plants (FSTP) in Lusaka.

Period	Employer & your title/ position. Contact info for references	Country	Summary of activities performed relevant to the assignment
	stefan.doerner@gopa-infra.com +260977770992		(ii) Research faecal sludge characterisation and respective quantification of sludge from various on-site sanitation facilities in different areas of the city and projection of qualities and quantities for 2020 and 2035; Design of four FSTP facilities in four zones of Lusaka. **(iii)** Detailed engineering design of the Manchinchi and Matero faecal sludge plants including treatment process, hydraulic and system sizing; Conceptual and detailed engineering of FSM facilities; Quantification of by- and end-products deriving from the treatment modules and listing of reuse options. **(iv)** Manchinchi and Matero FSTP construction supervision oversite **(v)** Development of O&M measures for the designed FSTPs and training of FSTP operators and managers in the O&M and management in the activities and schedules for efficient treatment of sludge and safe reuse of treatment by- and end-products. **(vi)** Training of FSTP operators on operations and maintenance of the designed FSTP
12/2021 to 01/2022	Employer: DOHWA Client: DAWASA Position: Design Engineer For References: Godlove Ngonda ESS Tanzania Director ngoda@essltd.co.tz +255713514446	Tanzania	**Provision of Facilitation and Technical Services for Creation of Essential Framework Conditions, Capacity Building, Preparation of Detailed Engineering Designs and Bidding Documents, and Construction Supervision of the Off-Grid Sanitation Works in Dar Es Salaam** **SUBCONTRACTOR FOR REDESIGN of FEACAL SLUDGE TREATMENT SYSTEM DESIGN** (i) Design report review of five FSTPs designed for DAWASA in Dar Es Salaam (ii) Process redesign of the FSTPs according to required sludge products endues and disposal standards (iii) Mass balancing of sludge treatment products at the designed FSTPS (iv) Treatment system modules resizing of the FSTPs (v) O&M specifications and scheduling of the designed FSTPS
12/2021 to 12/2022	Employer: China Civil Engineering Construction Corporation (ZAMBIA) Limited Client: Luapula Water and Sanitation Company Position: Design Engineer For References: Jason Xiow China Civil Project Manager	Zambia	**SUBCONTRACT FOR THE DESIGN AND CONSTRUCTION OF A WASTEWATER TO ENERGY SYSTEM IN MANSA WWTP** (i) Assessment of the wastewater, sanitation data and energy production from human wastewater (ii) Conceptual and detail design of biogas production from wastewater and adjustment of imhoff tanks to suit biogas trapping from wastewater (iii) Specifications of construction materials and appliance installation methodologies for biogas trapping from imhoff tanks (iv) Supply and install 20KW biogas engines (two engines with two in rotation and one on standby **(v)** Supply and install a Biogas scrubber for biogas cleaning

Period	Employer & your title/ position. Contact info for references	Country	Summary of activities performed relevant to the assignment
	ccecc_lpwater@163.com +260960628853		**(vi)** Formation of O&M operator team and training on operations and maintenance
08/2021 to 11/2023	Employer: China Civil Client: Luapula Water and Sanitation Company For References: Jason Xiow China Civil Project Manager ccecc_lpwater@163.com g +260960628853		**Design of Sludge Drying Beds for the faecal sludge treatment plants in Mansa and Samfya** (i) Sludge quantification for Mansa and Samfya (ii) Development of conceptual treatment processes (iii) Development of treatment system mass balances and treatment unit layout designs (iv) Development of technical system and detailed designs **(v)** Development of system O&M concepts
3. 04/2013 to date	Employer: BORDA Zambia Client: various Position: Senior Engineer For References: Laura Roig Senge BORDA Zambia Country Director roigsenge@borda.org +260962049729	Zambia	**Various including BMZ Projects** (vi) Research and development of on-site sanitation (OSS) solutions, sanitation management concepts, and project cost recovery tools. (vii) Development of business concepts for Decentralized Wastewater Treatment Systems (DEWATS) and Faecal Sludge Management (FSM). (viii) Detailed designs including structural engineering; Construction supervision; Performance monitoring; Monitoring and Evaluation of sanitation and wastewater energy projects, including FSTPs. (ix) Research on energy recovery from wastewater and solid waste. (x) Design support, supervision, monitoring and evaluation of FSM development and management models and their performance in the Southern African Region. (xi) Promotion of holistic sanitation approaches for liveable cities on national and international platforms. (xii) Research and development of on-site sanitation emptying and transportation methods in high density areas of Lusaka. (xiii) Conduct technical feasibility studies for DEWATS, solid waste and biogas projects including quality control and troubleshooting of DEWATS projects. (xiv) Supervised BMZ funded projects: timely coordination of information, resources and stakeholders of assigned implementation partners to BORDA. (xv) Development and implementation of Standard Operational Procedures (SOP's) for DEWATs. (xvi) Development and implementation of training materials for the construction and operation and maintenance of DEWATS. Training of DEWATS system caretakers, technicians and engineers in three Utilities, namely SWASCo, NWWSC and KWSC. (xvii) Development of technical standards for DEWATS implementation, hence contributing to the capacity development of WASH sector stakeholders in FSM and DEWATS plants.

