water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

Kakamas Waste Water Treatment Works

KAI !GARIB
MUNISIPALITEIT-MUNICIPALITY

Feasibility Study
Regional Bulk Infrastructure Grant

31312-REP002

31 March 2022

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ISSUE & REVISION RECORD

QUALITY APPROVAL

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This report has been prepared in accordance with BVi Consulting Engineers Quality Management System. BVi Consulting Engineers is ISO 9001: 2008 registered and certified by NQA Africa.

REVISION RECORD

Revision Number	Description	Date Issued	Revision By
00	31312-REP002: Kakamas WWTP Feasibility Study (March 2022)	22 March 2022	GH Meiring

Acronyms

ACIP	Accelerated Community Infrastructure Programme
ADWF	Average Dry Weather Flow
BEE	Black Economic Empowerment
CFO	Chief financial officer
CPI	Consumer price index
DM	District municipality
DWA	Departments of Water Affairs – presently DWS
DWS	Department of Water and Sanitation
EIA	Environmental Impact Assessment
ES	Equitable share
FBS	Free basic services
GDP	Gross domestic product
GVA	Gross value added
I&AP	Interested and Affected Parties
IDP	Integrated Development Plan
IRS	Implementation readiness study
kℓ	Kilolitre = 1 000 ℓ = 1 m3
KPI	Key performance indicator
kWh	Kilowatt hours
ℓ	Litre
ℓ/c/d	Litres per capita per day
ℓ/day	Litres per day
LM	Local municipality
m^3/a	Cubic litres per annum
$m^6/m^3/a$	Million cubic meters per annum
MIG	Municipality infrastructure grant
Mℓ	Mega litre = 1 000 kℓ = 1 000 m3
MTREF	Medium Term Revenue and Expenditure Forecasts
MWIG	Municipal Water Infrastructure Grant
NRW	Non-revenue water
O&M	Operation and maintenance
p.a.	Per annum
p.m.	Per month
PDWF	Peak Dry Weather Flow
PMU	Project management unit
RBIG	Regional Bulk Infrastructure Grant
RBIG	Regional bulk infrastructure grant
SALGA	South Africa Local Government Association
SDBIP	Service Delivery and Budget Implementation Plan
SMME	Small, Medium and Micro Enterprise
TOR	Terms of reference
VAT	Value Added Tax
WCDM	Water conservation and demand management
WSA	Water services authority
WSDP	Water services development plan
WSP	Water services provider
WTW	Water treatment works
WWTW	Waste water treatment works
ZFM	ZF Mgcawu District (formerly Siyanda District)

Table of Content

ANNEXURE A - LOCALITY MAP

ANNEXURE B – LAYOUTS OF THE PLANTS

ANNEXURE C – COST ESTIMATES OF THE VARIOUS TECHNOLOGY OPTIONS

ANNEXURE D – DETAIL COST ESTIMATE OF CHOSEN OPTION

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

The wastewater generated by the Kakamas and surrounding communities is treated at a set of oxidation ponds, located southwest of Kakamas. The existing pond system is located on high ground. This means that all sewage from Kakamas, is currently pumped to the treatment plant.

Large sections of Kakamas, and all the villages and farms located north and northwest of Kakamas as far as Blouputs, are all served by conservancy tanks, or combinations of dry sanitation systems such as VIP and UDS toilet systems. Kai !Garib Municipality is responsible for servicing these areas.

The wastewater from all these areas is currently transported by municipal suction tanker trucks, and disposed of at the existing Kakamas oxidation ponds. This is done at a calculated cost of approximately R9 810 000-00 per annum. Given that the seven (7) villages are currently also contributing to the current sewer load received at Kakamas, they should also be accommodated in the scope of work for this study.

The Kakamas Oxidation Ponds are no longer able to cope with the volumes of sewage delivered to the treatment plant. An analysis of the current plant capacity was done, and determined to be a maximum of 430m^3/day. The Kakamas Oxidation Ponds were originally constructed by the Department of Health, and designed to serve only the new Kakamas hospital which was constructed in the 1980's., as the town was primarily using septic tanks and soakaways. As the sub economic housing boom of the last 15 years took place, all the subeconomic areas were fitted with water borne sewage, but the oxidation ponds were never upgraded to keep pace with these residential developments. Subsequently all the subeconomic areas in Kakamas, now have waterborne sewers. The wastewater drains to three pump stations, and is then pumped to the existing wastewater treatment plant.

Upgrading or refurbishment of the existing WWTW is however not an option because of the current location of the WWTW. The treatment works is firstly, situated very close to the residential areas. The current location of the WWTP also stems further development to the north of the town, which is the only direction in which the town's future expansion can take place. This situation is therefore not ideal. Typically, a wastewater plant would be located at a town's lowest point to facilitate gravity drainage of sewers. Unfortunately, there are large tracts of high-value agricultural land located in the belt between the town and the Orange River, which is the lowest point. Subsequently the higher lying land to the south being the only location where the municipality has sufficient land available is the only resort.

The Engineer identified two possible approaches to this situation. Approach A being the construction of a single, large capacity wastewater treatment plant at Kakamas, and Approach B, being the use of several smaller decentralized wastewater treatment plants at Kakamas and the surrounding villages.

Several technology options were investigated for each approach, varying from a full-blown Activated Sludge WWTP, Aerated Facultative Ponds, Conventional Oxidation Ponds and Rotating Biological Contactor plants. For each option, the requirements in terms of capital costs, operational personnel, technical capability in terms of maintenance, chemical consumption and energy use was evaluated. In addition, the possible quality of the Treated Effluent was also considered, depending on where final disposal was to take place.

On completion of the evaluation of the various options, a Life Cycle Cost Analysis was done over a period of 30 years to determine the full cost of ownership.

The intention of the project is to relocate and construct one or more new Wastewater Treatment Plants and ancillary works to provide sufficient treatment capacity to avoid any public health risks, as well as environmental health risks.

This study has shown that the solution of this problem is not simple and straight forward. The option with the lowest capital costs being a single 4.5 Megalitre per day conventional Oxidation Pond system located at Kakamas. This however means that the cost of transporting wastewater from the villages will remain an ongoing expenditure for the future.

The option with the lowest capital costs for Approach B, was to construct conventional Oxidation Ponds at Kakamas, Alheit/Marchand, Augrabies, Lutzburg/Cillie and Riemvasmaak. Unfortunately, the space at Alheit/Marchand and Lutzburg/Cillie is very limited, and the plants would be located closer than 500m to the residential areas. Being anaerobic in nature, this would lead to objectionable odours. Subsequently, the use of Aerated Facultative Ponds was selected at these two villages, which are fully aerobic processes, with no risk for nuisance odours. Unfortunately, this combination of treatment plants now has the highest capital cost. The Operational Cost for this combination is however comparable with that of a single large capacity Conventional Oxidation Pond system located at Kakamas. None of the options would completely negate the transport of wastewater by truck. The primary reason for this being that none of the villages are reticulated with waterborne sewer systems, which means that conservancy tanks would still need to be emptied and the contents transported to the nearest WWTP. It does however make the distances involved significantly shorter, and the quantities transported a lot less.

It must also be kept in mind that oxidation ponds, by their nature, do not normally produce a Final Effluent that is fully compliant with the General Limit Values. Subsequently, at Kakamas, measures were included to achieve this, while at the smaller villages, provision has been made to irrigate the effluent onto sports fields.

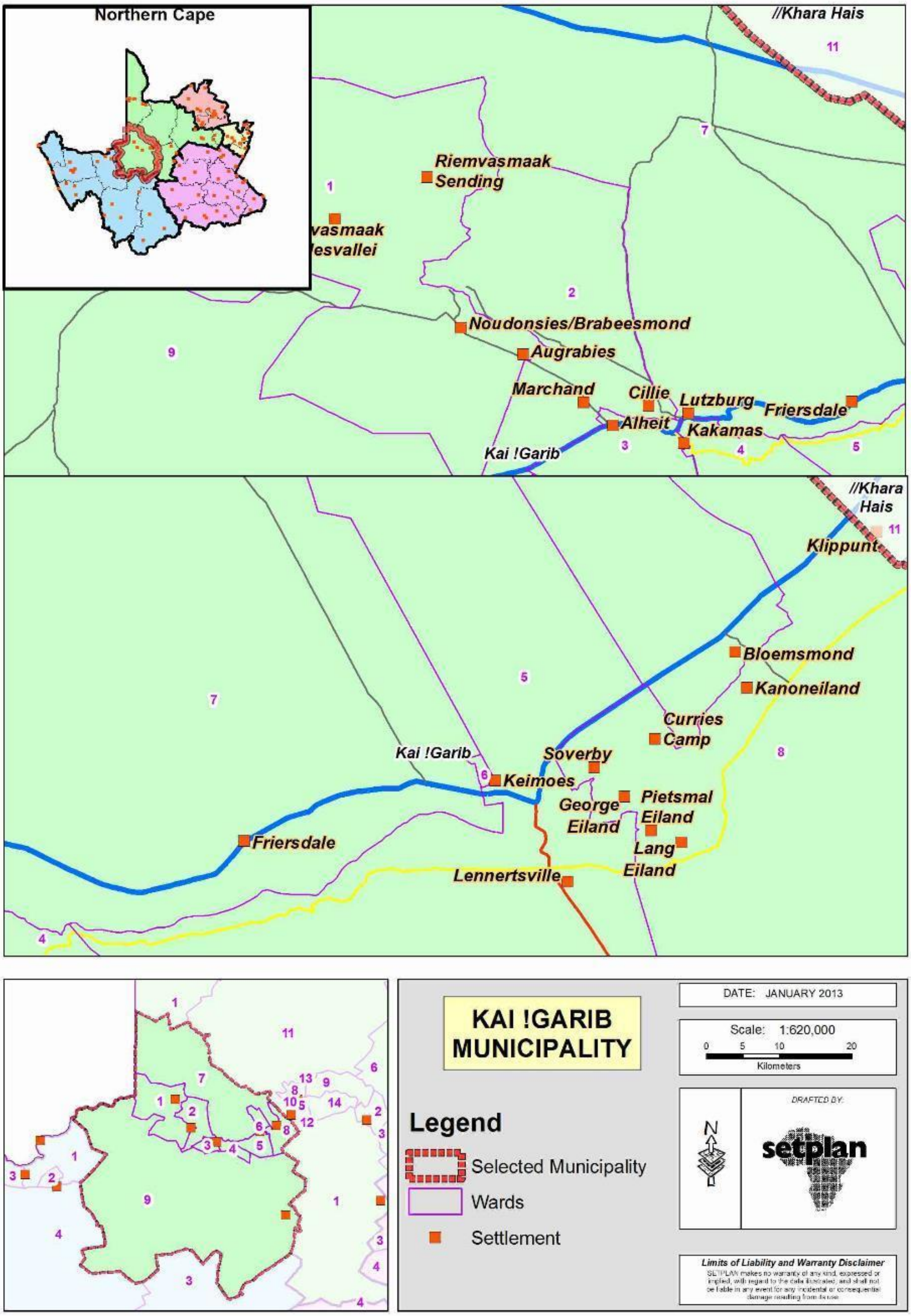
It is therefore proposed that in lieu of a single 4.5 Megalitre per day WWTP at Kakamas, that the following be constructed:

- A 2 Ml/day Conventional Oxidation Pond system with a Horizontal Flow Reedbed in series at Kakamas.
- An 800m3/day Aerated Facultative Pond system for Alheit & Marchand located at Alheit.
- A 500m3/day Conventional Oxidation Pond system for Augrabies Village and surrounds.
- A 450m3/day Aerated Facultative Pond system for Lutzburg & Cillie villages, located at Cillie
- A 250m3/day Conventional Oxidation Pond system located at Vredesvallei village.

The Kai !Garib Municipality will still need to operate a fleet of at least 6 vacuum tanker trucks to service these communities. One truck at each of the smaller villages, and two trucks at Kakamas.

The calculated capital cost for the construction of these WWTP's equates to a total project value of **R 143 033 875.16.** This value includes 10% Contingencies, professional fees and 15% VAT.

The social component of the Kakamas area has been calculated at 88.89%. This means that the Kai !Garib Municipality shall be required to contribute an amount of **R15 891 063.53** to cover the economic component of the project cost.


Northern Cape
//Khara Hais
Riemvasmaak
Sending
vasmaak
esvallei
Noudonsies/Brabeesmond
Augrabies
Marchand
Cillie
Lutzburg
Friersdale
Alheit
Kakamas
Kai !Garib
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Klippunt
Bloemsmond
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Curries
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George
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Limits of Liability and Warranty Disclaimer

1 INTRODUCTION

This report constitutes Phase 2A & 3A of the study to qualify for funding through the Regional Bulk Infrastructure Grant (RBIG) programme, to construct new wastewater treatment facilities to service Kakamas, as well as villages and farms along the Orange River. It has been compiled in response to the Terms of Reference (DWA, 2011) issued by the Department of Water and Sanitation.

1.1 History of Kakamas

Severe drought in 1895 over large parts of South Africa, the rinderpest, a fatal cattle disease, and the South African War saw 30 000 farmsteads being destroyed in the Transvaal and the Orange Free State.

These events led to thousands of farmers being without income and on the brink of starvation. Many became "bywoners" (labourers who provided their services in exchange for housing and food) on other farms, while others flocked to cities in search of work. The majority of these 'poor whites' were Afrikaans-speaking and members of the Dutch Reformed Church.

Following calls to the church to alleviate poverty, the idea of establishing labour colonies was born. The church investigated several sites for the establishment of such a settlement and settled on an area on the banks of the Orange River. This started the Kakamas labour colony in 1897, when the government granted the church two farms, Soetap and Kakamas, on the left bank of the Orange River for establishment of an irrigation settlement.

By April 1899, 11km of the left bank canal was completed. The first erven were allocated to the 60 men who had worked the longest. Lots were drawn for choice of plot, each being 5 ha in extent. In 1908, the left bank canal (35 km long), with extension to Marchand, was completed. This was followed by the completion of the 43 km-long right bank (north) canal in 1912. The scheme was financed entirely by the church through collections at Sunday services.

Primarily white labour was used and labourers were paid three shillings (30 cents) a day and promised a piece of irrigation land for their efforts. Food and clothing were supplied at cost price from a specially constructed warehouse, and the town of Kakamas grew out of this warehouse.

By 1945 there were 574 families on the scheme, and the total population was around 3 500. The main products grown were sultanas, wheat, peas, beans and lusern. The farmers themselves were responsible for cleaning the canals. Each man was responsible for the maintenance of the length running along his plot, the common portions being maintained by a system of calling up labour.

The plots remained the property of the church, and an annual rent of £10 was paid. If, after a probationary period of five years, the settler proved himself, he was allowed to stay on the plot. The Christian observance of Sunday was compulsory for adults and children, as was education. No dancing, swearing, filthy language, drunkenness, or immorality was allowed and the sale or making of liquor was strictly prohibited. All settlers had to sign a document, whereby they agreed to abide by these rules. Those who transgressed could be fined or removed from the settlement. From these hardy settlers, a thriving town grew out of nothing but the sheer will to survive.

1.2 Overview of Kakamas

Kakamas is situated amid a rocky landscape along the Orange River, characterized by contrasts between semi-desert with sandy plains and wavy hills. Intensely cultivated land occurs on either side of the river, with agriculture forming the largest economic base of this area. The Orange River is the biggest driving force behind the whole area, leading to massive economic expansion over the last two decades.

Kai !Garib Municipality is situated between the 20º00 EL (eastern longitude) and 21º 30 EL as well as between the 28º20ºSL (southern latitude) and 29º30º SL and is bordered by the municipal boundaries of Dawid Kruiper Municipality in the Northeast, and Namibia in the Northwest.

The Kai !Garib municipal area falls within the ZF Mgcawu District Municipality, and covers an area of 7449 km^2. The Municipal Area consists of 3 large towns, i.e., Kakamas, Keimoes and Kenhardt. In between these towns, 6 settlements are found, formerly administrated by the "Benede-Oranje" District Council before demarcation. Kakamas is located approximately 80km west – southwest of Upington on the N14 National Road between Upington and Springbok.

Kakamas is situated in an intensive irrigation farming community stretching from Groblershoop in the east up to Blouputs in the west. The agricultural sector is the main economic sector with the largest potential for economic growth. The commercial farmers farm especially with table grapes for fresh export, raisins and wine, while the emerging farmers also farm with small stock.

In the irrigation sector, focus is mainly on the cultivation of grapes in season. Lately, large plantations of various citrus varieties have also taken place, as it complements the grape season, allowing farmers to retain their labour year long, and also to utilize their packing and cooling facilities during the winter months.

The table grape industry is of national importance, as this industry generates huge value in foreign currency for South Africa. Exports to Europe, the United Kingdom, the United States of America, the Middle East and Far East being the dominant markets. In the order of 37 098 Megaton per year of table grapes are exported from the Kakamas area alone.

There is a large co-operative wine cellar at Kakamas, where high quality wines are produced, as well as grape juice concentrate. Lucerne, cotton, corn, and nuts, are also cultivated on a smaller scale under irrigation from the Orange River.

1.3 Project background

Currently, the wastewater generated by the Kakamas community is treated at a set of oxidation ponds located southwest of Kakamas and located on high ground. This means that all sewage needs to be pumped to the treatment plant. Large sections of Kakamas and all the villages and farms located north and northwest of Kakamas as far as Augrabies are mostly served by conservancy tanks, in combination with VIP and UDS systems. The wastewater from all these areas is currently emptied by municipal suction tankers, and disposed of at the existing Kakamas oxidation ponds.

Given that the villages and farms are contributing significantly to the current wastewater volumes, they must be accommodated in the scope of work for this project. In addition, especially the surrounding farms, contribute significantly to the municipal revenue, but then a service must be delivered.

The Kakamas Oxidation Ponds are currently not able to cope with the volumes of sewage delivered to the treatment plant. An analysis of the current plant capacity was done by BVi Consulting Engineers and determined to be 430m^3/day. The Kakamas Oxidation Ponds were initially designed to serve only the local hospital, as the town was primarily using septic tanks and soakaways.

As the sub-economic housing boom of the last 20 years took place, all the subeconomic areas were fitted with waterborne sewage systems, but the oxidation ponds were never upgraded to keep pace within these residential developments.

In addition to the town of Kakamas, the Kai !Garib Municipality is also responsible for approximately 13 villages located along the Orange River. The wastewater from six of these villages is also transported by tanker trucks to the Kakamas Wastewater facility. This causes further inflow which has led to total hydraulic overloading. It is estimated, from the truck loads delivered daily, that approximately 4 584m³/day are discharged into the Kakamas Oxidation Ponds, which is almost 11 times the volume it was designed to treat.

