Assessment of Roton Wastewater Lagoon in Juba

A component of the South Sudan Sustainable Water and Sanitation in Africa (SUWASA) Project

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Photo: By SUWASA

Tetra Tech
159 Bank Street, Suit 300
Burlington, Vermont 05401 USA

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CONTENTS

ACRONYMS

ASO	Assistant Sanitary Overseer
BOD	Biochemical Oxygen Demand
COD	Carbon Oxygen Demand
CPA	Comprehensive Peace Agreement
GOSS	Government of South Sudan
MDTF	Multi-Donor Trust Fund
MEDIWR	Ministry of Electricity Dams, Irrigation, and Water Resources
MLHPP	Ministry of Lands, Housing, and Physical Planning
RSS	Republic of South Sudan
SSCCSE	Southern Sudan Centre for Census, Statistics and Evaluation
SSUWC	South Sudan Urban Water Corporation
SUWASA	Sustainable Water and Sanitation in Africa Project
TN	Total Nitrogen
TP	Total Potassium
TSS	Total Suspended Solids
USAID	United States Agency for International Development
WASH	Water, Sanitation, and Hygiene
WSP	Water and Sanitation Program

EXECUTIVE SUMMARY

The rapid growth of Juba City, the capital of South Sudan, over the past 10 years presents municipal authorities with a multitude of challenges. One of these challenges is the provision of adequate sanitation facilities for an ever-growing population. Presently, information about the Roton Wastewater Lagoon that would ordinarily be available for planning purposes (such as design criteria or operating standards and manuals) is scarce or absent. As a result, there is a risk that future investments, based upon circumstantial evidence, will not target the areas of sanitation that should be prioritized. The provision of accurate data regarding current sanitation conditions at both household and city levels is a priority for the Government of South Sudan (GOSS) as it looks to make new investments in the city.

The United States Agency for International Development (USAID), through its Sustainable Water and Sanitation in Africa (SUWASA) program, is supporting the water and sanitation sector of South Sudan and is working with the Juba City Council to plan and prioritize sanitation investments across the city. To fill the current information gaps on the sanitation situation in Juba, SUWASA staff developed and undertook an assessment of the Roton Wastewater Lagoon between December 2013 and July 2014.

Through a collaborative process, the USAID Mission representative and the SUWASA team in Juba determined scope and content of the assessment prior to field deployment. The assessment tools were developed with a focus on understanding the design and operation of the lagoon, areas requiring rehabilitation or performance improvement, and opportunities for replication and scale up.

The survey was carried out in December 2013 by six enumerators working in pairs (three males and three females), using paper-based questionnaires. The enumerators also conducted a count of exhauster trucks in July 2014. SUWASA staff conducted interviews with relevant government and donor agencies, undertook an archival search for documents related to construction of the lagoon, and analyzed effluent from the lagoon.

The survey generated 35 questionnaire responses and 150 individual points of data from the exhauster count. SUWASA staff, with support from the Tetra Tech Home Office, undertook quantitative analysis of all data for presentation to local authorities and USAID.

The assessment has produced hitherto-unknown information, key being the following:

1) **The lagoon was constructed to only one-third of its potential capacity:** Only a portion of the lagoon was constructed, and has capacity of about 3,300m3/day. However, land is available at the site for expansion to a full capacity of between 6,800 and 9,500m3/day.
2) **The lagoon has sufficient capacity for the present population:** Even though only a portion of the lagoon was constructed, it has sufficient capacity for the current population as it is only operating at 70 percent capacity. However, this existing capacity will be reached by 2020 at current estimated population growth rates of 5.71 percent per annum.
3) **Inadequate operation and maintenance of the lagoon:** Existing management arrangements do not have adequate systems for proper operation and maintenance of the lagoon. This is further compounded by the lack of training of staff and operational manuals and leads to poor functionality of the lagoon.
4) **Insufficient treatment:** Even though capacity is not fully utilized, treatment processes at the lagoon are not fully meeting required effluent standards, mainly due to the poor maintenance of the lagoon.
5) **Lack of re-investment into the lagoon:** Even though the lagoon generates about US $1.2m annually from toll fee and emptying charges on exhauster trucks, none is reinvested in the lagoon due to a lack of ring fencing of the revenues.

1.0 INTRODUCTION

1.1 Background

Following the conclusion of the 2005 Comprehensive Peace Agreement (CPA) interim period and independence for South Sudan in July 2011, the Republic of South Sudan (RSS) continues to face new challenges in its endeavor to promote peace, development, and stability. Since signing the CPA, the Government of South Sudan (GOSS) has made much progress; however, its struggle to meet increasing demand for basic services and develop a broad economic base beyond the extractive industries still continues. The United States Agency for International Development (USAID) and other development partners have proactively engaged in helping South Sudan meet the challenges of maintaining stability and supporting development while upholding the governance capacity development.

Shortly after the CPA in 2006, South Sudan suffered from significant cholera outbreaks across the country that left more than a thousand people dead. The outbreaks were mainly in areas with relatively high population densities, such as (peri-) urban regions and military barracks. During that time, residents of the new capital (Juba) largely consumed untreated Nile River water. Urban sanitation coverage was estimated to be below 10 percent, resulting in high mortality rates from water-borne diseases. USAID and other development partners invested in emergency responses to address the sanitation disaster.

By 2009, it was estimated that urban sanitation coverage in South Sudan had increased to approximately 19 percent (Water and Sanitation Program [WSP] 2010). However, urban areas such as Juba continue to expand rapidly, while basic services such as sanitation have not kept up with this rapid growth. The exact population numbers for Juba remain contested; but in 2005, the population was estimated to be 163,000. In 2013, the population of Juba was estimated to be 500,000.

Despite the significant challenges surrounding urban sanitation, only limited government or donor investments have been made in urban sanitation due to many competing priorities. The main investment that has been made was by the World Bank-managed Multi-Donor Trust Fund (MDTF), which invested in the construction of the Roton Wastewater Lagoon for discharging septic exhauster trucks on the periphery of Juba (Figure 1.1).

At the same time, the private sector has stepped in to provide exhauster services throughout the city (Figure 1.2).

Prior to the construction of the Roton Wastewater Lagoon, human waste was collected by 10 private tankers and dumped on the south side of Mount Jebel Kujur without any regulation. The lagoon, commissioned in 2010, therefore represents significant progress in fecal sludge management in the city. However, projected continued rapid growth of the population means that more effort needs to be made to ensure that the wastewater treatment facilities in the city are adequate.