Period	Employer & your title/ position. Contact info for references	Country	Summary of activities performed relevant to the assignment
			(xviii) Support the development of an O&M manual for FSM plants. (xix) Training pit emptiers and FSTP operators including training of trainers of trainers in pit emptying and faecal sludge plant operators. (xx) Design of biogas stoves for the Zambian market and modification of LPG stoves to use biogas.
4. 02/19 to 06/19	Employer: Centre for Energy, Environment and Engineering Zambia (CEEEZ) Client: Climate Resilient Infrastructure Development Facility CRIDF II Position: Wastewater and Energy Expert For reference: Professor F.D Yamba – Director Ceeez2015@gmail.com +260977856167	Zambia	**Greenhouse Gas Emissions Mitigation Options for Livingstone Sewerage Network (Bankability: Feasibility) - Climate Resilient Infrastructure Development Facility (CRIDF)** (i) Feasibility study on the energy production potential of wastewater in Livingstone and determination of greenhouse gas reduction potential from sanitation facilities. (ii) Assessment of sewer pump station efficiencies through pump energy use monitoring and evaluation. (iii) Assessment of methane capture from wastewater facilities from household's sanitation facilities in Livingstone and assessment of direct and indirect GHG emissions from sanitation facilities. (iv) Design of new sewer networks with biogas facilities for methane capture, further evaluating the renewable energy potential for current and future sewer connections.
5. 06/18 to 12/18	Employer: BORDA Zambia Client: GIZ CFS Position: Facilitator, Researcher and Publisher For reference: Trevor Surridge CFS Zambia Zambia Coordinator trevor.surridge@giz.de +962 (0)792828826	Kampala, Dar es Salaam & Lusaka	**Three Cities Knowledge Exchange on OSS and FSM - Kampala, Dar es Salaam & Lusaka – GIZ CFS** (i) Demographic study of Kampala, Lusaka and Dar Es Salaam population. (ii) Stakeholder mapping, study of institutional and regulatory frameworks as well as city specific information regarding OSS and FSM along the sanitation service chain in the participating cities. (iii) Documentation of knowledge gained during the Knowledge Exchange for three cities, inc. a comparison of the sanitation status quo of the three participating cities, the enabling and limiting factors for OSS and FSM, and a way forward to improve sanitation in each of the participating cities. (iv) Facilitation of workshops with Zambian stakeholders from municipalities/local authorities, commercial water and sanitation utilities and regulators to share required knowledge to enable them to make informed decisions in the field of FSM and OSS (https://www.susana.org/en/knowledge-hub/resources-and-ppublications/library/details/3826?pgrid=1). (v) Advisory and stakeholder support in the implementation of the GIZ-CFS in action areas A,B,C and D, which included but was not limited to creating prerequisites for the implementation of climate-friendly sanitation services and FSM that reduce greenhouse gas emissions through the