Typically, oxidation ponds require a hydraulic retention period between 40 and 50 days as a minimum for successful treatment of domestic wastewater. The current retention period is now less than one day. This is partially due to the accumulation of sludge in the existing ponds over time, which has significantly eroded their original capacity, but primarily due to the excessive flow being discharged.

The hydraulic overload has two distinct effects:

- Firstly, the final effluent is unable to comply with the legally required water quality as given by the General Limit Values, and;
- Secondly, the ponds are just too small, and overflow constantly into a downstream watercourse, which eventually terminates in the Orange River, immediately upstream of the position where the towns' drinking water is abstracted.

This feasibility study is proposing the relocation and construction of one or more new wastewater treatment facilities to service Kakamas and the surrounding villages and farms.

1.4 Study area

The study area encompasses Kakamas, the surrounding villages of Lutzburg, Cillie, Alheit, Marchand, Augrabies, Riemvasmaak and farms along the Orange River. The study area is indicated in Figure 1.

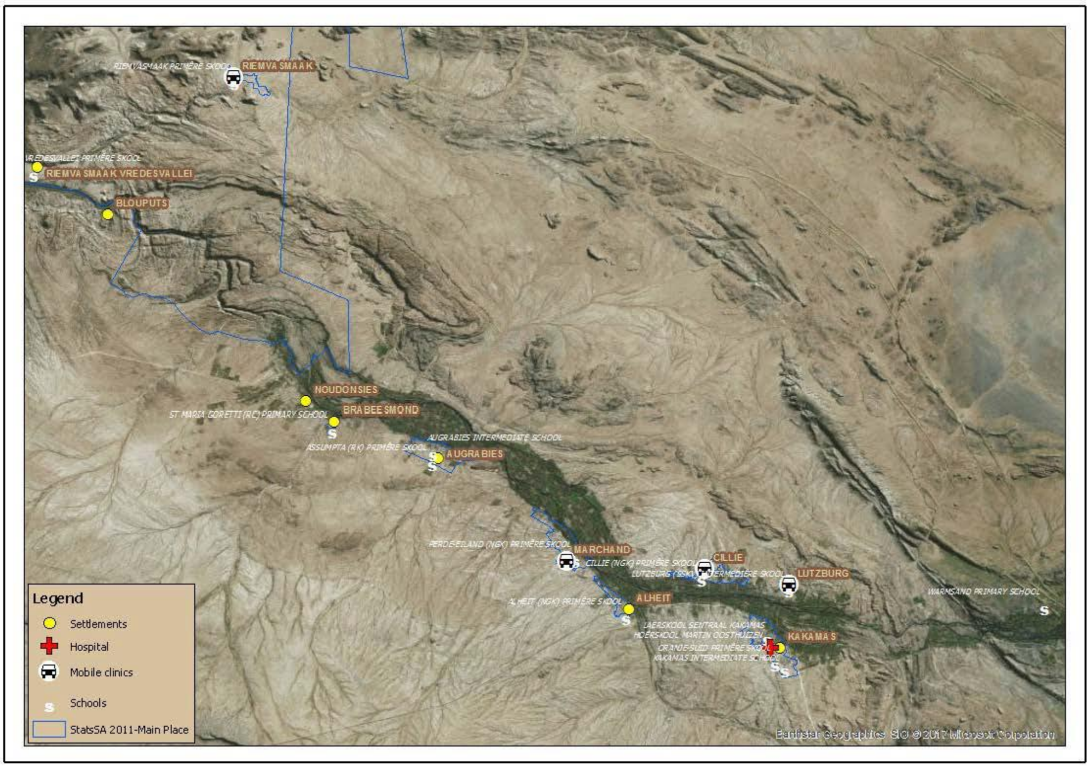

Figure 1. Project study area

The existing WWTW is situated south west of Kakamas and located on high ground, as depicted in Figure 2 overleaf.

Figure 2. Kakamas existing WWTW

1.5 Problem definition

The following major problems have been identified with regards to the existing WWTW:

- The existing wastewater treatment by means of Oxidation Ponds in Kakamas has become inadequate due to population growth. The current plant has a calculated treatment capacity of only 430m^3 per day, whilst the effluent produced by the town, villages and farms contributing to the load, is already exceeding 3 400m^3 per day.

- The Final Effluent of the Kakamas Oxidation Ponds does not comply with the General Limit Values as stipulated in the General Authorizations, in terms of Section 39 of the National Water Act.

- The existing asset is in an extremely poor condition.

- The current location of the existing WWTP impedes future residential development to the south of the town, and subsequently, the economic growth of the town.

1.6 Scope of feasibility study

This feasibility study aims to investigate and identify a project which will prove to be a sustainable, technical, and socio-economic solution for Kakamas's current wastewater challenges.

<u>This study will focus on five core areas, i.e.:</u>

- Survey of the existing system and socio-economic data.
- The identification and preliminary investigation of possible solutions.
- Identification of the most suitable technical solution(s).
- Investigation into the sustainability and financial viability of the selected option.
- Recommendation to the client and funding institution.

1.7 Opportunity statement

1.7.1 Project Objectives

This project aims to provide a long-term sustainable wastewater treatment works for the town of Kakamas and surrounding villages.

The project comprises the construction of new wastewater treatment facilities to treat the effluent sufficiently to comply with the DWA General Limits.

This study aims to prove that the proposed project is a feasible option, affordable for the community, and can be operated and maintained by the Kai !Garib Municipality, with their limited in-house resources.

1.7.2 Current circumstances requiring the need for this study

The problems experienced at the existing wastewater treatment works are primarily caused by the following:

- **Extensions of the town and surrounding villages due to the government drive to provide housing for indigent families.**

  The number of households in Kakamas alone, have increased from 9 375 in 2011 to 10 544 in 2016.

- **Deterioration of the existing wastewater treatment works and components.**

  The effluent from the existing wastewater treatment works does not comply with the General Limits. The asset is in a poor condition and the location of the WWTW stems further development of the town.

- **Population growth of Study Area**

  Population has increased from 38 223 persons in 2011 to 43 000 persons in 2016 (*StatsSA Census 2011; StatsSA*, *Community Survey 2016*).

- **Supply of free basic services**

  64% of the community have a monthly income which is less than the value of two state pensions (R3 020-00) and rely on grants and state pensions for income. They are classified as indigent, and therefore qualify for free basic services. This place enormous financial strain on the municipality due to reduced revenue, leading to serious shortage of funding for operations and maintenance.

1.8 STRATEGIC FIT STATEMENT

1.8.1 Municipal Backlogs

The Kai! Garib Municipality, as many others in the Northern Cape, are continually trying to decrease their backlogs in terms of housing, water supply, sanitation and electricity.

The latest official release of backlogs in terms of basic service delivery was in the 2018/19 Annual Report, which returned the following figures:

- Number of HH without access to basic water supply: 1 490 households
- Number of HH without access to sanitation (toilets): 3040 households
- Number of HH without access to Solid Waste removal: 5110 households
- Number of HH without access to electricity: 2090 households

The primary reason for these high backlogs being the rapid influx of people into the municipal towns and villages. This creates the rapid establishment of informal settlements, and the municipality is unable to keep up with the growth experienced.

1.8.2 Alignment with IDP and WSDP

The Kai! Garib Municipality has an active Integrated Development Planning process in place and their IDP was recently updated. The latest IDP document, for the 2021/22 financial year, was recently approved and adopted by council.

The Water Services Development Plan for this Municipality is continuously updated and the last draft was submitted in 2018 for review.

The upgrading of the Kakamas wastewater facilities is a priority project in both the IDP and the WSDP.

2 SOCIAL CRITERIA

2.1 Introduction

The project also requires an Implementation Readiness Study for the Regional Bulk Infrastructure Grant Programme. This report addresses the social criteria, which according to the TOR includes: [1]

- Number of households to receive basic and higher levels of service
- Number of indigent households to be served and the social cost
- Number of associated services benefiting e.g., schools, clinics and communal facilities
- Number of jobs to be created per category i.e., temporary and permanent
- Affordability of proposed water tariffs
- Contribution toward poverty eradication, social upliftment and health improvement
- Socio-political support for the proposed development options

The service area of the Kakamas WWTW works extends from Warmsand in the east and follows the course of the Orange River to Riemvasmaak in the west. The town of Kakamas has both conservancy tanks, as well as a waterborne sewer system in the newer residential areas. A Fleet of vacuum sewerage tanker trucks collect wastewater from conservancy tanks in Kakamas, as well as at settlements and farms along the river. The settlements served include:

- Lutzburg,
- Cillie,
- Alheit,
- Marchand,
- Augrabies,
- Brabeesmond/Augrabies Mission,
- Noudonsies,
- Blouputs,
- Sending Riemvasmaak,
- Vredesvallei Riemvasmaak; along with
- Farms situated along the river.

2.2 Number of households and people to be uplifted to basic and higher service levels

Population estimates are utilized to plan water services infrastructure at Kakamas. This section of the RBIG application reports on the number of persons for which the project caters. It is mainly based on secondary data, and sets out a most likely population estimate for Kakamas and the service area of the Kakamas WWTW until the year 2040. This is to inform future water demand and waste water needs.

[1] *Dept. of Water Affairs (2011) Water services regional bulk infrastructure programme – Framework for implementation. Version V10, January 2011. P 28.*

2.2.1 Population estimates to 2040

2.2.1.1 Factors affecting population growth

Population growth is determined by migration and natural growth, which is a function of fertility and mortality.

2.2.1.2 Migration

Historically the province has experienced a negative net migration since 2001. The 2016 mid-year population estimates indicated an out-migration of 77 914 persons from the Northern Cape and an in-migration of 74 759 resulting in a net migration of - 3 154.[2]

Kai !Garib Municipality, with strong pull-factors, may attract immigrants from other parts of the Northern Cape and beyond. Between 2011 and 2016, 11.2% of the Kai !Garib population had moved; a higher proportion than that of the district and province, which is largely attributed to the very mobile farm population. Please see table 1.

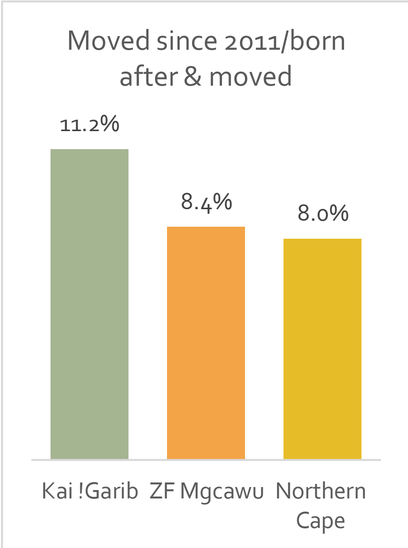

Figure 3. Migration since 2011 in Kai !Garib, ZFM and Northern Cape

The people of the Northern Cape are relatively immobile and tend to stay in the same place for their lifetime. The table below shows the extent of in-migration into Kakamas, farms and the settlements of the study area. Overall, 4% (366) of people moved into Kakamas between 2001 and 2011 (or were born after 2001 and had moved there), and the populations of Cillie, Lutzburg and Riemvasmaak were similarly immobile. Farm populations were very mobile, with almost half of the population having moved during the decade to 2011. Augrabies received the most persons (1389) persons, followed by Marchand (882) and Alheit (696). Within Kai !Garib, Kakamas and the farms were the main recipients of in-migration.

According to the 2014/15 IDP, informal areas are increasing due to in-migration, although the origin of the immigrants is not specified. However, it is most likely from surrounding farms and rural areas.

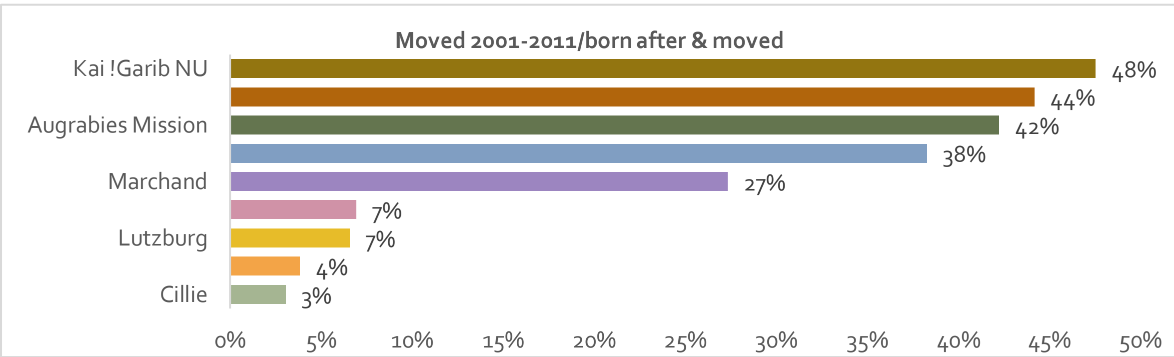

Figure 4. Population moved between 2001 and 2011 by place[3]

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[2] *StatsSA. Mid-year population estimates 2016. Statistical Release P0302.*
[3] *Data source: StatsSA. Census 2011, Interactive data in Super Cross.*

Table 1. Population living in the current location since October 2001[4]

		Lived in same place since 2001/born after	Moved since 2001/born after & moved	Total	Lived in same place since 2001/born after	Moved since 2001/born after & moved	Total
Settlements in study area	Cillie	1 905	60	1 965	97%	3%	100%
	Kakamas	9 171	366	9 537	96%	4%	100%
	Lutzburg	1 323	93	1 416	93%	7%	100%
	Riemvasmaak	645	48	693	93%	7%	100%
	Marchand	2 343	882	3 225	73%	27%	100%
	Augrabies	2 238	1 389	3 627	62%	38%	100%
	Augrabies Mission	123	90	213	58%	42%	100%
	Alheit	879	696	1 575	56%	44%	100%
Farms	Kai !Garib NU	11 682	10 596	22 278	52%	48%	100%
Other settlements in LA	Augrabies Falls NP	501	90	591	85%	15%	100%
	Asbosknop	141	48	189	75%	25%	100%
	Rooirant	105	9	114	92%	8%	100%
	Bloemsmond	474	21	495	96%	4%	100%
	Kanoneiland	138	33	171	81%	19%	100%
	Geelkop	150	6	156	96%	4%	100%
	Curries Camp	663	33	696	95%	5%	100%
	Soverby	660	309	969	68%	32%	100%
	Keimoes	10 767	1 230	11 997	90%	10%	100%
	Rooikopeiland	378	18	396	95%	5%	100%
	Loxtonberg	687	18	705	97%	3%	100%
	Kenhardt	4 629	213	4 842	96%	4%	100%
Total		**49 608**	**16 263**	**65 871**	**75%**	**25%**	**100%**

In 2001, 43% of Kai !Garib persons were living on farms or small holdings in rural areas. By 2011, it reduced to 35% and by 2016 to 24%.[5] This rural dynamic occurs because of migration into the 'urban' areas of Kai !Garib, mainly to settlements along the Orange River. The scattered homesteads of the rural countryside are disappearing, and a denser pattern of rural settlements along the Orange River is developing.

Table 2. Persons living on farms and in settlements in Kai !Garib and ZFM

	Kai !Garib			ZFM		
	2001	**2011**	**2016**	**2001**	**2011**	**2016**
Urban area	32 799	42 744	52 521	157 073	198 999	220 792
Tribal or traditional area	0	0	0	0	0	0
Farm	24 878	23 124	16 407	51 697	37 773	31 900
Total	**57 677**	**65 868**	**68 929**	**208 770**	**236 769**	**252 692**
% Farm	**43%**	**35%**	**24%**	**25%**	**16%**	**13%**

Rural to urban migration remains relevant in this part of the Northern Cape. Rural migrants choose to relocate to small towns such as Kakamas and peri-urban areas closer to their rural areas of origin. This is because of the cost of migration, lower cost of living in smaller towns and the better access to government social services and transportation. Living closer to areas of origin enables retention of

[4] *StatsSA. Census 2011, Interactive data in Super Cross.*

[5] *StatsSA, Community Survey 2016, Census 2011 and 2001. It is unclear whether the same definition of rural and urban was used in 2001 and 2011.*

family links providing support in the event of illness or unemployment.[6] Many migrants relocate to places where they have social networks, access to tenure or where a supply of housing is available. Although migrants are primarily attracted by employment opportunities, smaller towns and settlements offering the promise of access to housing and services, even with relatively weak economies making employment unlikely, are attractive.[7]

2.2.1.3 Natural population growth

Natural growth is a function of fertility and mortality.

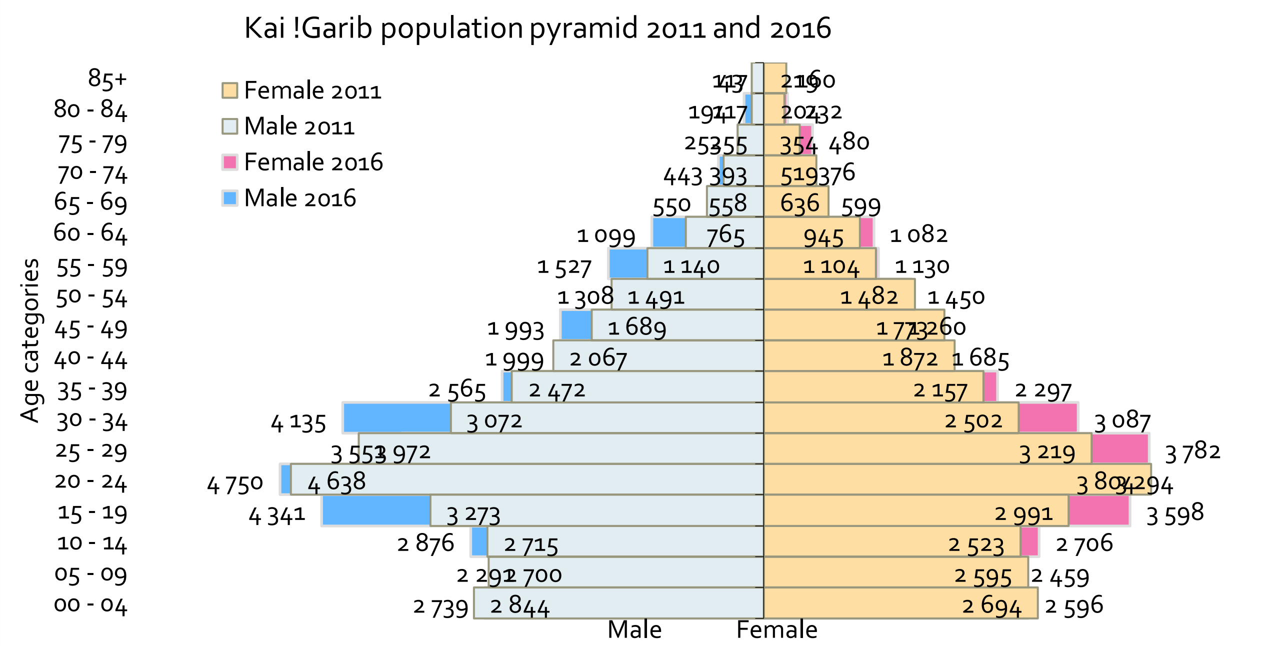

Figure 5. Age and sex of the Kai !Garib population in 2011 and 2016[8]

The population pyramid of Kai !Garib shows that the fertility rate has decreased because the youngest age groups of 0- to 14-year-olds is not the broadest age category. The age categories of 15 to 34 bulge in 2011 and in 2016, with it being most prominent in 2016. There is a slight gap in the male age category of 25-29 years which may represent an out-migration of this group, seeking employment elsewhere. Typically, females have a longer life expectancy than males which can be seen at the top of the pyramid.