Figure 1.1: Roton Wastewater Lagoon

Figure 1.2: Exhausters Emptying at Roton Lagoon

A Household Sanitation and Mapping Survey undertaken by Sustainable Water and Sanitation in Africa (SUWASA) program in October 2013 revealed that about 40 percent of households that have toilets invested in toilets that can be emptied by a vacuum tanker. The population of the city is expected to continue growing at a relatively high rate of about 5.71 percent. This means that the number of toilets and fecal sludge generated in the city will continue to grow, as will demand for treatment of wastewater. In the meantime, the Roton Wastewater Lagoon, of which only a portion of what was designed was constructed, remains the only public treatment facility in Juba. At the same time, there is no clarity on its operation and sustainability as systems for its proper management have not yet been clearly defined. The lagoon is therefore producing poor-quality effluent that is discharged into the environment with potential negative impacts. It is therefore important to obtain a clear understanding of how the lagoon is operating in order to assure continued safe disposal of human waste in Juba and to safeguard the gains made through this investment.

1.2 Assessment of Roton Wastewater Treatment Plant

It is against this backdrop that the SUWASA program has undertaken this assessment of the Roton Wastewater Lagoon. The broad objective of the assessment was to understand the operations of the lagoon and identify areas for improvement.

This report presents the results of the assessment highlighting design capacity and construction of the lagoon, current operations, usage, management, and financial potential. The report ends with recommendations on possible areas of improvement and consideration for future investments in wastewater treatment in Juba. This is one of five studies that SUWASA has undertaken in order to gain a full understanding of the sanitation situation in Juba. The other four studies that were completed include:

- Sanitation Mapping and Household Survey to Determine Sanitation and Hygiene Practices;
- Survey of Public Toilets;
- Survey of Private Exhauster Businesses to Determine Operations and Regulatory Environment;
- Mapping of Institutions Involved in Sanitation to Determine Operational Effectiveness.

The outcomes of this and all the other reports feed into the Juba City Sanitation Reform and Investment Plan.

The rest of the report is organized into four sections. Section 2.0 presents the methodology used for assessing the Roton Wastewater Lagoon. Section 3.0 presents the findings of the assessment. Section 4.0 draws some conclusions and discusses the implications of the findings for possible donor and government interventions. Section 5.0 presents some key lessons learned from this survey.

2.0 ASSESSMENT METHODOLOGY

2.1 Introduction

In order to capture all elements of the operations of the lagoon, information was collected from a number of sources including both document reviews as well as interviews with relevant groups. To execute this methodology, the team worked with Juba County, the Ministry of Lands, Housing, and Physical Planning (MLHPP); Ministry of Dams, Electricity, Irrigation and Water Resources (MEDIWR); and Juba City Council. Certain elements of the study (including administration of questionnaires to exhauster truckers) were conducted by hired enumerators. Documentation review and interviews with government agencies were conducted by SUWASA staff. The assessment also involved a number of visits to the lagoon for physical observations and sampling and testing of effluent from the lagoon. In some cases, two or more follow up interviews were made with staff to clarify findings. The assessment was undertaken between December 2013 and July 2014.

2.2 Definition of Research Questions

The broad objective of the assessment was to understand the operations of the lagoon and identify areas for improvement. A collaborative process involving the Juba County, Juba City Council, USAID, the Tetra Tech Home Office, and SUWASA further refined this objective into actionable research questions as follows:

- What were the design assumptions, criteria, and capacity of the lagoon?
- What are the levels of current usage and how effective is the treatment process at the lagoon?
- How is the lagoon being managed and what aspects require further attention?
- What is the revenue potential from the lagoon?
- What lessons can be drawn from the operations of the Roton Lagoon for future replication and scale up of wastewater treatment in Juba?

2.3 Data Sources and Collection for the Assessment

In order to answer these questions, information for the assessment of the lagoon was collected from four main sources described below.

2.3.1 Review of Documents from Gibb Africa in Nairobi, Kenya

SUWASA undertook an archival search and collected key documents, including reports, design drawings, bills of quantities, and other records related to the construction of the lagoon from the consulting firm Gibb Africa head office in Nairobi, Kenya in February 2014. Gibb Africa designed and supervised the construction of the Roton Wastewater Lagoon. Additional searches for the design report and other documents were done at MEDIWR, MLHPP, and the World Bank in Juba, South Sudan. Despite this effort, SUWASA was unable to locate the design report with the consultant or the government ministries. The documents that were collected formed the basis for answering most of the questions related to the design and construction of the lagoon.

2.3.2 Chemical Analysis of Effluent in the Lagoon

Two grab samples, from five locations during the dry season in March 2014 and eight locations in the wet season in July 2014, were collected by SUWASA staff. The samples were sent to Aquatech Industries in Nairobi, Kenya for analysis of typical effluent indicators. A strict protocol for collection was observed. Sterilized bottles were used to collect samples, based on the advice of Aquatech Industries.

A total of 1.5 litres of wastewater were collected at each point (the quantity of waste deemed adequate by the lab). Before samples were collected, the bottles were rinsed with adequate quantities of wastewater to enable favorable conditions for the sample. No

preservatives were added to the sample. The samples were immediately placed on ice and transported by air to the laboratory within 24 hours of collection. The lab confirmed that they had received the samples in good condition.

The aim of this exercise was to assess the quality of effluent in the lagoon.

2.3.3 Interviews

A series of interviews were conducted with the following staff:

- Staff of Juba County, including the Director of Public Health in charge of the Roton Wastewater Lagoon and the Assistant Overseer tasked with daily management of the lagoon. The interview guide used is attached as Annex 1.
- Senior staff of MLHPP and MEDIWR who had been involved with the design and construction of the lagoon.
- Staff of the World Bank who had been involved with design and construction of the lagoon.

The aim of these interviews was to gather information on operation of the lagoon, supervision of the exhauster tankers emptying at the lagoon, and financial transactions related to the use of the lagoon.

2.3.4 Survey of Exhauster Trucks

A survey of exhauster trucks was done in December 2013 and July 2014 and had two components:

1) **Administration of a Questionnaire to Exhauster Truck Drivers in December 2013**: The aim was to gather information on sources of the sludge and management of the trucks at the lagoon, including financial transactions related to the use of the lagoon for emptying sludge. The questionnaire was designed to be very simple so that it would not take more than 10 minutes per truck to avoid disrupting the work of the truckers. The questionnaire is attached as Annex 2 in this document. The questionnaire was administered by a team of SUWASA-trained enumerators. The team selected questions for their contribution to results analysis to ensure that only useful data are collected. The purpose of this rigorous review was to pare down the questionnaire to its essential elements, thus limiting respondent fatigue and improving data quality. The resulting survey was structured based on three components (see Annex 2 for the complete questionnaire):
   - General respondent demographic information including informed consent;
   - Information about the exhauster business; and
   - Information about the exhauster truck.
2) **A Count of Trucks Discharging into the Lagoon:** A count of trucks discharging into the lagoon was undertaken from July 21–25, 2014. Even though the lagoon is open from 7:00 am to 5:00 pm, the count was only undertaken between 8:00 am to 4:00 pm daily due to the prevailing security situation at the time. The exercise involved use of a simple form with six entries targeting time in, ownership of the truck, make of the truck, vehicle registration, truck capacity, and amount paid for emptying for each trip. The form is attached as Annex 3 in this document. The aim of this exercise was to assess the quantity of sludge being emptied into the lagoon.