Period	Employer & your title/ position. Contact info for references	Country	Summary of activities performed relevant to the assignment
			development of the ECAM tool for Zambia to include faecal sludge services, creation of the SFD tool for Lusaka, testing of pit emptying equipment in peri-urban on-site sanitation facilities in Lusaka, development of on-site by-laws to aid in the inspection of sanitation facilities in Lusaka and the creation of OSS and FSM training materials for OSS and FSM service providers.
6. 06/18 to 11/18	Employer : GFA Consultants Zambia Client: Technical Education, Entrepreneurship Vocational Authority (TEVETA) Position: OSS &FSM Expert For reference: Herbert Mwaanga-Senior Expert Herbert.Mwaanga@gfa-group.de +260977996688	Zambia	**OSS & FSM CURRICULUM DEVELOPMENT – Funded by GIZ CFS** (i) Development of FSM and OSS Training Curriculum for the Technical Education, Entrepreneurship Vocational Authority (TEVETA)-Faecal Sludge Treatment Plant Management Training Manual, Faecal Sludge Treatment Plant Operations and Maintenance Training Manual. (ii) Development of job profiles for the involved personnel to be trained. (iii) Training of trainers on FSM and OSS on the developed modules was conducted together with the Lusaka Business and Technical College.
7. 10/17 to 11/17	Employer: The Logie Agency Client: St. Francis Hospital Position: Wastewater and Energy Expert For reference: Chris Faldon Nurse Consultant undefined chris.faldon@borders.scot.nhs.uk	Zambia	**Feasibility of Implementation of a Wastewater and Biogas Recovery Treatment Facilities at St-Francis Hospital - The Logie Legacy** (i) Technical and social assessment for the provision of waste water treatment solutions. (ii) Development of wastewater, sanitation and energy concepts for the hospital and the surrounding community; on-site data collection and carrying out wastewater disposal investigations in order to clarify design parameters, wastewater treatment facilities positioning. **(iii)** Development of wastewater treatment systems, operations and maintenance requirements and assessment of local human and material resource availability for the construction of facilities.
8. 09/16 to 11/16	Employer: Munich Advisors Group Clients: SNV Zambia Position: Wastewater and Energy Expert For reference:	Zambia	**The Feasibility of Implementation of Medium Scale Biogas Projects for Zambia - SNV Zambia** (i) Feasibility study on the implementation of biogas to electricity from livestock. (ii) Assessment of organic waste resources from livestock farms in Southern, Lusaka, Central and Copperbelt provinces. (iii) Quantification of organic waste from livestock farms and calculating the potential of biogas production from the waste and the related electricity production from the produced biogas.

Period	Employer & your title/ position. Contact info for references	Country	Summary of activities performed relevant to the assignment
	Marc Mate Engineer marc.mate@cbu.ac.zm +260975121517		**(iv)** Calculations of the levelised cost of energy production and the net-present (NPV) from organic waste
10. 02/14 to 11/14	Employer: BORDA Zambia Client: Zambia Bureau of Standards and Ministry of Energy Position: Biogas Advisor For References: Zambia Bureau of Standards Tino Kalikiti, Officer tinokalikiti@zabs.org.zm	Zambia	**Development of Biogas Standards for Zambia - Financed by The Zambia Bureau of Standards** (i) Advisory services to the Zambia Bureau of Standards, the Ministry of Energy and the Energy Regulations Board on the development of biogas standards for stand-alone facilities and biogas micro-grids for Zambia. **(ii)** Stakeholder consultations, mobilisation and facilitation of workshops in order to collect information and development of standards.
11. 01/14 to 12/15	Employer: Devolution Trust Fund (DTF) and BMZ Client: Kafubu Water, Southern Water and North Western Water and Sanitation Company Position: Research Assistant For References: Jeannette Laramee, Researcher-Stanford University Jeannette.Laramee@stantec.com +14159941412	Zambia	**Project for Low-Cost Sanitation (P-LoCSan)** **Assessing Lifecycle Costs and Benefits of Integrated Sanitation and Energy Recovery Strategies in Low-Income Countries – Financed by DTF, BMZ and GIZ** (i) Assessment of potential of wastewater treatment and biogas facilities in low cost sanitation projects, evaluation of biogas production per capita in each of the three towns and the methane production potential of the implemented systems (ii) Development of structured questionnaires on energy use efficiency in households connected to biogas units in project areas, connection of biogas digester gas meters, connection of energy use monitoring meters and reading of energy gas use from biogas digesters and electric meters and evaluation of results (iii) Evaluation of household energy requirements and evaluation of greenhouse gas impacts on the installation of sanitation biogas digester, rectification of biogas networks and equipment to ensure safe gas usages, (iv) Development of training materials for DEWATS caretakers and training of caretakers, technicians and engineers in three commercial utilities with green house systems for sanitation https://doi.org/10.1016/j.jenvman.2017.12.064.
12. 02/2013 to 09/2013	Employer: (NGO) Water and sanitation Association of Zambia (WASAZA) Client: Devolution Trust Fund; • Southern Water and sanitation Company-Livingstone	Zambia	**Construction supervision of Household sanitation facilities, Shallow small bore sewers and Decentralised Wastewater Treatment Facilities and Operations and maintenance training of the implemented facilities in Three Utility Towns of Zambia** (i) Construction and installation supervision of 630 block and precast household toilets to be connected to shallow bored sewer systems