The pyramid is symmetrical i.e., balanced between males and females. The sex ratio is 1.14 i.e., 1.14 males to 1 female in 2016 and 1.08 in 2011, lower than the South Africa average of 95. This may indicate a migrant male population being employed in Kai !Garib.

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[6] *Roux. N (2009) Migration and urbanization: Towards A 10-Year Review of the Population Policy Implementation in South Africa (1998-2008). Department of Social Development. [Online]. Available: http://stepsa.org/resources/shared-documents/migration-and-urbanisation--dept-of-social [cited 9 August 2013]. P iii, P14.*

[7] *Ibid. P ii.*

[8] *Date source: StatsSA Census 2011, Interactive data. StatsSA Community Survey 2016, SuperWeb2.*

2.2.1.4 Population size and growth

2.2.1.4.1 Population in 2011 and 2016

In 2011 there were 38 223 persons in the study area based on the census data using a best fit of the enumeration areas to the service area of the project i.e., study area. Please see figure 2. Almost 10 000 people lived in Kakamas and another 19 000 in settlements along the Orange River. A further 9 000 lived on farms. This represented approximately 58% of the municipality's population.

With an average household size was 4.08, slightly higher than the average of the municipality (3.94), almost 10 000 households lived in the study area.

Table 3. Study area population and average household size in 2011[9]

	Population	Households	Average HH size
Kakamas	9 540	2 163	4.41
Settlements in study area	19 432	4 557	4.26
Farms in study area	9 251	2 655	3.48
STUDY AREA in 2011	**38 223**	**9 375**	**4.08**

Average household size is declining, a feature typical across South Africa. In Kai !Garib the average household size declined from 3.94 in 2011 to 2.99 in 2016.

Table 4. Households, population and average household size in 2011 and 2016[10]

	2011			2016		
	Population	Households	Average HH size 2011	Population	Households	Average HH size 2011
Kai !Garib	65 869	16 703	3.94	68 929	23 017	2.99
ZFM	236 783	61 098	3.88	252 692	74 091	3.41

The 2011 average household size for the study area, municipality and district is shown in the adjacent figure. It illustrates that the average household size was highest in Kakamas (4.41) and the lowest on farms in the study area (3.48). Overall, the study area's household size was higher than that of the municipality (3.94) and that of the district (3.8 8).

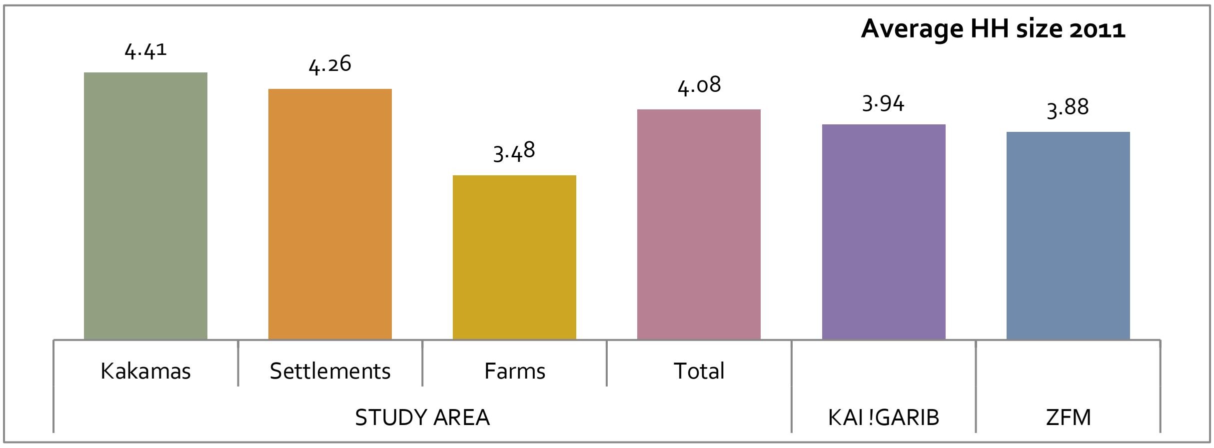

Figure 6. Average household size in the study area, municipality and district[11]

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[9] *Data source: StatsSA Census 2011; StatsSA.*
[10] *Data source: StatsSA Census 2011; StatsSA, Community Survey 2016.*
[11] *Data source: StatsSA Censuses 2011, and 2001.*

A 2011 distribution of household size in the Kai !Garib municipality shows that a quarter of households consisted of one person only (25%), while 15% of households consisted of seven or more persons.

Table 5. Household size distribution 2011[12]

HH Size	Households	%
1	4 155	25%
2	3 906	23%
3	2 430	15%
4	2 334	14%
5	1 374	8%
6	882	5%
7	591	4%
8	414	2%
9	234	1%
10+	381	2%
Total	**16 701**	**100%**

2.2.1.4.2 Historical population and household growth trends

Historical trends are illustrated in the table below for those settlements with enumeration areas that are similar across the three censuses of 1996, 2001 and 2011. In this sample of settlements with data, the annual average population growth has varied from -0.73% in Sending **to 6.72% in Alheit** between 1996 and 2011. Over the same period household growth was the highest in **Augrabies (11.96%)** and the lowest in Sending (0.79%) which although it recorded a negative population growth had a positive household growth rate. In all the examples household growth was higher than that of population growth.

Table 6. Historical population and household growth for some study area settlements[13]

	Number			Annual growth rate (p.a.)		
	1996	2001	2011	1996-2001	2001-2011	1996-2011
POPULATION						
Kakamas	7 016	7 304	9 540	0.81%	2.71%	**2.07%**
Alheit	595	682	1 578	2.77%	8.75%	**6.72%**
Marchand	1 710	2 393	3 222	6.95%	3.02%	**4.31%**
Augrabies	1 373	2 686	3 627	14.36%	3.05%	**6.69%**
Sending Riemvasmaak	773	703	693	-1.88%	-0.14%	**-0.73%**
HOUSEHOLDS						
Kakamas	1 227	1 318	2 163	1.44%	5.08%	**3.85%**
Alheit	112	216	183	14.04%	-1.64%	**3.33%**
Marchand	274	703	579	20.74%	-1.92%	**5.11%**
Augrabies	220	855	1 197	31.19%	3.42%	**11.96%**
Sending Riemvasmaak	160	162	180	0.25%	1.06%	**0.79%**

Between 1996 and 2016 the Kai !Garib population increased from 57 905 to an estimated 68 929 i.e., **0.88% growth p.a**. The most significant increase was recorded between 2011 and 2016. Meanwhile households increased at an average rate of 3.59% p.a. Over these two decades the average household size declined from 5.1 to 3.0, driving the growth in the number of households.

[12] *Data source: StatsSA Census 2011.*
[13] *Data source: StatsSA, census supercross tables.*

Table 7. Population and households in Kai !Garib 1996 to 2016[14]

Kai !Garib	1996	2001	2007	2011	2016	Annual growth 1996-2016
Population	57 905	58 671	56 502	65 869	68 929	0.88%
Households	11 367	14 032	17 389	16 703	23 017	3.59%
Average HH size	5.1	4.2	3.2	3.9	3.0	

Further inspection of urban and rural data of Kai !Garib and the district shows that the farm population declined between 2001 and 2011 by -0.73% and -3.09% respectively. Between 2011 and 2016 further declines in farm populations took place (-6.63% in Kai !Garib and -3.32% in ZFM). Although the number of households on farms declined between 2001 and 2011 in Kai !Garib and ZFM, the number of households increased between 2011 and 2016 (1.36% and 2.04% respectively).

The populations in urban areas of Kai !Garib increased during both periods, although it is the increase in the number of households between 2011 and 2016 that is the most striking (9.53% p.a.).

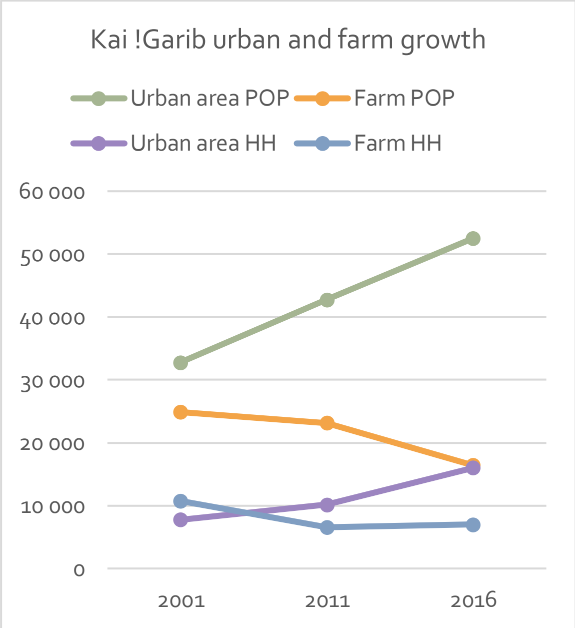

Figure 7. Kai !Garib urban areas and farm population and household growth 2001-2016

Table 8. Historical population and annual growth of Kai !Garib and ZFM 2001-2016 by geotype[15][16]

	Number						Growth p.a.			
	Kai !Garib			ZFM			Kai !Garib		ZFM	
	2001	2011	2016	2001	2011	2016	2001-2011	2011-2016	2001-2011	2011-2016
POPULATION										
Urban area	32 799	42 744	52 521	157 073	198 999	220 792	2.68%	4.21%	2.39%	2.10%
Farm	24 878	23 124	16 407	51 697	37 773	31 900	-0.73%	-6.63%	-3.09%	-3.32%
Total	**57 677**	**65 868**	**68 929**	**208 770**	**236 769**	**252 692**	**1.34%**	**0.91%**	**1.27%**	**1.31%**
HOUSEHOLDS										
Urban area	7 745	10 149	16 002	35 998	49 104	60 829	2.74%	9.53%	3.15%	4.38%
Farm	10 736	6 555	7 014	19 907	11 991	13 262	-4.81%	1.36%	-4.94%	2.04%
Total	**18 481**	**16 704**	**23 016**	**55 905**	**61 095**	**74 091**	**-1.01%**	**6.62%**	**0.89%**	**3.93%**

[14] *Data source: 1996, 2001 and 2011 censuses; 2016 community survey.*
[15] *Data source: StatsSA, census supercross tables; StatsSA, Community Survey 2016, SuperWeb2.*
[16] *Categories in 2001 are: Sparse (10 or fewer households), Tribal settlement, Farm, Small holding, Urban settlement, Informal settlement, Recreational, Industrial area, Institution, Hostel. In the 2011 census it was: Farm, Tribal area, Urban area.*

2.2.1.4.3

2.2.1.4.4 *Future growth expectations and assumptions*

In a paper of projections to 2021, Udjo set out the following assumptions for the Northern Cape:[17]

- Fertility rates will remain higher than the replacement rate of 2.2, decreasing from 2.8 in 2011 to 2.38 in 2021. According to a UN report, the South African fertility rate will reduce from a current 2.40 to 2.18 by 2025.[18]
- Life expectancy at birth of Northern Cape people will increase from 59.7 in 2011 to 61.8 in 2021. The UN report estimates that the South African life expectancy will increase from a current 57.1 years to 59.0 years in 2025, with decreasing infant and child mortality contributing to this.[19]
- Northern Cape's net migration (internal and international) will change from -1 323 in 2011 to 615 in 2016.

Udjo set about making predictions about the Northern Cape (2011-2021) which include: [20]

- The Northern Cape is projected to have the lowest annual growth of the population aged 15 years and over during the period 2018-2021 nationally (1.48% and 1.56% respectively)
- Nationally the average household size is projected to decrease from about 3.4 persons per household in 2011 to about 2.9 persons per households by 2021, while projected Northern Cape household size is 3.2 in 2021

In addition, two entities made crude projections of the Northern Cape population, namely:[21]

- 1.1 mil in 2011 to 1.4 mil in 2030 i.e., growth of 1.28% p.a. (NDP)
- 1.3 million in 2030 and 1.5 million by 2050, implying a growth rate of 0.88% p.a. (2011-2030) and 0.80% p.a. (2011-2050) (International Futures – base case)

Furthermore, Udjo projected the number of households per district in South Africa by 2021. The Northern Cape's households are projected to grow by an average of 2.76% per annum, with Frances Baard having the highest rate (3.46%) and Namakwa the lowest (0.86%). The growth rate in ZFM (3.10%) is only slightly lower than that of Frances Baard.

Table 9. Projected number of households per district by 2021[22]

	ZFM	Namakwa	Pixley Ka Seme	Frances Baard	JTG	Northern Cape
2011	61 098	33 855	49 191	95 928	61 332	301 404
2021	82 912	36 889	62 282	134 850	78 871	395 804
Annual growth rate	**3.10%**	**0.86%**	**2.39%**	**3.46%**	**2.55%**	**2.76%**

[17] *Udjo, EO (2015) Projecting population, numbers of households and dwelling units in South Africa 2011-2021. African Population Studies Vol. 29, No. 1, 2015. [Online]. Available from: http://aps.journals.ac.za*
[18] *United Nations, Department of Economic and Social Affairs, Population Division (2013). World Population Prospects: The 2012 Revision, Highlights and Advance Tables. Working Paper No. ESA/P/WP.228. [Online]. Available: http://esa.un.org/unpd/wpp/Documentation/pdf/WPP2012_HIGHLIGHTS.pdf [cited 11 August 2013] P 77.*
[19] *United Nations, Department of Economic and Social Affairs, Population Division (2013). World Population Prospects: The 2012 Revision, Highlights and Advance Tables. Working Paper No. ESA/P/WP.228. [Online]. Available: http://esa.un.org/unpd/wpp/Documentation/pdf/WPP2012_HIGHLIGHTS.pdf [cited 11 August 2013] P 77.*
[20] *Udjo, EO (2015) Projecting population, numbers of households and dwelling units in South Africa 2011-2021. African Population Studies Vol. 29, No. 1, 2015. [Online]. Available from: http://aps.journals.ac.za*
[21] *Go, A., Moyer, J., Rafa, M. and Schünemann, J. (2013) Population Futures: Revisiting South Africa's National Development Plan 2030. [Online]. Available: http://www.issafrica.org/uploads/AF7_15Oct2013V2.pdf*
[22] *Data source: Udjo*

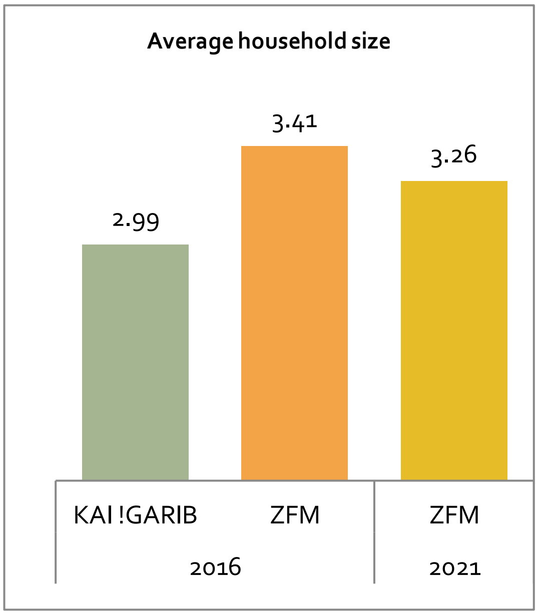

Figure 8. Average household size in 2011 and 2016

By 2021, the average household size of the Northern Cape is estimated at 3.2 persons per household.[23] Assuming that ZFM's average household size declines at the same rate, then it will decrease from 3.9 in 2011 to 3.26 in 2021.

It is expected that rural to urban migration will slow down, and natural growth will become the dominant growth factor due to the relatively large number of women in their reproductive ages of 15-44 years although fertility rates will continue to decline, and from increasing life expectancy and declining mortality rates.

Nevertheless, considering the past trends, and Kai !Garib's relative attraction as a place to migrate to given its economy, relatively high fertility rate and increasing life expectancy rate results in the predominant growth to be natural increases, supplemented with low immigration into the area.

The Reconciliation Strategies for the Augrabies Cluster and the Kakamas Cluster predicted annual growth rates from 2015 to 2030 of **0.95% and 0.94% respectively**.[24] Between 2010 and 2015 the growth rate of both clusters was estimated to be 1.8% p.a., while the recorded growth between the census years of 2001 and 2011 exceeded the Reconciliation Strategy estimate considerably.

In hindsight the Reconciliation Strategy's growth estimates for the Augrabies and Kakamas clusters are too low. **The population growth was reported to be 4.21% between 2011 and 2016**, and thus a higher rate is expected in Kakamas too if the urban areas in the study area are representative of the urban areas in the municipality. In Kai !Garib the farm populations declined by -6.63% per annum during the same period, and this rapid decline may imply that most of the farm outmigration has already taken place and that a period of stagnation will ensue.

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[23] *Udjo*

[24] *DWA (2009) Reconciliation Strategy for Augrabies Cluster. September 2009. P 9. AND Reconciliation Strategy for the Kakamas Cluster September 2009. P10.*

2.2.1.4.5 Future population estimates for the study area

Founded on the information detailed above and the use of the 2011 population census data as the base, low and high population estimates to 2040 are made as follows:

- Kakamas:
  - HIGH: as the main town in this vast rural area, it continues to grow at an average of **1.63% p.a.**
  - LOW: the population continues to increase at an average of 0.98% p.a. i.e., at a slower rate than its long-term trend of 2.07% p.a. (1996-2011 censuses)
- Settlements along the Orange River:
  - HIGH: continue to grow faster than Kakamas, and maintain a long-term population growth of **2.25% p.a**.
  - LOW: set at almost half (1.33%) of the long-term average given its relative lack of factors to attract and retain economically active persons
- Farms along the river:
  - HIGH: outmigration stagnates at a zero-growth rate
  - LOW: it is presumed that the farms will continue to house smaller families and with more employees living in nearby settlements and a long-term trend of -0.37% p.a. is applied

Table 10. High and low population annual growth rates 2011 to 2040

Growth rate p.a.	Scenario	2011-2015	2015-2020	2020-2025	2025-2030	2030-2035	2035-2040	Ave 2011-2040
Kakamas	HIGH	2.50%	2.08%	1.73%	1.44%	1.20%	1.00%	1.63%
	LOW	1.50%	1.25%	1.04%	0.87%	0.72%	0.60%	0.98%
Settlements	HIGH	3.50%	3.14%	2.47%	1.94%	1.53%	1.20%	2.25%
	LOW	2.50%	1.88%	1.41%	1.06%	0.80%	0.60%	1.33%
Farms	HIGH	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	LOW	-0.46%	-0.42%	-0.39%	-0.36%	-0.33%	-0.30%	-0.37%

By applying these growth rates, the Kakamas population is estimated to reach between 12 651 and 15 245 by 2040.