After receiving feedback from enumerators and a number of field tests, some questions were added and others were dropped. The surveys also involved physical observation of different aspects of the exhauster trucks and workers.

2.3.4.1 Enumeration: Training and Implementation

Upon completion of the survey design process for both, the survey management team conducted enumerator training before deploying enumeration teams to conduct the interviews.

SUWASA staff identified six enumerators (three males and three females) who had previously worked on the Juba Household Sanitation Survey and the Public Toilets Survey and who therefore had developed a good basic understanding of the SUWASA sanitation agenda. The training involved giving the enumerators a clear understanding of the intention of each question including

translating into Arabic to ensure correct meanings. The training included the following components:

- Introduction to SUWASA project;
- Familiarization with exhauster tanker survey objectives;
- Introduction to survey content using paper forms;
- Group practice; and
- Provision of basic skills in communications and people skills.

2.3.4.2 Data Transfer and Progress Monitoring

The survey management team seamlessly transferred interview data collected by enumeration teams from the paper based questionnaires to excel based spreadsheet. The team entered all the data into excel after completion of the survey. The total sample size for analysis consists of 35 interviews with truck drivers and a count of 150 exhauster trucks.

3.0 FINDINGS OF THE ASSESSMENT OF ROTON WASTEWATER LAGOON

3.1 Location of the Lagoon

Figure 3.1: Location of Roton Wastewater Treatment Plant

Roton Wastewater Lagoon is located approximately eight kilometers from Juba town center in Nyayin Village, North Juba at a place called Roton. The location is in Northern Bari Block, which is outside the City boundary but within the control of Juba County and under the jurisdiction of the Chief of the Block community with the Bari as the main ethnic group in the area. The site is on a nine-hectare piece of land and is surrounded by wetlands to the east, a developing residential area to the west, marshy spot and water course to the south, and the army barracks to the north (Figure 3.1).

3.2 Design of Roton

The Roton Lagoon was designed and the construction was supervised by Gibb Africa Limited in a Joint Venture with Kwezi V3 Engineers and in association with PADCO Limited under a consultancy financed by GOSS. Construction was undertaken by SPENCON Incorporated (Kenya) with co-financing from the MDTF managed by the World Bank and GOSS. The exact cost of the project is unclear, although some documents suggest it may have cost about US $4 million. The lagoon technology is an ideal method for treating fecal sludge in Juba. There are minimal electrical and chemical requirements and the facilities can be maintained with minimal labor and equipment compared to other treatment technologies.

The Roton Wastewater Lagoon opened in 2010 to receive fecal sludge for treatment. The existing facilities consist of a receiving station, a grit channel, an anaerobic lagoon, and a facultative lagoon. The anaerobic lagoons are deep (3 m) basins that are designed to reduce settlable solids, digest organic solids, and consume soluble organic material through anaerobic biological processes. The facultative lagoon uses a mixture of aerobic, anoxic, and anaerobic zones to remove soluble organic material and some nitrogen from the water further. Properly designed and operated, this type of configuration is effective at removing Biochemical Oxygen

Demand (BOD), total suspended solids (TSS), and fecal coliforms. Ultimately, the lagoon site can accommodate two additional anaerobic lagoons, one additional facultative lagoon, and a series of maturation lagoons that would act to remove suspended solids and fecal coliforms further (Figure 2.2).

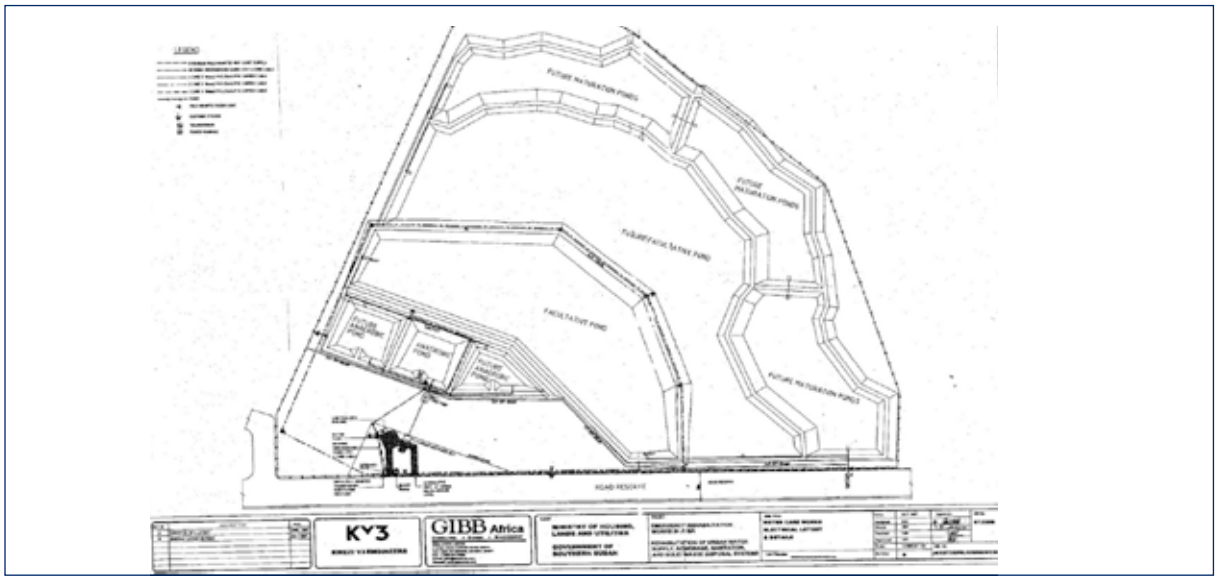


Figure 3.2: Layout of Roton Lagoon

The site also has a finished laboratory building, although it has never been equipped (Figure 3.3).

The lagoon is accessed via an unpaved gravel road. The road and the offloading bay area are in a poor state of repair, which makes access difficult, especially in the rainy season (Figure 3.4).

Site visits to the Roton Lagoon revealed that the above-ground, exposed structures and facilities were in good condition. The anaerobic basin had a significant amount of large debris, such as plastic bottles, which should have been screened out prior to effluent entering the lagoon. As a result of this accumulation, the influent appeared to be passing straight through the basin to the facultative lagoon instead of being dispersed in the basin. Piles of grit and sand on the banks of the anaerobic lagoon indicate that the basin does receive some cleaning. The facultative lagoon appeared to be properly functioning. Algae that is crucial to the successful removal of pollutants was present in the lagoon but not in such a significant amount that it seemed to be contributing to TSS in the effluent.