Period	Employer & your title/ position. Contact info for references	Country	Summary of activities performed relevant to the assignment
	Kafubu Water and Sanitation Company-Ndola And • North-Western Water and Sanitation Company-Solwezi Position: Supervising Engineer For References: Jonathan Phiri, WASAZA CEO phirij@wasaza.org.zm +260977846246		(ii) Facilitation and Supervision of household sewer connections (iii) Household toilet user trainings (iv) Preparation of training materials and training of utility personnel on the operations and management of simplified sewer connections (v) Biogas connections and training of households on biogas utilisation training (vi) Preparations of operations and maintenance manuals and training of utility personnel on the operations and maintenance of shallow bore sewers and decentralised waste water treatment facilities
13. 02/2013 to 09/2013	Employer: (NGO) Water and sanitation Association of Zambia (WASAZA) Client: (NGO) WSUP Position: Assistant Engineer For References: Jonathan Phiri, WASAZA CEO phirij@wasaza.org.zm +260977846246	Zambia	**Monitoring and Evaluation of the Kanyama FSTP for WSUP Zambia – financed by WSUP** (i) Evaluation of sludge pit emptying and transportation in Kanyama by the Kanyama pit emptying teams (ii) Evaluation of sludge treatment at the Kanyama FSTP (iii) Optimization of the Kanyama FSTP treatment plant performance. (iv) Monitoring of FSTP by and end product reuse and disposal (v) Improvement in sludge emptying and transportation and sludge treatment by-product reuse. (vi) Conceptualising of the Chazanga Faecal sludge treatment plant (vii) O&M training of sludge emptiers and treatment plant operators.
14. 09/2012 to 01/2013	Employer: SKF Zambia Client: Konkola Copper Mines Position: Trainee Engineer	Zambia	**Condition Monitoring of Mine Equipment - KCM** (i) Mechanical servicing of mine processing equipment. (ii) Condition monitoring of mine processing equipment which incl: Infrared thermography surveillance /analysis of high voltage electrical equipment, water and sludge pumps; Ultrasound inspection of high tension cables; and vibrations analysis of rotary production machinery and pumping equipment. (iii) Recommendations on prevention of breakdown maintenance.
15. 04/2012 to 07/2012	Employer: (NGO) Water and Sanitation Association of Zambia (WASAZA) Client: Various Position: Engineering Intern in the Sanitation	Zambia	**Water and Sanitation Association of Zambia (WASAZA)** (i) Sanitation feasibility studies for schools, hospitals and community centres. (ii) Project management assist in the implementation of rural sanitation centres. (iii) Facilitation of DEWATS educational site visits. (iv) Development of DEWATS O&M manuals.

Period	Employer & your title/ position. Contact info for references	Country	Summary of activities performed relevant to the assignment
	Engineering Department For References: Jonathan Phiri, WASAZA CEO phirij@wasaza.org.zm +260977846246		(v) DEWATS O&M capacity building.
15. 04/2011 to 08/2011	Employer: Mopani Copper Mines Position: Eng. Intern	Zambia	**Kafue Bulk Raw Water Supply Pipeline - Mopani Copper Mines** (i) Feasibility study of mine production materials and equipment; Engineering drawing production of mine processing tools and equipment. (ii) Quality assurance office on the installation of a 13 kilometres Kafue river raw bulk water supply pipeline. (iii) Monitoring of water pumping energy use and recommendations on efficient pumps for water pumping. (iv) Quality assurance on the fabrication and installation of a copper concentrate shed.

Membership in professional associations and publications:

- Registered Professional Engineer, Engineering Institution of Zambia (EIZ); EIZ No. 220502172014291
- Member of the German WASH Network
- Committee member and contributor on the development of the Statutory Instrument on OSS and FSM
- Lusaka District Urban Wash Committee Member
- Committee member and contributor on the development of the On-site sanitation and faecal sludge management Code of practice
- Committee member for the Development of the Lusaka OSS By-Law

Language skills (indicate only languages in which you can work)**:**

- English
- Bemba
- Nyanja

Other relevant information (e.g., Publications)

2023 Simwambi et.al (2023). Effects of Poor Solid Waste Management on Faecal Sludge Emptying, Treatment and Disposal Services in Lusaka

Effects of Poor Solid Waste Management on Faecal Sludge Emptying, Treatment and Disposal Services in Lusaka | European Journal of Applied Sciences (scholarpublishing.org)

2020 Simwambi et,al (2020). Renewable Energy Potential of Sewage in Zambia https://www.scirp.org/journal/paperinformation.aspx?paperid=1012302020