The farm population is estimated to reach between 8 298 and 9 251, and the population living in settlements is estimated at between 28 542 and 37 075 by 2040.

Together the study area's higher population estimate totals 61 571 and the lower population estimate totals 49 491.

These lower and higher population estimates are indicated in the table and figures below. It should be noted that projections and forecasts are typically based on several simplifying assumptions and are, in part at least, only as reliable as the data on which they are based.

Table 11. High and low population estimates to 2040

		2011	2015	2020	2025	2030	2035	2040
Study area	**HIGH**							
Kakamas		9 540	10 530	11 673	12 720	13 664	14 505	15 245
Settlements		19 432	22 299	26 031	29 411	32 380	34 929	37 075
Farms		9 251	9 251	9 251	9 251	9 251	9 251	9 251
Total		**38 223**	**42 080**	**46 955**	**51 382**	**55 296**	**58 685**	**61 571**
Study area	**LOW**							
Kakamas		9 540	10 125	10 774	11 345	11 845	12 278	12 651
Settlements		19 432	21 449	23 542	25 252	26 622	27 701	28 542
Farms		9 251	9 082	8 893	8 721	8 565	8 423	8 298
Total		**38 223**	**40 657**	**43 208**	**45 319**	**47 032**	**48 403**	**49 491**

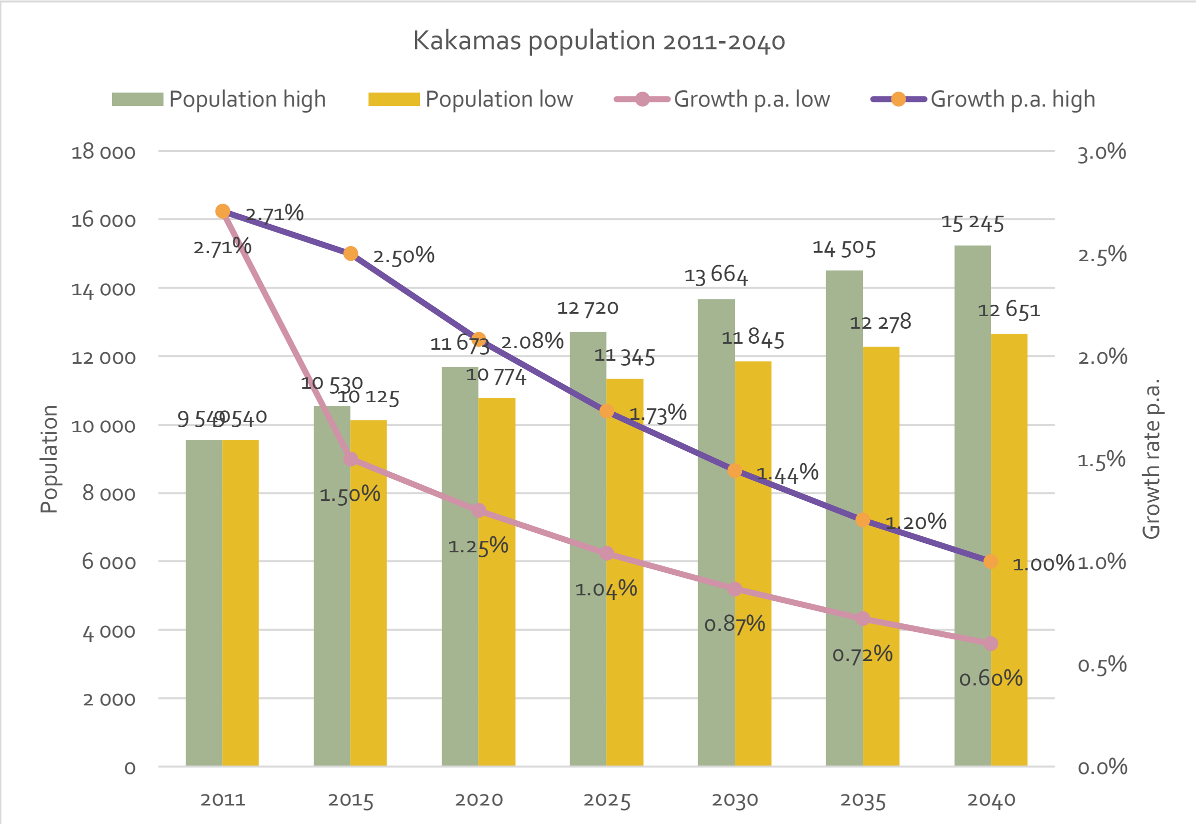

Figure 9. Kakamas population estimates and annual growth rates

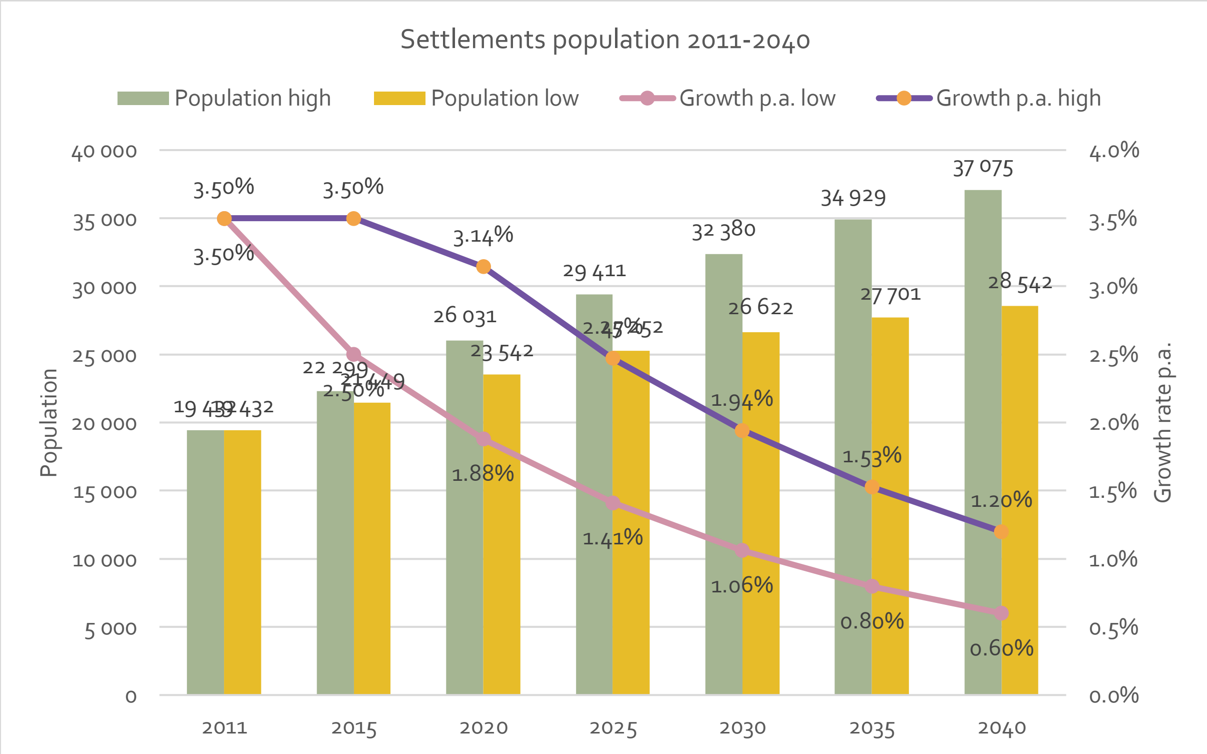

Figure 10. Population estimates & annual growth rates: settlements along the Orange River

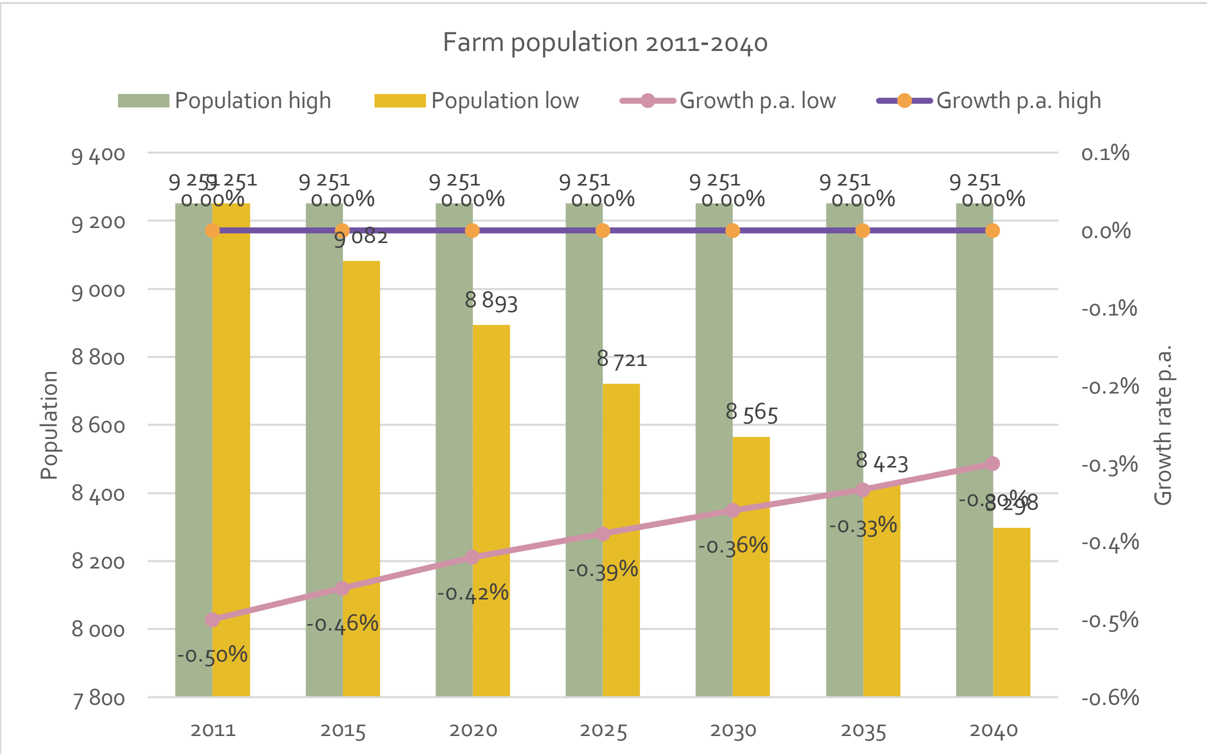

Figure 11. Estimates & annual growth rates: farm populations along the Orange River area

Table 12. Status of water supply on residential stands within the Kakamas service area[25]

FORMAL STANDS	House Connection	Yard Connection	Communal Standpipe	None	Unknown	Grand Total
Alheit		178				**178**
Augrabies	1	318	87		1	**407**
Cillie		242			67	**309**
Kakamas	1 421	99		94	176	**1 790**
Lutzburg		238				**238**
Marchand	159	128	127			**414**
Riemvasmaak Sending	1	155			1	**157**
Riemvasmaak Vredesvallei		136				**136**
Sub-total formal stands	***1 582***	***1 494***	***214***	***94***	***245***	***3 629***
INFORMAL STANDS						
Cillie		1				**1**
Kakamas		195	175			**370**
Lutzburg	1	13	10			**24**
Sub-total informal stands	***1***	***209***	***185***	***0***	***0***	***395***
TOTAL	**1 583**	**1 703**	**399**	**94**	**245**	**4 024**

There are 828 households (21%) with sanitation below basic standard living or that have an unknown type of supply. Most of these occur in Kakamas. It is noted that there are 175 buckets on informal stands in Kakamas.

Table 13. Status of sanitation supply within the Kakamas service area[26]

FORMAL STANDS	Flush to WWTW	Conservancy Tank	Septic Tank	UDS	VIP	Unimproved Pit	Bucket	None	Unknown	Grand Total
Alheit			5	159	14					**178**
Augrabies		104		207		42		51	3	**407**
Cillie		200		65					44	**309**
Kakamas	1 451				3			94	242	**1 790**
Lutzburg		217			21					**238**
Marchand	159			98	6	24			127	**414**
Riemvasmaak Sending	1				152			4		**157**
Riemvasmaak Vredesvallei					115			21		**136**
Sub-total formal stands	***1 611***	***521***	***5***	***529***	***311***	**66**		***170***	***416***	***3 629***
INFORMAL STANDS										
Cillie				1						**1**
Kakamas	195						175			**370**
Lutzburg	7	6		10				1		**24**
Sub-total informal stands	***202***	***6***	***0***	***11***	***0***	***0***	***175***	***1***	***0***	***395***
TOTAL	**1 813**	**527**	**5**	**540**	**311**	**66**	**175**	**171**	**416**	**4 024**

The Kai !Garib municipality had a project to replace 3 000 VIPs in 10 wards over a three-year period, but this was not approved by Council and it was decided to install VIPs instead.[27]

25 Aurecon (2016) Backlog model for DWS; and cross checked with 2008 data.
26 Aurecon (2016) Backlog model for DWS; and cross-checked with 2008 data.
27 Personal communication with Kai !Garib municipality on 5 February 2018.

2.3 Number of poor households to be served

2.3.1 Indigent policy

The Kai !Garib has an indigent policy that guides the implementation of free basic services to render free basic water and sanitation. Only registered indigents qualify for the free basic services.

Indigent households qualify for 6 kℓ of water free per month. However, if consumption exceeds the FBW monthly amount the consumer is charged at normal tariffs for actual consumption on the amount exceeding 6 kℓ.

The maximum income to qualify as an indigent household is equivalent to two state pensions and one foster care grant. Other criteria include:

- Property value ≤R100 000
- Property used for residential purposes only
- Over previous 12 months may not exceed:
    - 400 kWh electricity consumption; or
    - 18 kl water per month
- Will be fitted with a prepaid electricity and water meter

The monthly FBS package includes the following:

- Free electricity of 50 kWh
- Free water of 6kl
- 100% of the basic levy for one water, sewerage, refuse point
- 100% subsidy rates on the total property valuation
- 100% subsidy for installation of a prepaid meters

It is noted that outstanding debt will be written off against provision for bad debt provided that the household is fitted with both prepaid electricity and prepaid water meters.

2.3.2 Number and proportion of indigent households

There are several sources that measure the number of indigent households including the municipality's indigent household register and data from Statistics South Africa, which is used by National Treasury to determine equitable share amounts. National Treasury determined that there were 59.2% indigent households in Kai !Garib in 2018/19.

Table 14. Equitable share calculation by National Treasury 2018/19[28]

According to ES calculation by National Treasury	Kai !Garib
Households	23 017
Indigent	13615
% Indigent	**59.2%**

This is considerably more than on the indigent register kept by the municipality. There are 4 062 indigent households on the municipality's indigent register, and the 2016/17 budget made provision for 4 000 households. Furthermore, the number of registered indigent households can vary

[28] *Data source: Excel sheet from National Treasury 2018/LGESSummaryData&Formula.xls*

considerably from year to year, often depending on whether a registration campaign has been undertaken.

Thus, the Census 2011 data is consulted because it is a credible source used by National Treasury to determine equitable share amounts,[29] and because it is widely recognised that there is an under registration of indigent households by municipalities. A reason for this is that often there is no incentive to be registered especially in situations where households receive free basic services regardless of their status at the municipality.

A two-pension plus one foster care grant model is practiced at Kai !Garib municipality. In 2022, the value of two old-age pensions and one foster care grant was R 36 240 per annum. Assuming an even distribution in the R 19 201-R 38 400 category, then 45% of households in Kakamas, 71% in the study area settlements, and 67% of farms in Kai !Garib would have had incomes of ≤R 36 240 p.a. and could, therefore, be regarded as indigent households.

Table 15. Household income distribution + percent indigent and non-indigent 2011[30]

		%			Cumulative %		
		Kakamas	Settlements	Farms	Kakamas	Settlements	Farms
Indigent	No income	7%	8%	3%	7%	8%	3%
	R 1 - R 4800	2%	3%	1%	9%	11%	4%
	R 4801 - R 9600	4%	6%	2%	12%	16%	6%
	R 9601 - R 19 600	14%	29%	33%	26%	45%	39%
	R 19 601 - R 36 240	19%	25%	27%	**45%**	**71%**	**67%**
Non-indigent	R 36 241 - R38 201	2%	3%	3%	47%	74%	70%
	R 38 201 - R 76 400	21%	15%	19%	69%	89%	89%
	R 76 401 - R 153 800	16%	7%	5%	85%	95%	94%
	R 153 801 - R 307 600	9%	3%	3%	94%	98%	97%
	R 307 601 - R 614 400	5%	1%	2%	99%	99%	99%
	R 614 001 - R 1 228 800	1%	0%	1%	100%	100%	100%
	R 1 228 801 - R 2 457 600	0%	0%	0%	100%	100%	100%
	R 2 457 601 or more	0%	0%	0%	100%	100%	100%

2.4 Number of associated services benefiting

Associated services such as schools and health facilities will be connected to the WWTW.

Community halls and other social facilities

There are numerous social facilities in Kai !Garib including halls, libraries, cemeteries, and sports facilities.

It is the intension of the Kai !Garib municipality to provide five (5) additional community halls by 2016 by establishing one per annum, as well as one sport facility p.a. along with a functioning sport forum.[31]

[29] *Development of Models to Facilitate the Provision of Free Basic Water in Rural Areas, Report No 1379/1/05: March 2005. [Online] Available from: http://www.fwr.org/wrcsa/1379105.htm (Accessed: 9 June 2012).*

[30] *Derived from StatsSA, Census 2011.*

[31] *Kai !Garib Municipality. Draft Integrated Development Plan, 2017/2018. P*

Health facilities

Kakamas hospital is a district hospital, which has 30 beds.[32] However, no theatres are operational, and all surgery is undertaken in Upington. A primary health care clinic is also operated on the hospital premises. Another clinic is in the study area at Augrabies. Satellite clinics function at Lutzburg, Cillie, Alheit and Marchand on a few days per week.