Figure 3.3: Laboratory building next to the water tank and anaerobic pond in foreground

Figure 3.4: Unpaved and poorly maintained Access Road to Roton Lagoon

3.3 Sewerage Quantity and Capacity Analysis

As noted earlier, SUWASA has not been able to access the design report for the Roton Lagoon despite numerous efforts. However, the design capacity has been deduced based on available design drawings and the design criteria, as shown in Table 3.1.

Table 3.1: Roton Wastewater Lagoon Capacity Analysis Criteria

Criteria	Existing Facility	Future Facilities
Influent BOD (kg/m^3)	0.40	0.40
Anaerobic Lagoon		
Loading Rate (kg BOD/m^3/day)	0.20	0.20
Volume (m^3)	6,627	13,250
Design Capacity (m^3/day)	3,313	6,625
Facultative Lagoon		
Loading Rate (kg BOD/ha/day)	100	100
Area (ha)	3.6	4.3
Design Capacity (m^3/day)	3,300	3,567
Maturation Ponds		
Retention Time (days)	N/A	5
Volume (m^3)	N/A	41,250
Design Capacity (m^3/day)	N/A	8,250

Roton Lagoon has an existing capacity of approximately 3,300 m^3/day. The Roton Lagoon is not equipped with a flow measuring device. However, the survey of exhauster trucks conducted in July 2014 indicated that the lagoon is receiving 2,300 m^3/day of fecal sludge. This means that the Roton Lagoon is operating at approximately 70 percent capacity. With the future expansions envisioned in the original design for the site, the total expanded capacity is estimated to be between 6,500–9,800 m^3/day.

3.4 Sewerage Quality

Grab samples were taken on two separate events to obtain data on the water quality at various points in the treatment process. Table 3.2 summarizes the results and Table 3.3 compares the results against Environmental Health and Safety Standards for wastewater discharges published by the World Bank.

Table 3.2: Sewerage Quality Sampling

Parameter [1]	Receiving Area	Anaerobic Lagoon Effluent	Facultative Lagoon Effluent
Sample event: March 2014			
pH	7.24	7.2	7.68
Suspended Solids	371	261	655
Conductivity	3840	3560	3790
BOD	365	328	216
Carbon Oxygen Demand (COD)	912	820	653
Potassium	21.8	20.6	18.9
Ammonium	190.3	160.05	152.03
Copper	0.23	0.46	0.02
Nickel	0.172	0.191	0.353
Lead	0.005	0.004	0.004

Arsenic	0.07	0.03	0.03
Cadmium	ND	ND	ND
Total Nitrogen	330	190	190
Total Phosphorous	73.1	95.5	79.5
Fecal Coliform	16	16	9.2
Sample event: July 2014			
pH	8.44	8.01	8.58
Suspended Solids	488	654	643
Conductivity	4400	4120	3090
BOD	384	466	184
COD	712	1165	460
Potassium	61.3	85.9	79.6
Ammonium	65.89	190.99	120.03
Copper	0.04	0.29	0.11
Nickel	0139	0.256	0.226
Lead	0.004	0.004	0.003
Arsenic	0.03	0.02	0.02
Cadmium	ND	ND	ND
Total N	180	210	165
Total Phosphorous	23.9	77	68.1
Fecal Coliform	5.2	9.2	5.2

Notes: *(1) All units in mg/l except for Fecal Coliform in count per ml. ND = Not Detected*
Source: *SUWASA Assessment of Roton Lagoon in Juba, 2013/14*

It is important to note that the data in Table 3.2 is based on grab samples that were taken in the absence of a specific sampling protocol. The results therefore should be considered as a generalized single snapshot of the overall quality and a more rigorous sampling program may yield different results. Nevertheless based on the data, there is evidence that the Roton Lagoon is somewhat effective at removing BOD and Total Nitrogen (TN). No design effluent data standards were available. However, Table 3.3 shows that standard effluent discharge limits as set by the World Bank, which financed construction of the lagoon, are not being met. The high suspended solids in the effluent may be due to the presence of algae and not sewerage pollutants.

Table 3.3: Effluent Quality Comparison

Parameter	Roton Effluent	Effluent Standards – World Bank
pH	7.68 – 8.58	6 – 9
BOD	184 – 216	30
COD	653 – 460	125
Total Nitrogen	165 – 190	10
Total Phosphorous	68.1 – 79.5	2
Total Suspended Solids	643 – 655	50
Total Coliform Bact.	5.2 – 9.2	400

Source: *SUWASA Assessment of Roton Lagoon in Juba, 2013/14*

Additional sample locations include sites one and two kilometers downstream of the effluent discharge point. Further samples at the stream's entrance to the Nile and at two points in the Nile upstream of the stream's entrance were taken in July 2014. The data are provided in Table 3.4 below.

Table 3.4: Stream and River Quality Data

Parameter [1]	1 km downstream from discharge	2 km downstream from discharge	Stream entrance to Nile River	Nile river 2 km upstream of stream entrance	Nile River upstream of Juba
Sample event: March 2014					
pH	7.57	7.62	No Sample	No Sample	No Sample
Suspended Solids	659	673	No Sample	No Sample	No Sample
BOD	270	264	No Sample	No Sample	No Sample
COD	674	660	No Sample	No Sample	No Sample
Total Nitrogen	178	181	No Sample	No Sample	No Sample
Total Phosphorous	80.4	77.9	No Sample	No Sample	No Sample
Fecal Coliform	5.1	9.2	No Sample	No Sample	No Sample
Sample event: July 2014					
pH	8.51	8.53	7.94	8.13	8.12
Suspended Solids	814	678	208	48	29
BOD	664	183	17.6	5	2
COD	1668	458	44	12	5
Total N	110	135	8	4	1
Fecal Coliform	9.2	5.2	2.2	None Detected	2.2

Notes: *(1) All units in mg/l except for Fecal Coliform in count per ml.*

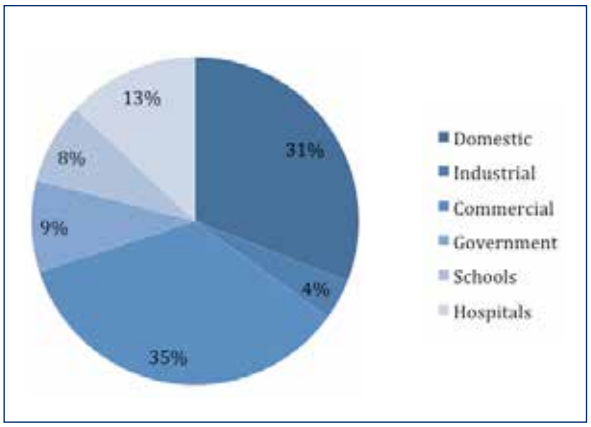
The stream data is highly erratic with some pollutant concentrations exceeding the raw wastewater quality. In addition to the sampling limitations mentioned above, it is possible that the presence of livestock and other environmental factors are heavily influencing the water quality at these locations. For future sampling of this area, it is recommended to obtain samples upstream of the effluent discharge point to establish a background level of pollutants for the stream.