2020 Contributor: Lior Sperandeo & Shobana Srinivasan (2020), The Heroes Behind Sanitation: An insight into faecal sludge management workers in Zambia

https://www.susana.org/_resources/documents/default/3-3762-7-1581082612.pdf

2020 Simwambi et.al (2020). Three-cities OSS & FSM knowledge exchange – Lusaka, Kampala and Dar Es Salaam (Case study), https://www.susana.org/en/knowledge-hub/resources-and-publications/library/details/3826?pgrid=1

2019 Simwambi, A (2019). FSM 5 Poster Researcher: Effects of Solid Waste on the FSM Service Chain-The Case Study of Lusaka https://as5fsm5.com/app/posters.html

2018 Contributor: Kevin Tayler (2020), Fecal Sludge and Septage Treatment: A Guide for Low- and Middle-Income Countries Faecal Sludge and Septage Treatment: A Guide for Low- and Middle-income Countries - 9781780449869_01670055003.pdf (practicalactionpublishing.com)

2017 Simwambi,et, al. (2017). Approaches to Faecal Sludge management in Peri-Urban Areas: A Case Study in the City of Lusaka https://www.susana.org/en/knowledge-hub/resources-and-publications/library/details/2760

2017 Presenter on FSM management models for Lusaka at the FSM 4 conference in Chennai on "Current and Recommended FSM Operation Models for Over-coming Current and Future Challenges - A Lusaka Case Study http://www.susana.org/_resources/documents/default/3-2744-7-1488876750.pdf

Adequacy for the assignment:

Detailed Tasks Assigned on Consultant's Team of Experts	Reference to Prior Work/Assignments that Best Illustrates Capability to Handle the Assigned Tasks
	• Lusaka Sanitation Program (LSP)_Detailed Design, Procurement and Supervision of Sewerage Works under AfDB and WB Component of the Lusaka Sanitation Program – Financed by AfDB and WB • Provision of Facilitation and Technical Services for Creation of Essential Framework Conditions, Capacity Building, Preparation of Detailed Engineering Designs and Bidding Documents, and Construction Supervision of the Off-Grid Sanitation Works in Dar Es Salaam Subcontractor for design review and redesign of faecal sludge treatment systems • Subcontractor for the design and construction supervision of a wastewater to energy production system at the Mansa Wastewater Treatment Plant • Expert for data collection on water and sanitation for the implementation of the ECAM Tool in six (6) selected Commercial Utilities in Zambia _Southern, Luapula, Lusaka, Lukanga, Nkana and Mulonga Water and Sanitation Company) • Development of FSM and OSS Training Curriculum for the Technical Education, Entrepreneurship Vocational Authority (TEVETA)-Faecal Sludge Treatment Plant Management Training Manual, Faecal Sludge Treatment Plant Operations and Maintenance Training Manual. • Training of trainers on FSM and OSS in Zambia in collaboration with the Lusaka Business and Technical College. • World Health Organisation (WHO) Trained in Sanitation Safety Planning • Experienced user of global sanitation Toolkit planning frameworks- CLUES (Community Led Urban Environmental Sanitation) and SAN 21 • Contributor in the development of the NWASCO regulatory frameworks for service provision and regulation of Urban OSS and FSM • Experienced practitioner of City Wise Inclusive Sanitation approaches • Training of pit emptiers and vacuum truck operators in Lusaka

	• Over 9 years' experience in training FSTP operators • Research and publication on Approaches to Faecal Sludge management in Peri-Urban Areas: A Case Study in the City of Lusaka • Research and publication on Effects of Poor Solid Waste Management on Faecal Sludge Emptying, Treatment and Disposal Services in Lusaka • Monitoring and Evaluation of the first FSTP and its operationalisation in Lusaka • Advisory on the development of FSM standards for Lusaka and Zambia (Lusaka OSS and FSM by-law, OSS and FSM code of practice and OSS and FSM Statutory instrument) • Research and development for the implementation wastewater to energy in Zambia • Installation supervision of block and prefab toilet under the pilot for Low Cost sanitation in three utility towns including user trainings of sanitation facilities and wastewater conveyance and treatment systems

Expert's contact information : aubrey.simwambi@gmail.com

Certification:

I, the undersigned, certify that to the best of my knowledge and belief, this CV correctly describes myself, my qualifications, and my experience, and I am available to undertake the assignment in case of an award. I understand that any misstatement or misrepresentation described herein may lead to my disqualification or dismissal by the Client, and/or sanctions by ZPPA.

Aubrey SIMWAMBI		14.11.2023
Name of expert	Signature	Date