The targeted number of visits to a primary health care facility, i.e., a clinic or community health centre, is 3.5 visits per person per annum.

Schools

There are 14 schools in the study area, which had 5 365 learners and 228 educators in 2017.

Table 16. Schools in the study area with learner numbers 2017[33]

Name of settlements and school	Learner Number 2017	Educator Number 2017
Augrabies	**781**	**33**
Assumpta (Rk) Primêre Skool	428	16
Augrabies Intermediate School	191	10
St Maria Goretti (Rc) Primary School	162	7
Kakamas	**3706**	**159**
Alheit (Ngk) Primêre Skool	112	7
Cillie (Ngk) Primêre Skool	445	16
Hoërskool Martin Oosthuizen	232	21
Kakamas Intermediate School	1012	42
Kakamas Primary School	770	19
Laerskool Sentraal Kakamas	325	20
Oranje-Suid Primêre Skool	810	34
Lutzburg	**321**	**11**
Lutzburg (Sskv) Intermediêre Skool	321	11
Marchand	**353**	**14**
Perde-Eiland (Ngk) Primêre Skool	353	14
Riemvasmaak	**116**	**6**
Riemvasmaak Primêre Skool	116	6
Vredesvallei	**88**	**5**
Vredesvallei Primêre Skool	88	5
Grand Total	**5365**	**228**

2.5 Estimated number of jobs to be created

The number of jobs to be created will be addressed once the type of WWTW has been selected.

2.6 Affordability of the proposed water tariffs

2.6.1 Water and sanitation tariffs

Kai !Garib has a two-part tariff structure in place for water. Differentiated water tariffs are charged per customer category, and there is a difference between metered and prepaid tariffs. The monthly availability charge is R 69.00 for domestic consumers, while bulk users are charged:

- R367.58 for a 50mm connection

[32] *Northern Cape Heath Service Transformation Plan 2014; and confirmed telephonically by the hospital manager on 30 October 2014. Three clinics were confirmed too. 054 431 0866*

[33] *Dept of Basic Education (2017). EMIS [Online]. Available from: https://www.education.gov.za/Programmes/EMIS/EMISDownloads.aspx*

- R2336.27 for a 75-mm connection
- R6093.58 for a 100mm connection
- R277.03 for a raw water connection

Volumetric tariffs for all metered consumers start at R 6.01 (ex VAT) per kℓ in the first block, increasing to R 7.77 per kℓin the last block, which is initiated at 50 kl. Prepaid charges range from R6.60 per kl in first block to R8.40 in the last block (>50kl). Consumption charges increased by 20% between 2016/17 and 2017/18

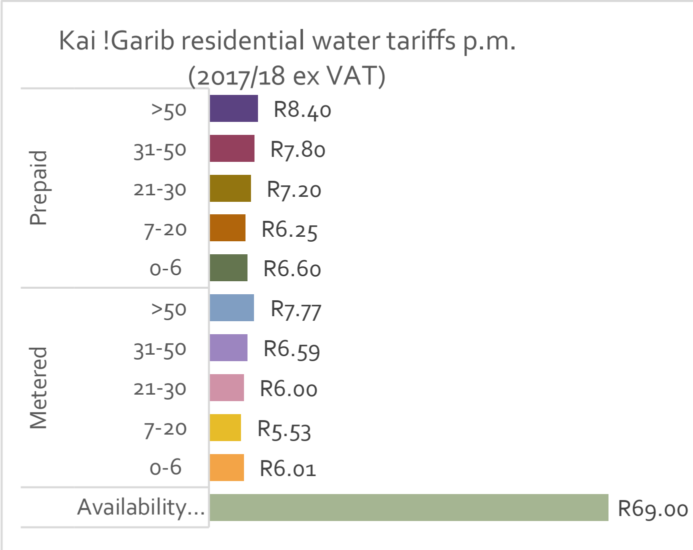

Figure 12. Kai !Garib domestic water tariffs 2017/18 excluding VAT[34]

The sewerage availability tariff varies from R 152.49 for domestic users with a sewerage connection R6109.49 for bulk users exceeding 500kl/pm. Suction tanker services are also charged at R138.61 for buckets to R300 per kl for a rural service. Sanitation charges increased by 20% between 2016/17 and 2017/18, except for suction tankers services in urban areas that increased by 118% and in rural areas by 1678%.

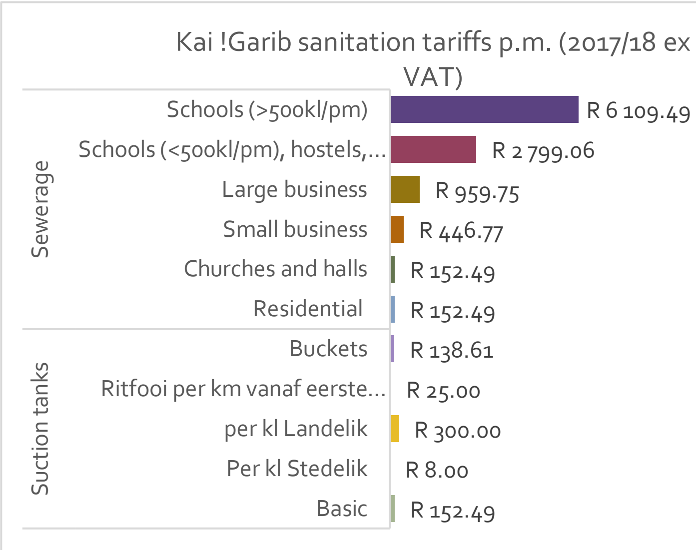

Figure 13. Sanitation availability tariffs per connection by type of consumer 2017/18 ex VAT[35]

2.6.2 Affordability

Typically, a household can afford to pay up to 5% of household budget on water services according to international standards. Several developing countries have adopted polices to promote an affordability index for poor households of 3-5% and implement measures to reduce the burden of expenses.[36] Therefore, affordability calculations are made for Kai !Garib based on water and sanitation services comprising 5% of household income.

If a typical household uses at least 400 litres per day, the monthly consumption is 12 kl, costing R157.59 p.m. Together with a basic sanitation charge of R173.84, this would cost R331.49 p.m.

[34] *Data source: KG. Tariff list sent via email on 10 January 2018.*
[35] *Data source: KG. Tariff list sent via email on 10 January 2018.*
[36] *Smets, H. (2009) Access to drinking water at an affordable price in developing countries. Water Academy, France. P58.*

(inclusive of VAT). Thus, for a household to be able to afford 5% of household income on water services, **they would need to have an annual income of at least R79 544 in 2017/18.**

Discounting income of R79 544 p.a. in 2017/18 to 2011 using the CPI index of Statistics South Africa, results in a 2011 income of R57 664 p.a. Thus, approximately 58.1% of households in Kakamas, 81.3% in settlements, and 79.6% on farms in the study area. **This proportion of households would not be able to allocate 5% of household income to water and sanitation.**

Table 17. Assumptions and calculations of water affordability 2017/18[37]

Affordability	WATER	SANITATION	TOTAL
Tariff per kl	Block tariff		
Kl free to non-indigent HH	0	0	
Basic charge	R 78.66	R 173.84	
Typical household consumption in kl (based on 400l/d)	12.0		
Thus: Amount payable	R 157.59	R 173.84	R 331.43
At 5% of income then monthly household income is at least in 2017/18			R 6 629
At 5% of income then annual household income is at least in 2017/18			R 79 544
HH income pa 2011			R 57 664
% HH with income less than R# pm			
Kakamas			**58.1%**
Settlements			**81.3%**
Farms			**79.6%**

2.7 Contribution towards poverty eradication, social upliftment and health

The *Framework for Implementation* of bulk regional projects sets out drivers of regional bulk infrastructure.[38] These drivers, which contribute directly towards poverty reduction, social upliftment and health, relate to the Kakamas WWTW project as follows:

- **Need to address access to basic services**: Backlogs in basic services are reliant on bulk water services provision. Besides backlogs, new housing developments and projects require services. Housing projects with business plans that have been submitted include: Kakamas 750 sites, Augrabies 400 sites, Vredesvallei 688 sites, Marchand 330 sites, Lutzburg 72 sites, Cillie 210 sites and Alheit 250 sites.
- **Need to support economic growth and development**: Bulk infrastructure must provide both economic and social needs.

  This project will contribute to poverty reduction, increase levels of service, uplift and stimulate economic growth because it will have a significant stimulus on:

  - The water service provider's business
  - Socio-economic benefits resulting from a quality water services that is compliant to standards
  - Construction with impacts on spending, employment, and taxes and in its operational phase where there are multiplier effects

  The project is aligned to the priorities set in the IDP.

  The Kakamas WWTW is a set of oxidation ponds which were last upgraded during the 1980's (37 years ago). Its capacity insufficient, and needs to be enlarged to cater for population and economic growth. The Kakamas Water Treatment Works is a package-type plant, last upgraded in 1987, and it has now exceeded its design life of 25 years.

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[37] *Derived from StatsSA CPI index and Census 2001 and municipal tariffs*

[38] *Dept. of Water Affairs (2011) Water services regional bulk infrastructure programme – Framework for implementation. Version V10, January 2011.P. 11.*

- **Need of new infrastructure to improve water services quality**: Kakamas performed poorly in the 2013 Green Drop scoring only 32.98%. However, this was an improvement over its 2011 score of 10.5%. The highest scoring plant in the municipality was in Kenhardt (49.7%), while the lowest score was at Keimoes (28%). In 2013, Kai !Garib had a green drop score of below 30% which indicates ***that "the overall municipal wastewater business is not on par with good practice and legislative compliance***". Such municipalities are placed under regulatory surveillance, in accordance with the Water Services Act (108 of 1997) section 62 and 63.[39] The Kakamas WWTW scored 76.47% in the cumulative risk rating (CRR) in 2013, climbing from 94.1% in the previous year. The Green Drop Report reported that "although there is improvement per plant, the performance remains unsatisfactory. Keimoes remains in a critical state while the **Kakamas and Kenhardt systems have 'progressed' to a 'very poor performance 'status"**. Among the issues highlighted is that WWTW staff do not meet regulatory requirements, preventative maintenance is required, as well as plant authorisations, and the review of bylaws. Uncertainty also exists regarding the capacity of the plants, and the flow into facilities is also not measured.[40][41]
- Water service quality has a direct impact on the **health** of a population. Childhood diarrheal diseases is a preventable cause of under-five mortality. Childhood diarrhoea is closely associated with insufficient water supply, inadequate sanitation, water contaminated with communicable disease agents, and poor hygiene practices.[42] **Health risks result from the overflow of final effluent from the WWTW that makes its way to the Orange River, while the WTW needs to be relocated because it is below flood level.**

2.8 Socio-political support for the proposed development

A bulk infrastructure project must be aligned with, and listed in the Integrated Development Plans (IDP) and Water Services Development Plans (WSDP) of the participating municipalities.[43]

The new Kakamas WWTW is specifically listed as a project in the Kai! Garib IDP. In addition, the Kakamas WWTW was listed as an RBIG project in Appendix W5 of the 2016 national budget.

2.9 Social component

The Regional Bulk Infrastructure Grant (RBIG) is to finance the social component and to enable economic development. [44]

2.9.1 Guidelines on how to calculate the social component

The social component of the project needs to be determined because that is the capital portion that is funded from the RBIG. The social component and enabling economic environment, which are the only components that can be funded by RBIG, include:[45]

- Basic level of domestic use
- Associated social requirements e.g., schools and clinics

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[39] *Department of Water Affairs. 2013 green drop report, volume 1 - municipal and private waste water systems. P 358.*
[40] *Department of Water Affairs. 2013 green drop report, volume 1 - municipal and private waste water systems. P 359.*
[41] *DWA, Green Drop 2012. P 132.*
[42] *http://www.who.int/ceh/risks/cehwater/en/*
[43] *Dept. of Water Affairs (2011) Water services regional bulk infrastructure programme – Framework for implementation. Version V10, January 2011.P. 19.*
[44] *Dept. of Water Affairs (2011) Water services regional bulk infrastructure programme – Framework for implementation. Version V10, January 2011.P. 16.*
[45] *Department of Water Affairs and DFID. (2008) Funding agency booklet. April 2008. P.8.*

- Social economic development objectives (enablement of economic development)

While the RBIG fund must enable economic development, the proportional capital cost of higher levels of domestic, commercial and industrial uses must be co-funded from suitable sources.[46]

Thus, the RBIG Programme has been established to supplement funding for regional bulk water infrastructure with the specific purpose to supplement the "social component" and the "enabling economic environment only". [47]In the absence of a manual that details how to calculate the social component of the RBIG, a slide by Constantinides (2011) provides guidance, which was further clarified by comments on the Mamusa RBIG.[48]

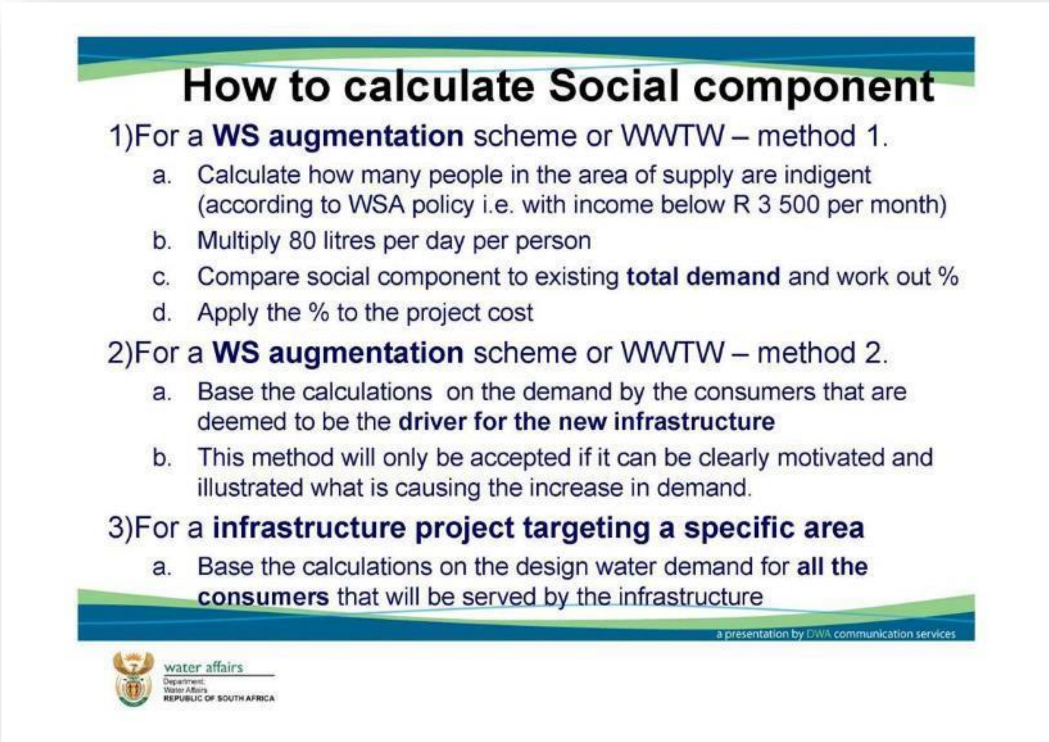

Figure 14. How to calculate the social component[49]

[46] Blazer, P. (2010) Regional bulk infrastructure grant (RBIG) programme. Presentation to the Portfolio Committee: Water and Environment on 16-17 March 2010. P.6.
[47] Department of Water Affairs. Strategic Plan 2010/11-2012/13. P.7.
[48] Determining the social component of the Mamusa RBIG for the implementation ready study - Draft for discussion 20 January 2012. Response from Constantinides received per email via Mr Jasper Fourie (DWA) dated 1 February 2012.
[49] Constantinides, G. (2011) Presentation at RBIG Stakeholder workshop 'Planning, funding process guidelines and master plans' on 15 February 2011. Addendum E. Department of Water Affairs. Slide 7.

Aspects that were confirmed of Method 1 described in the figure above are: [50]

- RBIG acknowledges the indigent definition of the Municipality. Thus, indigent policies need to be referenced and the definition of the Municipality is used. The source of the number of indigents needs to be detailed and assumptions specified.
- "existing total demand" is assumed to mean the total water demand in 2010 e.g., from all water sources
- In addition, projections to 2030 in respect of population and water demands need to be made.

It is advised that the method used be based on the circumstances of the project for example: [51]

- Method 2: usually applied to projects that address backlogs. The profile of consumers that drive the infrastructure need and their demand is used.
- Method 3: used if a project is dedicated to a specific area and related to specific new water supply schemes and not for augmentation of total water supply.

However, Method 2 and Method 3 do not seem to apply to this case.

In addition to the criteria above, the following average water demands can be used, detailed in the table below.

Table 18. Water supply parameters for indigent households[52]

Level of supply	Litres per capita per day
Full	80
Yard connection	55
Communal standpipe	25

Allowance can be made for the following factors in the calculation of the social component: [53]

- Peak demand which may vary for different entities and times e.g., domestic, industrial, commercial (The Red Book should be consulted)
- Seasonal factors for holiday towns can deter the determination of the social component, which then needs to be calculated on an individual basis
- Water losses of 15% are acceptable which may be added to the social component
- In rural area where standpipes or yard connections are provided, stock water can be added although it should not exceed 80 litres per capita per day
- Fire flow, which must be illustrated as a ratio of social and economic provision
- A scheme with different large components, may require a social component to be determined for each component

[50] *Determining the social component of the Mamusa RBIG for the implementation ready study- Draft for discussion 20 January 2012. Response from Constantinides received per email via Mr Jasper Fourie (DWA) dated 1 February 2012.*
[51] *Determining the social component of the Mamusa RBIG for the implementation ready study- Draft for discussion 20 January 2012. Response from Constantinides received per email via Mr Jasper Fourie (DWA) dated 1 February 2012.*
[52] *Email from Mr. J Fourie dated 15 September 2012.*
[53] *Email from Mr. J Fourie dated 15 September 2012.*

2.9.2 Norms used

The water requirements of the population and associated social requirements are determined using a set of norms that are highlighted in the table below. Based on these norms the proportion of water that can be allocated to indigents and associated users is calculated.