The data obtained from the Nile presents a general idea of the water quality around Juba. However, other contributions to the river as it flows past Juba obscure any particular influence that may be caused by the Roton effluent.

Additional parameters particularly metals were also tested. The metals sampled include potassium, copper, nickel, lead, arsenic, and cadmium. None of the metals concentrations detected are unusual for sewerage.

It should be noted that the fecal sludge quality received at the lagoon is greatly dependent upon where the exhauster trucks received their load. The survey of truck drivers found that the majority of sludge is collected from commercial premises including shops and offices. This is closely followed by domestic sludge (Figure 3.5).

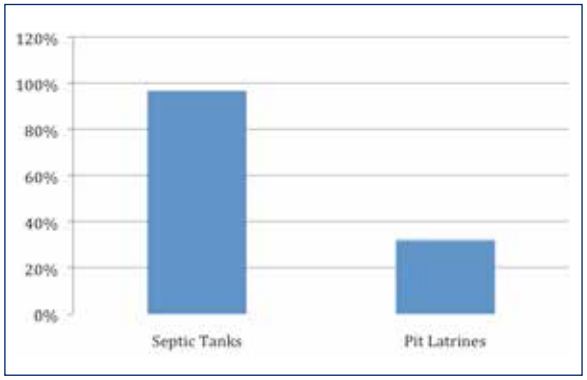
Figure 3.5: Sources of Sludge in Juba by Type of Property



It is worth noting that there is very little industrial waste going into the lagoon, a reflection of the fact that there are currently very few industries in Juba.

The survey of truck drivers also revealed that the main source of the sludge is from septic tanks, with almost all drivers reporting that they collect from septic tanks. Only 32 percent collect sludge from pit latrines (Figure 3.6).

Figure 3.6: Sources of Sludge collected by trucks in Juba by Type of Toilet Facility



This might be a reflection of the fact that pit latrines are generally not lined and are therefore not adaptable to be emptied by vacuum tankers. Alternatively, the result could also be a reflection of the high price of emptying sludge, which may limit the practice to those households with septic tanks and who would probably be in the higher-income groups. The importance of this is that a truck coming from a hotel or apartment building that is fully plumbed is likely to have sludge that is more dilute than a truck that has been filled with fecal sludge from pit latrines. As a result, limited grab samples at the receiving station are not likely to capture the full range of wastewater quality entering the lagoon. The pollutant concentrations from receiving station data presented in Table 3.2 are higher than what would be expected from a location with high access to water, but also significantly less than septage or pit latrine concentrations.

Effluent from the facultative lagoon is discharged into the wetland on the southern boundary, which ultimately discharges to the Nile River. Generally, the effluent is a reddish color (Figure 3.7).

3.5 Ownership and Management of the Lagoon

There is lack of clarity on ownership of the lagoon, although it is managed by Juba County through the Department of Public Health presently. This is partly due to the fact that Northern Bari Block is currently under

Figure 3.7: Red Effluent at the outflow of Roton Wastewater Lagoon

jurisdiction of Juba County and not the City Council, but mostly due to the fact that the Juba City Council did not exist in 2010 when the lagoon was commissioned.

The lagoon is managed by an Assistant Sanitary Overseer (ASO) who reports to a Sanitary Overseer, who in turn reports to the Director of Public Health in Juba County. The ASO also reports directly to the Director of Public Health in Juba City Council. There are currently two ASOs who take turns manning the lagoon. The tasks of the ASO include collecting payments from the exhauster trucks and supervising the three casual/temporary workers employed to keep the surroundings clean. The ASOs are the only salaried staff at the lagoon. The casual workers are paid on a daily basis by Juba County. Currently, none of the staff managing the lagoon have any engineering or sanitation-related qualifications. This impacts the proper management of the lagoon and is further compounded by a lack of operational manuals and staff training. In addition, none of the workers at the lagoon were seen with protective clothing, although it was reported that such clothing is provided.

Use of the wastewater lagoon is regulated through payment of a toll fee to Northern Bari Block, which is determined annually by Juba County and paid each time a truck goes to empty at the lagoon. Emptying at the lagoon is also regulated through payment of an emptying charge for every truck. The charges vary from SSP10 to SSP50 per truck, depending on truck size. Finally, use of the lagoon is regulated through control of opening hours. The lagoon is open 7:00 am–5:00 pm, Monday to Saturday; 7:00 am– 12:00 pm on Sundays; and 7:00 am–10:00 am on public holidays. The lagoon is closed for all national holidays.

3.6 Revenue Potential of the Lagoon

The lagoon represents a major source of revenue for the public sector from both the toll fee as well as from the emptying fees charged. As shown in Table 3.5 below, Northern Bari Block and Juba County Government jointly received US $1,252,138 in revenue based on fees applied in 2014.

Table 3.5: Revenue Collected from Exhausters by Public Agencies

Item	Revenue per Week (SSP)	Revenue per year (SSP)	Revenue per year (USD)	Agency Collecting Revenue
Toll Fee	415,38	2,160,000	696,774	Northern Bari Payam
Lagoon emptying Fee	33108.25	1,721,629	555,364	Juba County Government
Grand Total		**3,881,629**	**1,252,138**	

These revenues could potentially be sufficient to operate and maintain the lagoon effectively and even carry out limited infrastructure improvements. However, there is no clarity on how to use those funds to either maintain or expand operations of the lagoon. Furthermore, there is a high risk of loss of the funds collected at the lagoon, as the person collecting is allowed to keep the funds for a week and deposit them in a special sanitation account held by the County either on Friday or the following week. This risk is further heightened by the fact that the whole system is cash based. Although the County has a special sanitation account, the funds deposited are not reserved for reuse in maintenance of the lagoon, but are used for general purposes of the County. These funds are therefore not ring-fenced. Finally, the basis on which the different charges are developed is not clear, meaning that their linkage to cost recovery is not known. All these elements suggest that there is need to reexamine these financial transactions in order to build systems for long-term financial sustainability of the lagoon specifically and the sector more broadly.

4.0 DISCUSSION AND RECOMMENDATIONS

The Roton Wastewater Lagoon represents the first major public infrastructure for the safe disposal of fecal sludge in Juba. Its successful operation is therefore cardinal to the strengthening of the sanitation framework and in particular the safe disposal of fecal sludge. This section examines both the key findings of the assessment and makes recommendations on possible interventions.

4.1 Operation and Maintenance

A primary concern of the lagoon system is its current operational state. Although the Roton Lagoon is operating at only 70 percent of its constructed capacity, it is not producing the quality of effluent that would be expected from a properly operated and maintained facility. While there appears to be some attempt to clean the lagoon, its current condition indicates little or no maintenance, which results in the accumulation of debris and large solids in the anaerobic lagoon. It is also likely that the accumulation of grit in the ponds is limiting the available treatment volume and reducing the effectiveness of the lagoon. The following activities are recommended to address this issue.

4.1.1 Conduct Key Studies

- Conduct comprehensive influent and effluent sampling for BOD, Carbon Oxygen Demand (COD), Suspended Solids (SS), TN, Total Potassium (TP), and coliforms.
- Perform extended exhauster truck surveys to further document influent flow.
- Investigate the extent of grit buildup in the anaerobic pond and removal of debris present.

In the near future, additional studies should be conducted to determine the level of grit buildup in the anaerobic basin, identify potential causes for the red effluent, and develop possible strategies to reduce short circuiting in the basin.

4.1.2 Set Effluent Standards

In order to get the most out of the investment in the lagoon and to protect the environment, it is necessary that the government sets and enforces standards for effluent entering and leaving the lagoon. This will require both development and enactment of bylaws by the local authority and fast tracking of the proposed Environmental Law to empower enforcement by the Ministry of Environment.

4.1.3 Ring-Fence Revenues

The Roton Lagoon generates revenues from the exhauster tankers, which could potentially be used for operation and maintenance and some limited expansion works. However, it is unclear how these funds are used to cover the expenses of operating the lagoon. Sewerage treatment facilities by nature require significant capital investment and often require third-party financing as a precondition to construction. A system of ring-fencing-generated finances is also necessary for adequate operation and maintenance. In this regard, a number of actions are recommended.

The City Council should develop a clear tariff guideline based on cost recovery principles for the exhausters, develop a system on the use of the funds, ensure that funds collected are deposited in the bank on the same day, and develop purposes for which the money collected can be used, and develop methods for how the money collected is to be accounted. The charge for dumping at the lagoon (lagoon revenue) should be set so that it is sufficient to cover all operating costs: labor, equipment, maintenance, and depreciation. It should also include costs to regulate the exhauster trucks and perhaps a small amount to cover other related costs, such as education. It is important to balance the cost of dumping at the lagoon with the ultimate charge to users, as increasing costs to users will exclude the portion of the population that cannot afford toilets. This charge should also not be higher than the penalty for the exhausters depositing in open land, which pollutes the environment.

There should be procedures for proper documented collection of revenues and agreement on the purposes for which the revenue should be utilized, including the procedures for such use. Finally, the system should also allow transparency and auditing of the collection and use of the revenue.

4.1.4 Streamline Institutional Arrangements

Achieving the ring-fencing is closely linked to the need to transition from the current arrangements to a situation where ownership, operations and revenues get brought together under a single entity. While Juba County has managed the lagoon since it was commissioned in 2010, it is more ideal that the city that is producing the fecal waste should also take responsibility for managing that waste as it is directly in their interest to do so. From an end-user standpoint, it would be preferable to have the system owned and operated at the local level rather than the state level. This would align with the provisions of existing policies, such as the Local Government Act; National Water Policy; and Water, Sanitation, and Hygiene (WASH) Sector Strategic Framework. The ultimate aim should be to lay a foundation for delivering the entire system to a water and sewerage company/ corporation so that wastewater treatment facilities, sewerage, and piped water networks can be planned and developed concurrently.

Based on these observations, it is recommended that the ownership and operation of the Roton Wastewater Lagoon, including relevant revenue streams, be transitioned from the County to the Juba City Council so that the City Council has overall responsibility and accountability for the lagoon. However, the Juba City Council should establish a governing council that would oversee the management of the lagoon. Further details on the proposals to establish a governing council are given in the report on Sanitation Institutions Mapping in South Sudan. However, the governing council would include representatives from the Juba County, the City Council, and other key stakeholders. The City Council should build its capacity by engaging some sanitation experts, as the Roton Lagoon should have engineers on its staff. Alternatively, Juba City Council could engage a private company to operate the lagoon on its behalf. The management of the lagoon by the governing Council is proposed here as an interim measure. Ultimately, the lagoon (together with the piped water and sewerage network) must be managed by one entity. The duration of this interim measure is dependent upon how soon the to-be-passed water legislation takes effect.

4.2 Capacity Building Support

Given the limited sanitary expertise in the sector, the agency tasked to manage the lagoon must be provided with capacity building assistance. This should target three elements:

(i) Technical aspects focusing on operation and maintenance

(ii) Financial aspects, including providing an understanding of the need for and how to ensure long term sustainability of the lagoon and

(iii) Health and safety including legal as well as social aspects of occupational health hazards related to fecal sludge management.

4.3 Capacity of Roton

As indicated in Section 3.0, only a portion of the lagoon was constructed. The land is already secured for the expanded capacity. In order to assess when this capacity will be fully utilized, population growth has been projected and used as a basis for assessing fecal sludge generation in the city of Juba. The most recent official population data for Juba was recorded in the 2008 Census, published by the South Sudan Centre for Census, Statistics and Evaluation (SSCCSE). The Census identifies the population of Juba County as 368,436. The three Payams that compose Juba town were reported with a population of 230,195. The population breakdown is provided in Table 4.1.

Table 4.1: Juba Population 2008

Payam	2008 Census Population
Juba Town	82,346
Kator	64,130
Munuki	83,719
Total	**230,195**

Since 2008 the population of Juba has been impacted by the combination of internal growth, conventional migration and migration of internally displaced persons. As a result, the city has experienced significant growth with new informal areas increasing and older informal neighborhoods transitioning into formal areas. A recent mapping and household density study estimates the current (2014) population of Juba at 500,000. An annual population growth rate of 5.71 percent was estimated assuming a linear historical growth pattern from 2008 to 2014. Table 4.2 presents the estimated population up to 2030.

Table 4.2: Juba Total Projected Population

Year	Population	Comments
2008	230,195–368,436	2008 Census
2013	500,000	Estimate based on mapping
2020 (year 5)	697,693	Based on a 5.71% annual growth rate

Over the next 15 years the population of Juba is expected to increase approximately 3.3 times (i.e., 1,215,688 people).