Table 19. Norms used in the water allocation per category

Category	Water use per day in litres	Source	Comment
Indigents	80 per capita	Specified in the RBIG	70l waste water per capita per day[54]
Non-indigents	25 per capita	Strategic framework for water services[55]	
Schools (day)	20 per learner	Red Book[56]	Based on actual learners per school
Schools (boarding)	140 per learner	Red Book	Based on actual board numbers
Hospitals	300 per bed	Red Book	Based on number of used beds
Clinics	20 per outpatient visit	Red Book specifies 5l, which is considered low.	Based on 3.5 visits per person to a clinic per annum which is the target of the Dept. of Health. However, if current use is higher than the 3.5, the actual number is used.
Community halls	90 per seat	Red Book	Number of seats estimated at 2.5% of population
Crèches	20 per leaner		Assumed to be the same as learners at schools, learners estimated at 10% of total school leaners

2.9.3 The WWTW project

The Kakamas WWTW needs to be replaced because capacity is inadequate, and it was upgraded in the 1980s, about 37 years ago. A new site is being investigated for the WWTW. The Kakamas municipality has not yet selected its preferred option from those set out in this feasibility study. Initial estimates indicate that the WWTW will be a 4.5 Megalitre/day plant, if a single plant configuration proves to be the most feasible option.

The option of providing several smaller decentralized treatment facilities is also being investigated, as this may be more economic in the long term.

2.9.4 Social component for the project

Based on the norms, number of indigents and associated users, the social component of the project is calculated based the assumptions of Method 1 outlined above and projected to 2040. **The portion of the project that delivers water to the social component is 88.89%.**

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[54] *Confirmed at the Northern Cape RBIG meeting on 21 February 2018.*
[55] *DWAF (2003) Strategic framework for water services. P68.*
[56] *CSRI Building and Construction Technology (2000) Guideline for human settlement planning and design. Volume 2. P.21.*

Table 20. Calculation of the social component

	Kakamas WWTW	Population 2040	% indigent	Users 2040	Wastewater l/day	Wastewater Ml/day	WWTW Ml/day 2040	% Social Component
Kakamas	Indigents	15 245	45.00%	6 860	64	0.440	4.50	9.78%
	Non-indigents		55.00%	8 385	20	0.170	4.50	3.78%
Settlement	Indigents	37 075	71.00%	26 323	64	1.690	4.50	37.56%
	Non-indigents		29.00%	10 752	20	0.220	4.50	4.89%
Farms	Indigents	9 251	67.00%	6 198	64	0.400	4.50	8.89%
	Non-indigents		33.00%	3 053	20	0.070	4.50	1.56%
	Subtotal	***61 571***		***61 571***		***2.990***		***66.44%***
	Associated users	**2017**	**Growth pa**					
	Schools (day) learners	5 365	1.60%	7 729	16	0.130	4.50	2.89%
	Schools (boarding)	240	0.00%	240	112	0.030	4.50	0.67%
	Crèche learners	537	1.60%	773	16	0.020	4.50	0.44%
	Hospital beds	30	1.60%	43	240	0.020	4.50	0.44%
	Clinic outpatients (headcount)			215 499	3.5	0.760	4.50	16.89%
	Prison/police cells	20	1.60%	29	120	0.010	4.50	0.22%
	Community hall seats			1 539	20	0.040	4.50	0.89%
	Subtotal					**1.010**		**22.44%**
					TOTAL SOCIAL COMPONENT			**88.89%**

The chart below shows that as the capacity of the WWTW reduces, the social component increases.

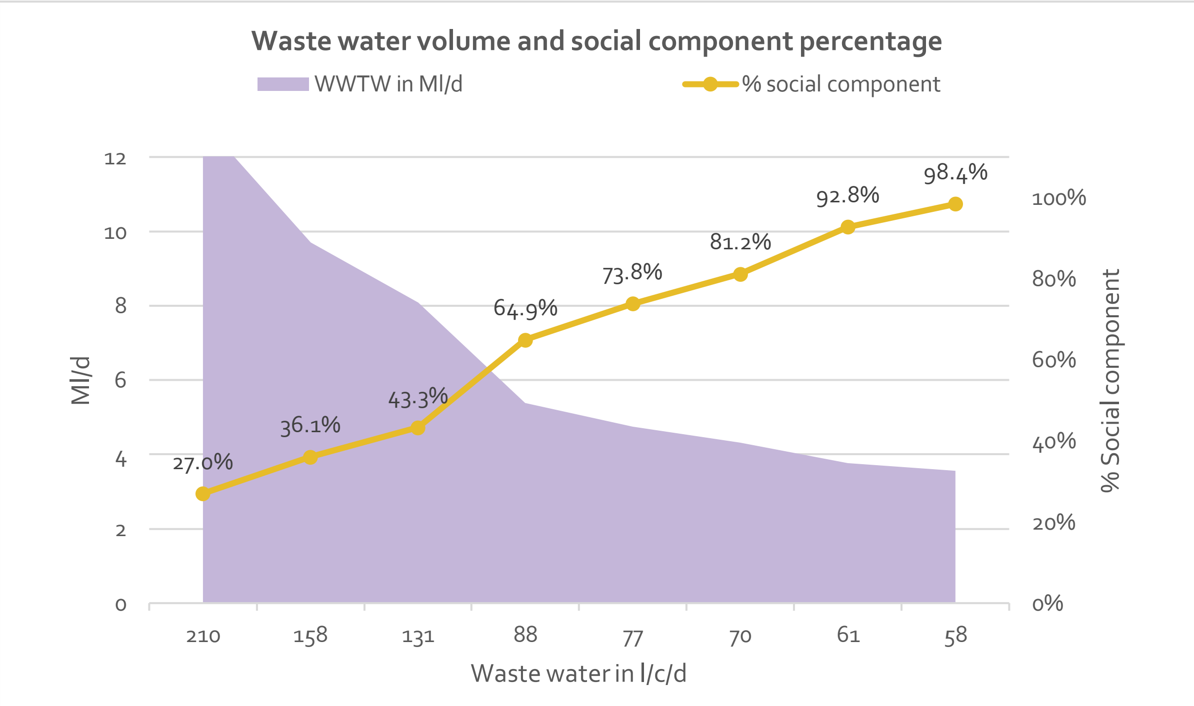


Figure 15. Social component plotted against the waste water volume in Ml per day

3 UNCERTAINTIES

3.1 Possible Obstructions / Limitations

3.1.1 Cost Factor

The primary obstructions and limitations of a proposed project for the upgrading of the Kakamas wastewater treatment works is the cost factor.

The financial position of the Kai !Garib Municipality is dire, like many others in the Northern Cape Province. This situation means that this municipality is not able to embark on critical projects of this nature without financial assistance in the form of a grant.

Should the municipality take up a loan to fund such a project, they would not be able to service the loan repayments due to the socio-economic status of most of their inhabitants.

3.1.2 Technical Capacity

The Kai !Garib Municipality **does not currently have sufficient technical capacity** to operate and maintain installations such as water and wastewater treatment facilities, pump stations and pipelines. Therefore, the level of technology being used to address this problem should be appropriate for the very limited skills and capacity of the municipal operational staff.

4 STRATEGIC RISKS

4.1 Risks preventing the continuation of the project

The primary risks preventing the continuation of the proposed project are:

- Lack of sufficient funding.
- Possibility of environmental constraints on the proposed project.

4.2 Operational risks of the project

The operational risks of the proposed project are real and experienced on a daily basis. The following have been identified as serious operational risks:

- Regular vandalism and sabotage of electrical and mechanical equipment.
- **Lack of any continuous preventative maintenance on installed equipment.**
- **Inadequate budget for operation and maintenance purposes.**

Both the financial capacity, as well as the technical capacity of the Kai !Garib Municipality has deteriorated significantly over the past 15 years. The municipality is in serious financial trouble and for all practical purposes, bankrupt.

The availability of technical know-how is almost zero, and currently limited to a fairly competent Electrical Services manager. Even at artisan level, there are almost no specialized skills available for regular operational and maintenance activities.

Serious thought must be given to outsource the required technical skills from either a parastatal organization such as a water board, or the private sector to ensure sustainability.

5 OPTIONS TO ADDRESS THE OBJECTIVES

5.1 Philosophy and criteria employed

The basic philosophy employed to solve the problem is:

- To construct either a new centralized wastewater treatment works at Kakamas to deal with all the incoming wastewater, or
- To construct a smaller wastewater plant for Kakamas, and multiple smaller facilities at the various villages, to deal with wastewater from the villages and farms.

The existing Kakamas WWTP is to be decommissioned once the new wastewater treatment facility(s) have been commissioned and are fully operational.

In addition, the chosen solution(s) should be such, that it is easy to operate and maintain, and could be done with the current resources available to the Municipality.

Figure 16. Kakamas Oxidation Pond system after emergency works in 2018

5.2 Existing WWTW Capacity

The existing Kakamas Wastewater Treatment Works is a conventional ***anaerobic-facultative-aerobic configuration oxidation pond system*** relying on the natural action of bacteria and microorganisms for water treatment. In the absence of available design information for the WWTW, the current estimated **hydraulic capacity** of the existing works was assessed at **430m^3/day**.

The existing plant comprises the following units:

- Anaerobic Ponds:
    - 4 x Anaerobic Ponds each with an area of 360m².
- Facultative Pond:
    - 2 x Facultative Ponds with areas of 4 557m² and 3 300m² respectively.
- Secondary Aerobic Ponds:
    - The primary purpose of these ponds is to serve to provide sufficient hydraulic retention time to ensure sufficient reduction of bacteria due to natural bacterial decay or die-off. Typically, 2 to 3 ponds should be provided in series with each having a minimum hydraulic retention period of 7 days.
    - In the case of Kakamas, four secondary aerobic ponds with a total surface area of 7 106m².
- Storage Ponds:
    - 3 x Storage Ponds with a total area of 9 462m².
    - The depth of the ponds is unknown, but it is assumed that they are of the order of 1 to 1.2m deep. It should also be noted that the existing treatment works does not have any flow meter or grit and screenings removal.

The Kakamas WWTW is currently **hydraulically overloaded**, receiving 87.5% more flow than its rated design capacity. The Kakamas WWTW **will need to be upgraded from its current capacity of 430m³/day to an expected 4 584m³/day** to accommodate the additional flow.

5.3 Projected run-off volumes for design purposes

For the purpose of this feasibility study a design horizon of 20 years was chosen. The projected population in 2040 for a high growth scenario is estimated to be 61 571 persons. If a low growth scenario is taken, then the 2040 population is projected to be 49 491 persons.

Normally, run-off would be calculated using the existing flows to a plant as basis. Unfortunately, the Kakamas facility had no flow measuring facility in place. A calculation was also done to try and determine the current volumes, by taking the number of Vacuum Tanker Truck loads deposited at the plant per day. The initial volumes derived at are as follows:

No of Truckloads/day: 66 at 7000 litres per load =	**462m³/day**	(from villages and farms)
From Kakamas Pump Station:	**2 938m³/day**	
Total Volume calculated:	**3 400m³/day**	
Average per capita run-off:	**70 litres/capita/day**	

Just to calculate an order of magnitude, as a check on the above, an average of the 2020 population figures was used. An assumption was made to do runoff calculations at 80 litres per capita per day, as an average. Typically, areas served by a waterborne sewer, would have a higher per capita flow, while areas served by conservancy tanks will have lower flows.

Population:	42 080
Qty per capita:	80 litres per person per day (average)
Calculated Volume:	**3 366 m^3 per day**

It is required practice to allow for 15% storm water infiltration into sewer systems as well as to apply a peak factor of 1.06 calculated from the Harmon formula.

This peak factor may be misleading when the total population to be served, is used for calculation.

Typically, the smaller a town or village is, the higher the peak factor. This is due to the shorter time of concentration, and the lack of large, long sewers, which serve to attenuate any peaks.

This figure of 1.06, should therefore be applied with care. Again, just to calculate an order of magnitude, it is used as a first assumption.

This implies that:

Peak Wet Weather Flow:	**3 366 x 1.15 x 1.06 = 4 103 m^3 per day**

Typically, when designing a sewage treatment plant, the inlet works is designed for the peak wet weather flow, and the subsequent unit processes are designed to accommodate the average dry weather flow. Typically, units such as aeration basins and clarifiers, having quite large volumes, and provide a degree of attenuation, allowing absorption of the peak flows. Oxidation Ponds, having similar large pond volumes, have a similar response with regards to peak flows.

For a 20-year design horizon, the expected population will by 49 491 if a low growth scenario is accepted, and 61 571 persons if a high growth scenario is accepted. We chose to take an average of these scenarios, and derived a future population figure of 55 531 persons.

Subsequently, the new works, if a single, centralized WWTP is selected as the treatment option, it should be designed for a Dry Weather Flow in the order of **4 442m^3 per day**.

There are both pros and cons to having a single, centralized wastewater treatment facility.

The primary advantage being in the economy of scale. The cost to construct a single large plant will generally **cost less per Megalitre of treatment capacity**, compared to a small treatment plant.

The disadvantages are that such a plant will have a disproportionate size in relation to the community it is serving, the large flow it has to deal with, as it includes flow from the surrounding villages and farms. Volumes in this order makes the use of higher technology such as activated sludge a given, which is a problem operationally.

In addition, the use of a single centralized WWTP implies that all the sewage from the various villages and farms, still need to be transported to the plant, using a fleet of vacuum tanker trucks. This is currently a major part of the municipality's problem due to the high costs associated with operating and maintaining such a tanker fleet.

At Kakamas, wastewater is currently transported over distances in excess of 30km in one direction! We calculated that with a fleet of 6 trucks, each travelling an average of 27.5km per trip, and averaging 266km per day per truck, the cost of transporting the wastewater to Kakamas equates to a **unit cost of R88-39 per kilolitre**, or an **annual cost of R9 801 000-00** per annum. Given that this is only transport cost, the cost of replacing these trucks every 5 years, as well as the cost of treatment must still be added.

Table 21. Cost of transporting wastewater to Kakamas

Village	Households	litre/day/house	Volume/day (litres)	No. of trips/day	Distance (km)	Distance travelled/day (km)	Running cost/day	Annual cost
Alheit	183	156	28548	5	10	50	R838.61	R306 090.83
Augrabies	1198	156	186888	27	27	729	R12 226.86	R4 462 804.23
Cillie	375	156	58500	9	10	90	R1 509.49	R550 963.49
Lutzburg	322	156	50232	8	6	48	R805.06	R293 847.19
Marchand	579	156	90324	13	16	208	R3 488.60	R1 273 337.83
Sending	180	156	28080	5	58	290	R4 863.91	R1 775 326.79
Vredesvallei	120	156	18720	3	62	186	R3 119.61	R1 138 657.87
Totals			461292	66		**1601**	**R26 852.13**	**R9 801 028.22**

If the second option of just catering for the town of Kakamas, is considered, and several smaller decentralized wastewater treatment plants to cater for the villages and farms are selected, then the figures change considerably. The table below illustrates an approximation of plant sizes required to treat Kakamas and each of the villages' flows individually.

Table 22. Calculation of the WWTP size for individual villages

Town/Village	Population	Households	Per Capita Flow / day	ADWF (m^3/day)	PF (Harmon)	PDWF (m^3/day)	PWWF (m^3/day)	Plant Size Reqd
Kakamas proper	13949	2164	120	1673.873	2.810	4703.6	6377.4	1800
Alheit	3243	183	80	259.4035	3.413	885.5	1144.9	260
Marchand	5783	579	80	462.6769	3.186	1474.0	1936.7	470
Augrabies Village	6510	1198	80	520.8346	3.137	1633.8	2154.6	520
Augrabies Mission	316	29	80	25.27131	4.069	102.8	128.1	30
Cillie	3082	375	80	246.56	3.432	846.3	1092.9	250
Lutzburg	2540	322	80	203.193	3.503	711.7	914.9	200
Riemvasmaak (sending)	1015	178	80	81.19578	3.796	308.2	389.4	100
Farms	9251	2655	80	740.08	2.988	2211.5	2951.6	750

This table indicates that if a WWTP is required for Kakamas town only, a plant with capacity of only 2.00 Megalitres per day would be required.

The sizes of the various village WWTP's would vary between 100m³/day to 750m³/day. These flows, being well within the range where oxidation ponds and reedbeds, or a combination thereof could typically be used successfully.

It also means that at least seven (7) wastewater plants would need to be constructed in lieu of a single centralized plant in Kakamas.

This option does not totally negate the use of vacuum tanker trucks, but would significantly reduce the number of trucks needed, as well as shorten the distances considerably that the wastewater would need to be transported. Facilities could also be shared between villages that are not too far from one another, which would reduce the number of facilities required.

Therefore, to summarize, for this project the following two approaches where used:

Approach A:

- The construction of **a single, large capacity, centralized Wastewater Treatment Plant located at Kakamas with an expected treatment capacity of 4500m³/day.**

  This approach would mean that all wastewater from the villages and farms would still need to be transported by vacuum tanker truck over distances as high as 30km in one direction. All wastewater to be discharged to the Orange River after treatment.

Approach B:

- The construction of a smaller 2 0**00m³/day wastewater treatment plant at Kakamas**, which would cater only for the towns' current and future needs. Again, all Treated Effluent to be discharged to the Orange River.

  Then the construction of, say 4, smaller decentralized wastewater treatment plants as follows:

- A single **450m³/day WWTP north of Kakamas to serve Lutzburg and Cillie villages**. Space at the Lutzburg commonage is limited, while Cillie village has plenty of space available. Lutzburg and Cillie are 6.5km apart, and could share a facility. This water could be partially re-used for the irrigation of sports fields, and the remainder discharged to the Orange River;

- A single **800m³/day WWTP at either Alheit or Marchand village**, to treat the wastewater from both villages. These two villages are 5km apart. There is space on municipal land at either of the two villages. Treated Effluent could again be partially used for irrigation of sports fields, with the remainder either discharged to the Orange River, or alternatively to the Hartbees River if constructed at Alheit;

- **Augrabies Village is large, and would need a plant of at least 500m³/day.** If allowance is made to also treat 75% of the farms' sewage at Augrabies, then a plant of at least 1000m³/day would be required. This would then cater for dealing with farm sewage from 5km to the south-east and 10km north-west of Augrabies Village. At Augrabies, there is also potential for sports field irrigation at both communal and school sports fields. Any remaining Treated Effluent to be discharged to the Orange River;

- **Riemvasmaak would require a 250m³/day stand-alone plant to serve both Vredesvallei and the Mission villages.** Unfortunately, the road between these two villages is a rough gravel road, over fairly difficult terrain, which would wreak havoc on a trucks' suspension. These two villages are 15km apart. **The other option would be to construct a 100m³/day plant at Riemvasmaak Mission Village and another 150m³/day plant at Vredesvallei village.** Both villages at Riemvasmaak also have sports fields, which could be used to dispose of effluent by means of irrigation.

It must again be stressed, that neither Kakamas, nor any of the villages are fully reticulated with waterborne sewage systems. This means that wastewater will still need to be transported from the individual household conservancy tanks to the various wastewater treatment plants. Kakamas is about 60% reticulated, but even there, trucks will still be needed. This was taken into account as an operational cost for each facility.

Given the above, it is now required that various technologies for treatment be considered.