Based on this population, fecal sludge generation rates have been worked out. Sludge generation rates for latrine based systems vary greatly. Based on the Kenya data, SUWASA used rates from 0.1–0.7 litres per capita per day (l/cap/day) for latrines and 1.7–2.6 l/cap/day for septic tanks (Kazimbaya Senkwe, 2014). Other sources cite 0.164–0.220 l/cap/day as reasonable design criteria for latrine and septic systems respectively. These rates assume significant sludge digestion occurring in the pit latrine over time, which may be the case for un-lined latrines in Juba. However, there is little opportunity for digestion with lined latrines that are routinely pumped. It has been reported that lined latrines are open to the soil at the bottom. In areas with a high water table, ground water can enter the pit, increasing the volume of sludge to be pumped and reducing the time the waste stays in the pit before being taken out to the treatment plant.

Other methodologies link the generation of sludge as a function of access to water (Table 4.3).

Table 4.3: Sludge Generation Based on Access to Water

Water Service	Water Demand (Liters)	Sewerage Demand (Liters)
House connection with full plumbing	120	96
Single tap on plot	50	40
Communal water (point per 23 plots)	50	40
Less accessible communal water	30	24

Notes: *1. Sludge generation based upon 80 percent of water demand*

Existing data from the survey at the Roton Lagoon provide a basis for a reasonable generation estimate for lined latrines and septic tanks that are regularly serviced by exhauster trucks. Previous studies indicate 82 percent of the population has access to toilets and 40 percent of these toilet facilities are regularly serviced by exhauster trucks and contribute to the sludge flow at the Roton Lagoon (Table 4.4).

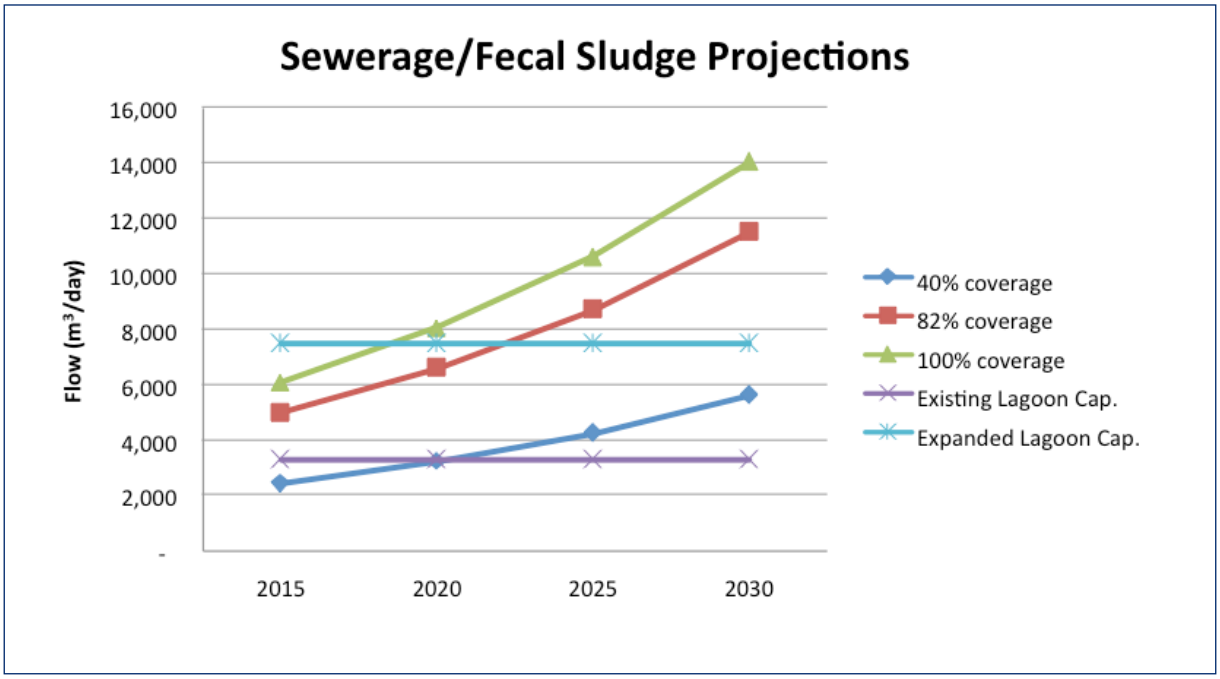
Table 4.4: Juba Fecal Sludge Generation Rate Calculation

Parameter	Value
Roton Lagoon Flow (l/day)	2,309,566
Juba Population (cap)	500,000
Ratio of population contributing to Roton Lagoon	0.4
Juba Population contributing to Roton Lagoon (cap)	200,000
Sludge Generation Rate (l/cap/day)	11.55 l/cap/day

The 11.55 l/cap/day value lies between the reviewed latrine generation rate and the water access generation rates and seems to reflect the mix of latrines and pour/flush toilets present in Juba. Projected sewerage rates are developed using a 40 percent coverage (representing the ratio of sludge received by the Roton Lagoon; 82 percent coverage (representing total toilet access in Juba) and 100 percent.

Figure 4.1 below presents the projections in relation to the existing and expanded capacity of the Roton Lagoon facility to the year 2030.

Figure 4.2: Sewerage/Sludge Projections



As the figure shows, sewerage/sludge rates are projected to more than triple over the next 15 years. This means that the existing capacity of the Roton Lagoon is projected to be attained in 2020 at 40 percent coverage. However, with increases in coverage expected through implementation of expanded sanitation facilities this capacity is likely to be exceeded earlier. If completed, the expanded/full capacity of the lagoon will provide treatment for approximately 53 percent of the projected sludge flows in 2030. Given the growth occurring in Juba, a general recommendation is made to immediately commence with activities to expand the lagoon to its full capacity.

Given the rapid expansion of the city, it will also be in the interest of the City Council to begin the process of securing land for additional wastewater treatment facilities.

4.4 Equip the Laboratory

Aside from completing the lagoon, it will also be important to examine and recommend measures to equip the laboratory at the lagoon, including providing relevant training and manuals.

5.0 CHALLENGES AND LESSONS LEARNT

1) The major challenge experienced with this assessment was related to the inability of SUWASA to locate or access the design reports for the lagoon. This delayed the assessment and meant that the team had to make certain assumptions about the lagoon. Despite this, the direct interaction with the supervising consultant allowed the team to gather drawings that the team used to make some of the key conclusions contained in this report. These documents have now been made available to government for their future use. A key lesson is that even though public infrastructure belongs to government, they may not necessarily be the best place to store important documentation especially in a post-conflict situation. That said, the consultant did not do much better in terms of having documentation readily available.

2) Data analysis, follow up on data cleaning, and completion of the report were severely delayed by the political crisis in December 2013.

3) The collaboration among SUWASA, Juba City Council, and Juba County has made for production of a very useful and interesting report that provides key information about the operation of Roton Lagoon, information that was hitherto unavailable.

4) Aside from the Council, the young data enumerators have benefited from extra skills in research and social skills, income, and a greater understanding of the sanitation challenge in Juba. The SUWASA team passed on these skills to the staff of the City Council and ensured that the project has a good and productive relationship with the key client partners. The entire SUWASA team continued to strengthen its skills in dealing with data gaps; this approach can be replicated relatively easily by both SUWASA, the Republic of South Sudan in other cities and towns, and beyond South Sudan.

5) Although Juba has a new and relatively large wastewater treatment facility, its functionality and sustainability are endangered by the limited institutional capacity of public agencies. This suggests that emergency responses can produce physical infrastructure but institutional set up requires much longer developmental interventions.

6.0 REFERENCES

1) Government of South Sudan, **Laws of Southern Sudan, The Local Government Act, 2009**

2) Government of South Sudan, **National Water Policy 2007**

3) Government of South Sudan, 2008 **Southern Sudan Centre for Census, Statistics and Evaluation** (SSCCSE)

4) Barbara Kazimbaya Senkwe, 2014, **Opportunities for Fecal Sludge Management in a Post-conflict Situation: A Case Study of Juba,** Paper Presented at the AFWA Congress, Abidjan, February 2014.

5) Republic of South Sudan, MWRI, 2011, **Water, Sanitation and Hygiene (WASH) Sector Strategic Framework**. August 2011.

6) SUWASA-USAID, 2013, **Juba Sanitation Mapping and Household Survey**

7) WSP 2010, **Country Status Overview, Water Supply, Sanitation and Hygiene in Southern Sudan,** Draft 2010.

Annex 1:
Interview Guide for the Manager of the Lagoon

1. Name of interviewee:……

2. What are your academic qualifications and work experience: ……

3. What is your job title and what is your role in the exhauster and lagoon management business:……

4. How long have you been working at the lagoon:……

5. What training have you received since you started working at the lagoon……

6. What is the job title of your supervisor and in which government agency do they sit……

7. What is your working relationship with the Payam councils:……

8. How many people are employed here and what do they do:……

9. What protective clothing is provided to you and other employees working here……

10. What are the hours of operation of the lagoon:……

11. How many trucks empty here on a daily basis:……

12. How much do you charge for emptying the different trucks?(May I see the receipt book)……

13. How do you record the trucks coming to empty everyday (May I have a look at your record books): …… ……

14. What other information do you collect about the exhauster trucks (May I have a look):……

15. What rules are the trucks required to observe here:……

16. Which government agency comes to inspect the operations of the lagoon and when was the last time they came here:……

17. Do you have any manuals on how to manage this lagoon?(May I see them):…… ……

18. What are the sources of power and how much does the county spend daily on power to manage the lagoon:……

19. Do you have a first Aid Box in the office:……

20. What are the major challenges you face in your job: ……

21 Any other comments you wish to add:……

Annex 2:
Interview Guide for Sewage Exhauster Truck Drivers

Name of Enumerator_____Date:_____/_____/2013 (dd/mm/yy)

Good morning/afternoon, my name is _____ I have been engaged by Juba County council to collect information about the exhauster businesses operating in Juba. The information collected is strictly confidential and will be used by the County with Support from SUWASA to improve sanitation services in Juba city. I will be grateful if you could spend about 30 minutes to answer some questions about your exhauster business. Are you willing to participate? If so, Kindly sign here to indicate your consent

Sign_____

Truck Registration no: *a) Number plate _____b). City council Reg. no_____*

A. Demographics of the Respondent

1) Role of the respondent? (Tick as appropriate). DO NOT interview if the respondent is not an employee managing the exhauster truck.
   a. Employee managing the Exhauster (specify)_____

2) Gender of respondent (Tick appropriate one)
   a. Male
   b. Female

3) Age of respondent (years): _____

4) Nationality of respondent: _____

5) How long have you been working with this business_____

6) What protective clothing does the company provide for the employees
   a) Over all
   b) Gumboots
   c) Gloves
   d) Facial mask
   e) Others (specify)_____
   f) None

Are you registered with;-	Registration fee (SSP)	Renewals		Inspection		Payams where your exhauster business is operating
		No. of renewals/ years	Renewal fee	Number of inspection per year	Cost of inspection per year	Munuki Juba Kator Northern Bari Rejaf
Juba City council						
Others-Specify						

B. Information about the Exhauster Business

7) What is the name of the Exhauster business_____

8) Location and physical address of exhauster business (where is your business premises/office). Payam: ¬¬¬¬¬¬¬¬¬¬¬¬¬¬¬¬¬¬¬¬_____Block_____

9) Are the owners of the business

   a) South Sudanese

   b) Foreign Nationals (Name Nationality)_____

   Contact: Name: _____Tel: _____

10) Registration with Juba city Council

11) Information about exhauster trucks

   a) How many exhauster trucks does the business have? _____

   b) Information about this truck

Truck	Truck information
Type of truck	
Capacity of truck	
Which country did you buy the truck from	
In Which Year did you buy the truck	
How many drivers drive this truck	
How many turn boys does this truck have?	
Do you empty Septic tanks	***a) Yes b) No***
How many septic tanks do you empty per day	
How much do you charge for each septic tank ***(ssp)***	
Do you empty Pit latrines	***a) Yes b) No***
How many pit latrines do you empty per day	
How much do you charge for each latrine***(ssp)***	
How many trips do you make per day	
How much do you pay for emptying each truck ***(ssp)***	
When was the last time your truck was taken for full service ***(mm/yy)***	
When was the last time your truck broke down ***(mm/yy)***	
How long did it take to fix it (repair)***(Days)***	
How much did it cost to repair it ***(SSP)***	
Where did you get spare parts ***(Country)***	
12) Do you collect sewage from these clients?	a) Domestic b) Industrial c) Commercial d) Government/Ministries e) Schools f) Hospitals

13) What are the main challenges you face in exhausting?

C. Physical Observation

(Observe and take photographs of the following)

1. The state of repair of the exhausters
2. The cleanliness of the exhausters
3. Protective clothing of the workers

Thank you very much for taking part in this study

Questionnaire checked by: Name _____Sign_____

Annex 3:
Juba Exhauster Tanker Census

Enumerator _____ Date: ____/____/2014 (dd/mm/yy)

NO.	Time in	Truck ownership	Make of Truck	Vehicle Registration Number	Truck Capacity(ltrs)	Amount paid (SSP)
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						

U.S. Agency for International Development
1300 Pennsylvania Avenue, NW
Washington, DC 20523
Tel: (202) 712-0000
Fax: (202) 216-3524
www.usaid.gov