6 ASSESSMENT OF BIOLOGICAL LOAD

Sewage characteristics can be divided into four main categories:

- concentration of oxidizable organic material, or substrate,
- concentration of nutrients present
- solids concentration.
- pH and alkalinity value

The concentration of oxidizable material is normally expressed as an oxygen demand and is a measure of the strength of the sewage.

The nutrients generally refer to nitrogen and phosphorus present, and is a measure of the propensity for the treated effluent to give rise to eutrophication (algal growth) downstream from the works.

The solids concentration is an indicator of the relative amount of sludge likely to be produced, and the alkalinity needs to be adequate to sustain full nitrification (oxidation of ammonia to nitrate).

A set of grab samples was taken at the Kakamas WWTP on 16th June 2018 and sent for basic analysis at AL Abbott & Associates analytical laboratory in Cape Town. Samples were taken as follows:

- Raw Sewage sample at the Inlet
- Outlet of Anaerobic Ponds 1 & 2
- Outlet of Pond 3
- Outlet of Pond 4
- Outlet of Pond 6
- Final Effluent at outlet of Pond 8

Table 23. Summary of water analysis results – Kakamas WWTP

Parameter	Outlet of ponds in mg/l							Gen. Limit Values
Identifier	Raw Sewage	Ponds 1 & 2	Pond 3	Pond 4	Pond 5	Pond 6	Pond 7	
Cond mS/m	77.4	104	83.5	94.1	80.5	86.3	82	Max. 70mS/m above Intake
pH	6.96	7.36	7.2	6.92	7.41	7.42	7.51	6.5 - 9.5
COD (mg/l)	3013	1578	634	413	302	189	97.9	<75mg/l
TKN (mg/l)	98.8	136	98.8	40.8	196	134	99	NA
NH_4 (mg/l as N)	96	113	96	21	191	129	249	<6 mg/l
Ortho-P (mg/l as P)	29.5	8.9	10.5	2.6	23.3	15.5	26.2	<10 mg/l
Tot P (mg/l as P)	36.6	14.4	11.9	8.8	26.6	17.1	29.6	
Fecal coliform count (/100ml)		>2419	>2419	>2419	>2419	>2419	>2419	<1000
Oil & grease (mg/l)	156	96	156	20	36	244	24	2.5 mg/l
Tot Susp Solids (mg/l)	2018	354	229	106	78	66	25	<25 mg/l

The results of these samples subsequently provided a good indication of what was going on in the plant as well as what the expected chemical load received at the plant could be.

The Raw Sewage had an extremely high COD concentration, which is probably due to the fact that the raw sewage is mostly from conservancy tanks, and subsequently would have a high COD concentration if the retention time in these tanks was low. Further to the above, the wastewater from the trucks, is a mix of wastewater from many different origins. Similarly, the Total Kjeldahl Nitrogen and the Ammonia concentrations were also extremely high.

The Final Effluent from the ponds was slightly better than the raw sewage received, but given the high volumes of wastewater, very high organic and nutrient concentrations, it is no surprise that the existing oxidation ponds are performing very very poorly. **There is not a single parameter that complies with the General Limits.**

From these analysis results, the following loads could be calculated:

6.1 Organic Load

The organic load, or carbonaceous fraction of the waste in the wastewater is measured using either the Biological Oxygen Demand (BOD_5) or the Chemical Oxygen Demand (COD) in mg/l. For the Kakamas WWTP, this was determined to be 3 013 mg/l COD. Typical domestic sewage should be anything between 400mg/l and 700mg/l, but typically is in the order of 650mg/l. Subsequently, the result for Kakamas WWTP raw sewage is considered very high. Using this value, the Organic load is calculated as:

Flow x COD concentration = load in kg/day

For Kakamas the values are as follows:

COD: ***10 141.8 kg/day***

The industry standard for the COD value per person is typically in the order of 100 to 160g per person per day. If one takes a value of say 100g/person per day, and multiply it with the population of 42 080 persons residing in Kakamas, a value of only 4 208kg/day is calculated. This is again an indication that the incoming wastewater is highly concentrated. Typically, a COD value of 650mg/l, would return an Organic Load of **say 2 187.9 kg/day**, which is an acceptable value for domestic wastewater.

6.2 Nutrient Load

The most significant nutrients in sewage treatment processes are nitrogen and phosphorus. Phosphorus is usually the limiting nutrient when effluents are discharged to a watercourse, and its presence leads to the growth of benthic algae in rivers. This phenomenon is known as eutrophication. Certain species of algae can be toxic to livestock. The discharge of phosphorus concentration is therefore limited in certain catchments.

High nitrogen concentrations are also limited, as there is a General Authorization limit on ammonia and nitrate concentrations in discharges. High concentrations of nitrate are harmful when consumed by infants, which is a consideration when there is further abstraction downstream of a wastewater plant. Ammonia is toxic to various aquatic organisms, including many species of fish. Nitrogen concentration is generally determined as Total Kjeldahl Nitrogen (TKN) which measures the sum of the free ammonia and ionized ammonium concentrations, as well as organic nitrogen concentrations.

The raw sewage at Kakamas contains the following concentrations:

COD:	3 013 mg/l
TKN:	98.8 mg/l
Ammonia	96.0 mg/l
Phosphorous:	36.6 mg/l

From these, a daily load is again calculated for each parameter as follows:

COD:	***10 141.8 kg/day***
TKN:	***332.6 kg/day total Nitrogen***
NH4:	***323.1 kg/day Ammonia***
P:	***123.2 kg/day Phosphorous***

6.3 Wastewater Characterization

In order to characterize the wastewater, the ratios of the various constituents are compared as follows:

COD : BOD	***2.029***
TKN : COD	***0.033***
NH4 : COD	***0.032***
Ortho.P : COD	***0.009***

The C: N : P ratio of domestic wastewater is usually in the range of 100 : 10 : 1 to 100 : 5 : 1. For the Kakamas WWTP, the raw sewage, the ratios are:

COD	:	N	:	Orth P
10 141.8	***:***	332.6	:	36.6
277	***:***	***9.08***	***:***	***1***
100	***:***	***3.27***	***:***	***0.36***

From this comparison, it is clear that we are still dealing with **a wastewater that is primarily domestic in nature**, but that the nutrient content is slightly below that which is normally encountered. Low nutrient content could cause problems in an activated sludge process, as a certain amount of nutrients are needed to sustain the bacterial population in the process. If the COD : P ratio is not favorable, then phosphorous cannot be removed biologically. In this case, we do not have this problem.

7 TREATMENT OPTIONS CONSIDERED

The past 15 years has seen a rapid decline in especially the technical capacity of rural municipalities. This decline has led to a severe shortage of mechanical and electrical maintenance personnel as well as trained and experienced operational personnel. For this reason, it is suggested that so-called **low-tech technologies** are promoted for installations such as required at Kakamas and surrounding villages as far as possible.

The primary consideration that influences the decision as to which treatment process to engineer is based on economics, treatment robustness and environmental awareness.

Treatment robustness reflects the systems' inherent capacity to respond to wastewater volume and quality input variations. This has a direct bearing on the consistency of the treated wastewater quality.

The choice of technology/treatment option is to be guided by the following:

- Quality of Treated Effluent required (i.e., Irrigation standard, General Limit, Special Limit) with respect to Water Resource Quality Objectives (WRQO) as adjusted by the Department Water & Sanitation from time to time.
- Available land area/space available for construction (high technology = small footprint and vice versa)
- Technical capability of the institution that will operate the treatment plant
- Ability to conduct preventative maintenance on installations
- Cost of energy for operations and energy efficiency

In addition to the above, the South African Water Research Commission (WRC) published a report in 2015 with the title: "***Wastewater Treatment Technologies – A Basic Guide***" (WRC Report No.TT 651/15).

This WRC report describes the available technologies, and also includes a Decision-Making Tool that can be used to guide a designer in his choice of technology. This is not a cut and dry selection, and the designer should always apply his mind, to ensure that he is making the correct choice for the specific Client, and his specific conditions and abilities. This tool uses the population size as basis for the initial decision making.

Biological based treatment systems (as opposed to chemical and or physical based treatment systems) are ideal to improve the quality of nutrient rich wastewater. Metabolic activities exchange nutrients in wastewater for bacterial cells, separating contaminants from wastewater in the process. Separation of bacterial cells from wastewater is readily attained by filtration and or sedimentation. The self-sustaining metabolic activities associated with microscopic life effect basically unattended operation.

Distinction must be made between what are known as "natural" treatment systems and what are known as "conventional" systems. Both types utilize biological processes, but in natural systems, the operator has very little control or ability to manipulate the process in any manner. Natural systems are dependent on climatic factors such as temperature, sunlight and time, and as such, normally have much larger footprints than conventional systems. Examples of "natural" systems include oxidation ponds and constructed wetlands or reed bed treatment systems.

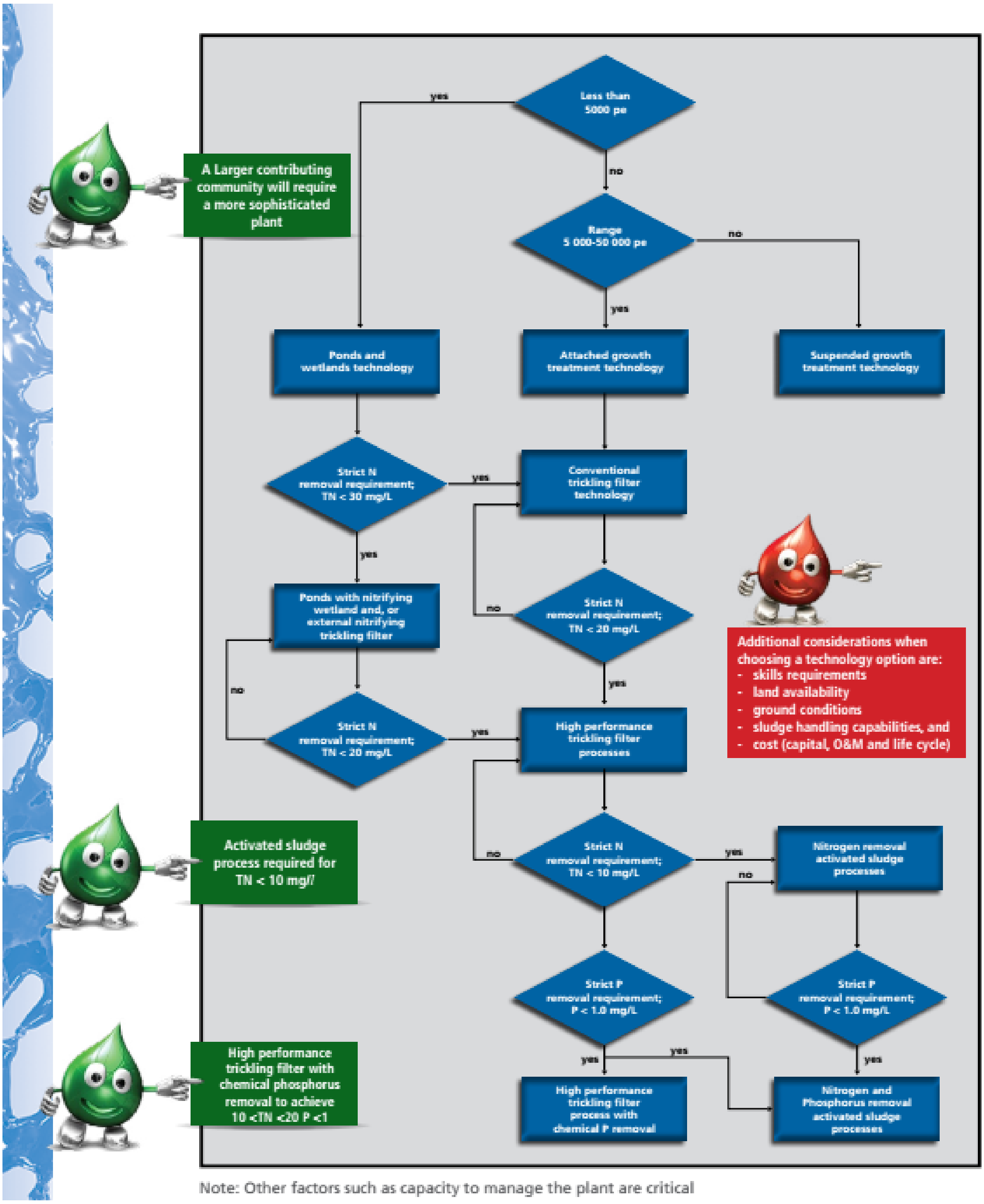


Figure 17. Decision Making Tool from WRC Report TT

Conventional systems on the other hand use mechanical means to introduce energy and oxygen to the process, and usually have a decreased footprint, as the biological processes are artificially accelerated and subsequently can take place in smaller volumes. The downside of conventional systems is that they employ a higher degree of technology, and as such require specialized mechanical and electrical maintenance on a constant basis, to ensure successful operation.

Accordingly, the following options were investigated for Kakamas wastewater treatment:

- Activated Sludge
- Aerated Facultative Ponds and Maturation Ponds
- Anaerobic Ponds followed by conventional Facultative and Maturation Ponds
- Attached growth Biological Filtration process (Rotating Biological Contactors)

Each of the above is described briefly in terms of the processes involved, technical complexity, land requirement, capital, operation and maintenance.

7.1 Activated Sludge Wastewater Treatment

Activated sludge (AS) is a process dealing with the treatment of sewage and industrial wastewaters. There is a large variety of design, however, in principle all AS consist of three main components:

- An inlet works comprising screening, grit removal and flow measurement;
- an aeration tank, which serves as a biological reactor;
- a settling tank or clarifier for separation of the biomass from the treated water;
- a return activated sludge system, usually comprising a pump of some form, to transfer settled biomass from the clarifier back to the aeration tank inlet.

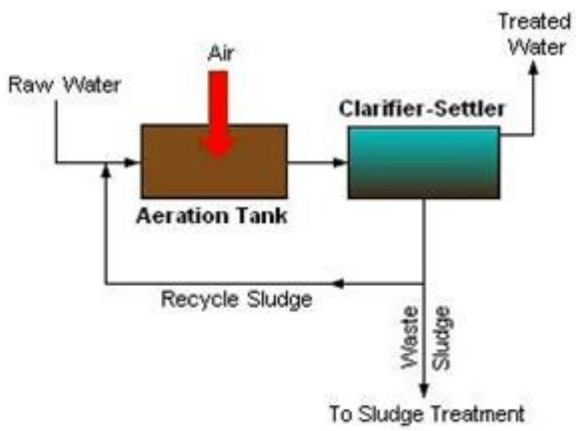


Figure 18. Typical Activated Sludge process flow diagram

Atmospheric air is introduced to a mixture of screened sewage combined with naturally occurring micro-organisms to develop a biological floc, known as "Activated Sludge" (AS). The mixture of raw sewage and biological mass is commonly known as Mixed Liquor.

With all activated sludge plants, the concentration of biodegradable components present in the influent is reduced due to biological (and sometimes chemical) processes in the aeration tank. The removal efficiency is controlled by different boundary conditions, e.g.:

- the hydraulic residence time (HRT) in the aeration tank, which is defined by aeration tank volume.
- Influent load (COD, Nitrogen, Phosphates) in relation to the activated sludge solids present in the aeration tank
- Available food for the micro-organisms (F:M Ratio),
- oxygen supply,
- temperature.

At the outlet of the aeration tank, mixed liquor is discharged into settlers or clarifiers and the supernatant, or treated waste water, is then disinfected and run off to be discharged to a natural water course, or to undergo further treatment before discharge.

The settled biomass in the clarifier is then returned to the inlet of the aeration tank (known as Return Activated Sludge) to re-seed the incoming raw sewage entering the tank, and to ensure the desired concentration of active biomass in the aeration tank.

Due to exponential biological growth, and other non-biodegradable solids present in the raw waste water, which are only partly degraded, excess sludge eventually accumulates beyond the desired concentration in the aeration tank.

This excess concentration of solids, known as Waste Activated Sludge (WAS) is then removed from the treatment process to keep the ratio of biomass to food supplied (in the form of sewage or wastewater) in balance, and the F:M ratio in a defined range.

Waste Activated Sludge is stored and treated separate from the main treatment process. Depending on the constituents thereof, it could be treated further by digestion, or if aerobic in nature, simply thickened, dried and disposed of.

Depending on the requirements of the receiving environment, an activated sludge configuration is selected and designed to remove the carbonaceous fraction, the nitrogen fraction and the phosphate fraction occurring in the raw wastewater. If all 3 fractions are to be removed, the plant is termed a Biological Nutrient Removal wastewater plant.

There are many different configurations of the activated sludge process, ranging from basic oxidation ditch configuration to very complex Fine Bubble Diffused Aeration systems.

The following process configurations are most common in South Africa:

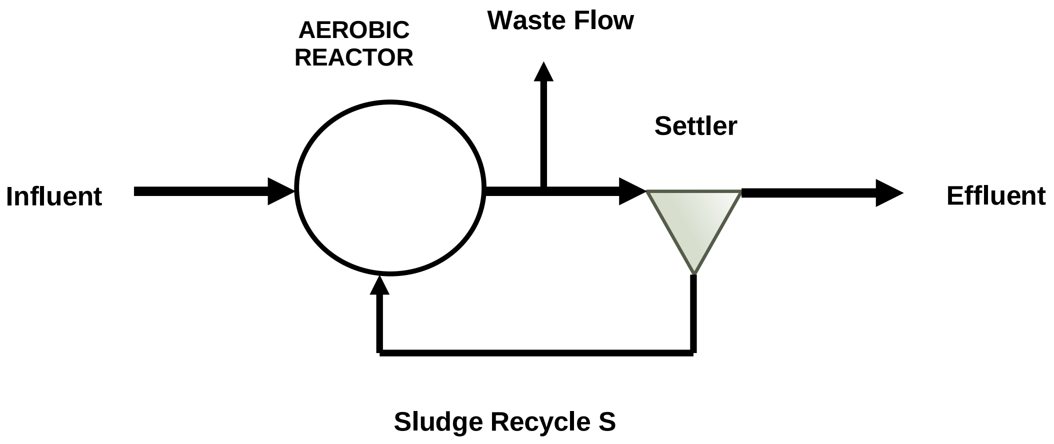


Figure 19. Basic Activated Sludge process

The basic process has the ability to convert Ammonia to Nitrate and Nitrite, but cannot completely remove the nitrogen from the stream. Similarly, the ability to remove phosphates is very limited.

The modified Ludzack-Ettinger process, or MLE process is a variation on the standard process, designed to be able to remove nitrogen by addition of an Anoxic Zone.

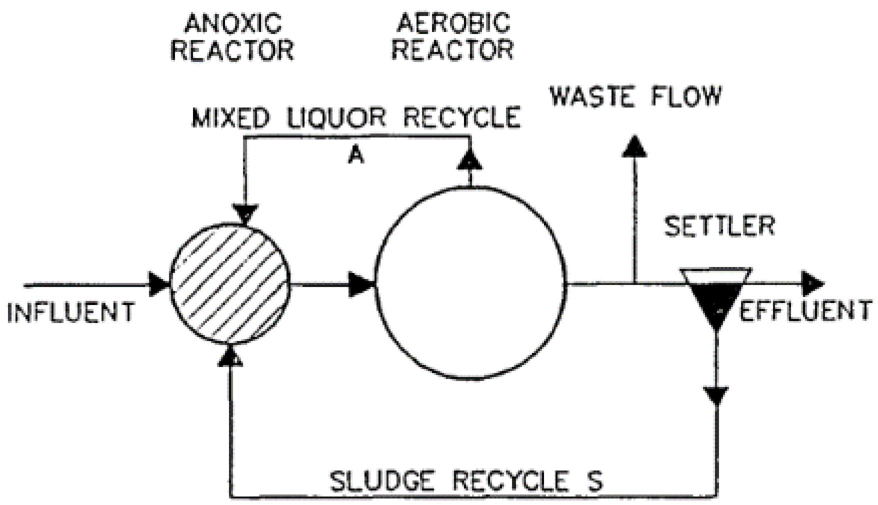


Figure 20. Modified Ludzack-Ettinger AS process

This process nitrifies the Ammonia, and then recycles the Nitrate-rich water back to the Anoxic Zone known as the A-Recycle, which is deficient of free available oxygen. Ammonia is written as NH_4. When ammonia is exposed to free oxygen, O_2, the ammonia is converted to Nitrite (NO_2) and Nitrate (NO_3), which contains "bound" oxygen. The bacteria in the anoxic zone then utilize the bound oxygen in the nitrate molecule, and the nitrogen is released to atmosphere as a gas, and subsequently removed from the stream.

The third commonly found variation, is known as the UCT process. The process was developed by the University of Cape Town, as a modification to the basic Ludzack-Ettinger process. It was designed to facilitate biological removal of phosphates, by the addition of an anaerobic zone ahead of the Anoxic Zone as described below.

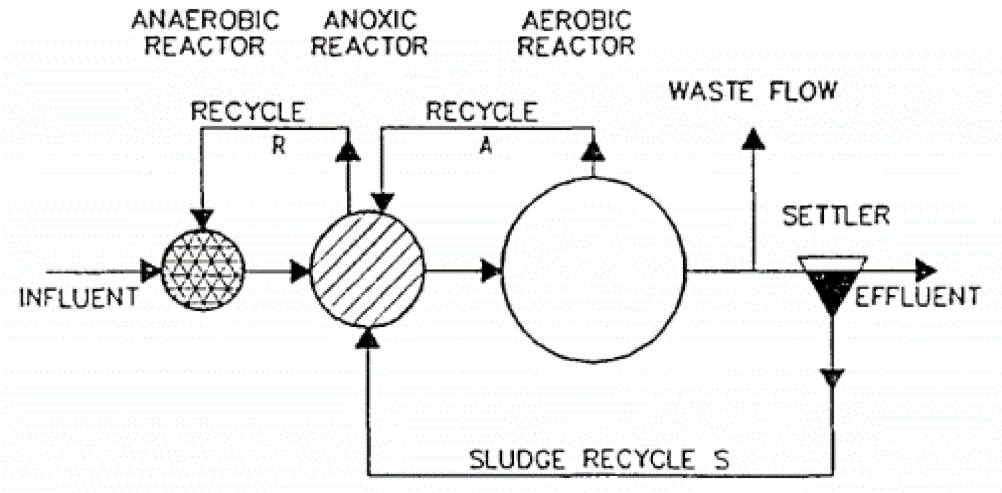


Figure 21. UCT process for biological nitrogen and phosphorus removal

Phosphorous, or P removal occurs due to the ability of certain micro-organisms to accumulate large quantities of polyphosphate (Poly-P) within the cellular mass. In an Activated Sludge plant, one therefore creates conditions which are favourable for these specific micro-organisms to flourish. Therefore, in order to create conditions needed for both Poly-P as well as non-Poly-P organisms, a wastewater plant will need an aerobic zone, an anoxic zone, as well as an anaerobic zone.

An Anaerobic Zone, is defined as a zone in which the contents are kept deficient of dissolved oxygen and nitrates, while an Anoxic Zone, still contains the bound oxygen found in nitrates. The Anaerobic Zone is fundamental to the removal of P.

Short Chain Fatty Acids (SCFA), are generated in the Anaerobic reactor by non-Poly-P organisms, acting on the Readily Biodegradable carbonaceous fraction of the incoming raw sewage.

Under anaerobic conditions, and in the presence of Short Chain Fatty Acids (SCFA), the Poly-P organisms, hydrolyse stored polyphosphate, which in turn, releases ortho-phosphates to the surrounding liquid. The energy released in this process, is utilized by the Poly-P organisms to absorb, process and store the SCFA within the organism. This is then reserved for use by the Poly-P organisms when they enter the anoxic and aerobic zones downstream.

Once entering the aerobic environment, the Poly-P organisms utilize the stored SCFA for growth and multiplication, by abstracting ortho-phosphate from the surrounding liquid. This phenomenon is known as excess P uptake, which occurs in aerobic environments.

To achieve the above, a third Recycle Stream is required to recycle liquid from the Anoxic Zone back to the Anaerobic Zone, again mostly using pumps. Care must be taken to operate the Anoxic Zone at optimum, to avoid any nitrates or dissolved oxygen from entering the Anaerobic Zone. The latter requires constant care and monitoring by operational personnel. Phosphorous, can also be removed chemically by the addition of metal salts, but is not dealt with further in this chapter.

These are the basic configurations for the treatment of wastewater using activated sludge. The processes that are utilized, are essentially process that occur naturally in the environment. In the AS wastewater treatment plant, various environments are artificially created, in which the various bacteria which remove the impurities, can thrive. This is done by adding energy in the form of mixers, and oxygen in the form of aeration, or by creating zones depleted of oxygen, in order to "activate" or enhance the workings of these natural processes.

The current unit cost of an Activated Sludge Wastewater Treatment Plant is now in the order of R18 000 000-00 per Megalitre of treatment capacity. This does come down a little when constructing large plants, due to the economy of scale.

Activated Sludge plants have quite high electrical energy requirements due to firstly the Aeration system, which requires approximately 3 to 4W per m^3 for mixing and 10 to 12W per m^3 for aeration purposes. The three are the recycle pumps for the S-recycle, A-recycle and the R-recycle streams. All of these equipment items operate for 24 hours per day, hence, a high energy requirement.

Activated sludge plants are however the only solution if a very high quality of Final Treated Effluent is required on a constant basis.

7.2 Conventional Oxidation Ponds

Waste Stabilization Ponds, or commonly known as Oxidation Ponds are large, lined shallow basins enclosed by earthen embankments, in which raw sewage is treated by natural processes involving both algae and bacteria. Because of the use of natural processes, the rate of oxidation is slow and as a result, long hydraulic retention times are employed, retentions of 40 to 55 days being normal.

Ponds have considerable advantages, particularly regarding costs and maintenance requirements and the adequate removal of faecal bacteria, over other methods of treating the sewage from communities of more than about 100 people. Ponds are the most important method of sewage treatment in hot climates, where sufficient land is normally available, and where the temperature is most favourable for their operation.

There are three major types of ponds relying on natural processes:

1. Facultative ponds;

2. Aerobic ponds or maturation ponds; and

3. Anaerobic ponds

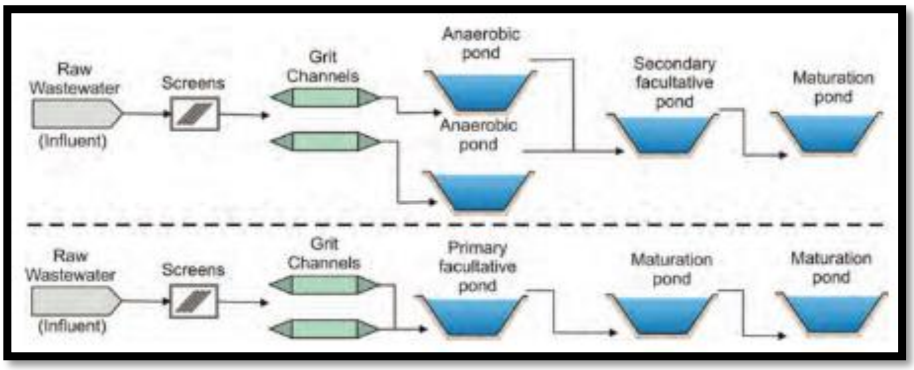


Figure 22. Typical pond system configurations used in South Africa

Ponds can be used singly or in various combinations to treat wastewater. Experience has shown that a combination of various types of ponds in series is best for the treatment of domestic wastewater.

Anaerobic ponds are especially effective in bringing about rapid stabilization of waste that is high in organic content, while aerobic ponds are more suited to stabilising the soluble organic component. Anaerobic ponds are usually used in series with the other types, enabling almost complete stabilization of the effluent.

Limitations of Oxidation Pond Systems

Compared to conventional treatment plants, ponds produce **a stable effluent that does not usually comply with the General Limit Values** as required by law, due to the excessive quantity of suspended solids in the final effluent. These suspended solids are primarily due to the nature of oxidation ponds which utilize algal photosynthesis to provide the oxygen required in the process.

What does the Algae do?

Algae are essentially plants, that utilize carbon dioxide, and nutrients in the waste water and sunlight to produce sugars and oxygen through photosynthesis. The problem with algae is that they have a neutral density. This means that both live and dead algae do not settle to the floor of the pond, nor does it float to the surface, it basically remains in suspension in a uniform concentration through the water profile in the ponds.

Problem with Total Suspended Solids in Oxidation Pond effluent

Although the algae are essential for the production of dissolved oxygen to nitrify ammonia and break down the organic fraction, they do however create a problem with suspended solids in the final effluent. The General Limit Value for Total Suspended Solids in Final Treated Effluent is 25mg/l. Typically oxidation pond effluent will not comply to this requirement. Hence the requirement for further treatment to ensure compliance.

Temperature dependence of bacterial and algal metabolism

Oxidation Ponds typically have a retention period varying between 40 to 55 days, in order to provide sufficient retention time for natural bacteria to oxidise and stabilize the pollutants in the water. Typically, the metabolism of the active bacteria and algae are temperature dependent. The higher the water temperature, the more active the metabolism of the bacteria, and vice versa. Subsequently, the lowest average ambient temperature of the area where the ponds are to be constructed, dictates the size of ponds and by implication, the retention time needed to fully treat the wastewater. Oxidation Ponds are therefore less active during periods of low temperature, and more active during periods of warm temperature.

A hot climate is ideal for pond operation. Solar radiation is intense and as a result, pond temperatures are high and there is more than an adequate intensity of light. The long daylight hours enable algal photosynthesis to occur for extended periods and so provide a reserve of dissolved oxygen for use during the night.

The effluent from pond systems is often irrigated, which is a highly suitable disposal route. If the system is carefully designed, a pond system effluent would be preferable in many cases to an effluent from a mechanical plant that is not well operated.

Facultative Ponds

Facultative ponds are the most commonly constructed type of pond. They normally receive raw sewage or sewage that which has received only preliminary treatment. The term 'facultative' refers to a mixture of aerobic and anaerobic conditions, and in a facultative pond aerobic conditions are maintained in the upper layers, while anaerobic conditions exist towards the bottom. Although some of the oxygen required to keep the upper layers aerobic comes from re-aeration through the surface, most of it is supplied by the photosynthetic activity of the algae that grow naturally in the pond, where considerable quantities of both nutrients and incident light energy are available. So profuse is the growth of algae, that the pond content is often green in colour. The pond bacteria utilise this 'algal' oxygen to oxidise the organic waste matter. One of the major end-products of bacterial metabolism, is carbon dioxide, which is readily utilised by the algae during photosynthesis, as their demand for it exceeds its supply from the atmosphere. Thus, there is an association of mutual benefit ('symbiosis') between the algae and bacteria in the pond. Since photosynthesis is a light-dependent activity there is a diurnal variation in the amount of dissolved oxygen present in the pond, and a similar fluctuation in the level of the 'oxypause' (the point below the surface at which the dissolved oxygen concentration becomes zero) occurs.

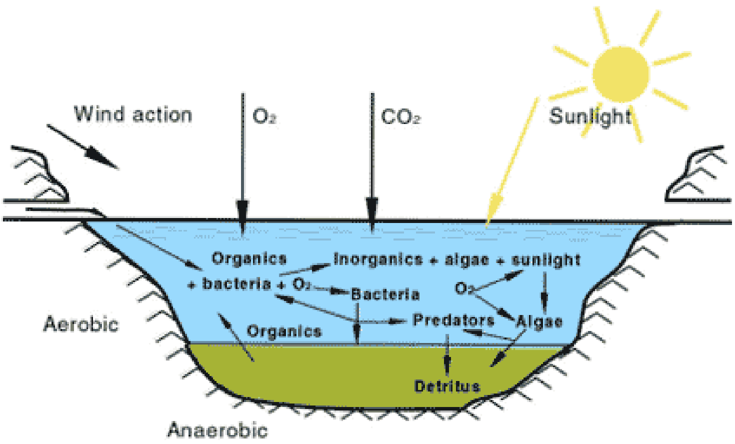


Figure 23. Typical processes in a facultative pond

Mixing

Wind and heat are the two factors of major importance which influence the degree of mixing that occurs within a pond. Mixing fulfils a number of vital functions in a pond:

- it minimises hydraulic short-circuiting and the formation of stagnant regions;
- it ensures a reasonably uniform vertical distribution of COD, algae and oxygen.

Mixing is the only means by which the large numbers of non-motile algae can be carried up into the zone of effective light penetration (the 'photic' zone). Since the photic zone comprises only the top 150 to 300 mm of the pond, much of the pond contents would remain in permanent darkness, if mixing did not occur. Mixing is also responsible for the conveyance of the oxygen produced in the photic zone, to the deeper layers of the pond. Efficient mixing therefore increases the safe organic load that can be applied to a pond.

Sludge Layer

As the sewage enters the pond, most of the solids settle to the bottom to form a sludge layer. At temperatures greater than 15°C, intense anaerobic digestion of the sludge solids occurs; as a result, the thickness of the sludge layer depth is seldom more than 250 mm. Desludging is rarely required, maybe once every 10 to 15 years. At water temperatures greater than 22°C, the production of methane gas is often sufficient to float sludge particles to the surface, where drifting sludge mats are formed. These must be removed so that they do not prevent the penetration of light into the photic zone. The soluble products of fermentation diffuse into the liquid of the pond where they are oxidised further.

7.3 Aerated Ponds

Aerated ponds are mechanically aerated wastewater treatment ponds. These are completely mixed process units, utilising either surface-type aerators, submerged propeller, or turbine-type aerators.

The principal source of oxygen is therefore from mechanical aeration rather than by algal photosynthesis. Depending on the configuration, the purifying organisms which develop in an aerated pond are similar to those found in an activated sludge process. Mechanical aeration could also be used to optimize a Facultative Pond by the addition of oxygen and controlled mixing of the contents.

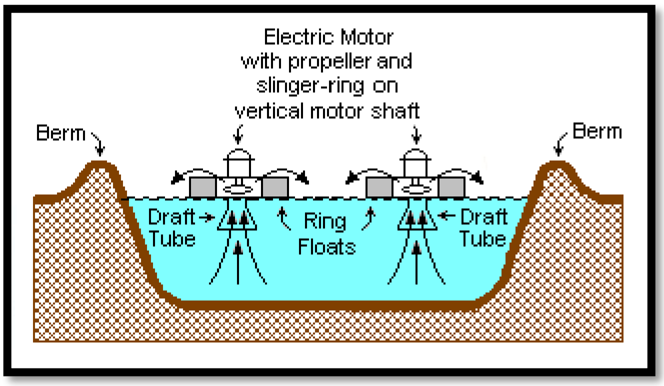


Figure 24. Diagram of floating aerators on a pond

The solids carry-over from an aerated pond must be removed by a clarification process following its treatment in the aerated pond. This is usually achieved by passing the effluent into one or more downstream maturation ponds.

The advantage of using an aerated lagoon over a natural primary pond is that a much smaller ponds will be required, as the process is accelerated by mechanical aeration, and therefore requires a shorter retention period. A typical unaerated facultative pond in South Africa typically has an effective oxygenation capacity of 120 to 180 kg/d.ha. The same amount of oxygen could be supplied by a mechanical surface aerator of about 7 kW. The size of the primary pond would then be governed by COD or BOD removal kinetics rather than natural oxygen dissolution rates.

A pond system is an attractive treatment option in a semi-rural environment, and it may be worth considering an aerated pond as primary treatment, particularly if sufficient suitable land is unavailable, or if the use of conventional pond systems become too large due to the population that they need to serve.

Aerated Facultative Ponds

BVi have come across a proprietary system developed in the United Kingdom, which uses Medium Bubble Diffused Aeration and a low-speed mixer with a gentle action, to optimize the natural process in a Facultative Pond. The system has been developed and designed by the company Gurney Environmental.

Typically, the system comprises a relatively deep earthen pond, which should be lined by an HDPE lining, as one would construct a normal oxidation pond. The use of Medium Bubble Diffused Aeration, however allows the pond depth to be increased to 5.0m. This means that the pond area could be considerably reduced.

Figure 25. Example of an Aerated Facultative Pond system

Mixing and Aeration in aerated facultative pond systems

The mixers/aerators are primarily wind-powered, and fitted with an auxiliary electrical motor of 0.5kW, which powers the mixer if the wind velocity drops to below 7 km/h. The action of the mixer is such, that it does not disturb the sludge layer found on the bottom of the facultative pond, but serves to oxygenate the total water depth above the sludge layer. If compared to a regular unaerated facultative pond, where the aerobic layer is seldom more van 250mm deep, this system achieves an aerobic layer of 2 to 3m deep, which greatly enhances the treatment capacity of the pond.

Figure 26. Wind-powered aerator/mixer

Diffused Air aeration system

In addition to the mixers, a stainless-steel diffuser system is place inside the facultative pond across the width of the pond. This system produces millions of air bubbles, which augment the dissolved oxygen levels within the pond to deal with the oxygen demand of the incoming raw wastewater. The air source for the diffused air aeration system is done by means of a low -pressure centrifugal fan, in lieu of a blower. This allows the use of a much smaller electrical motor, and a subsequent saving in energy.

Further to the above, the system utilizes a computer controlled dissolved oxygen control system. Several Dissolved Oxygen (DO) sensors are placed inside the pond to monitor the DO levels. For normal operation, sufficient DO will be introduced into the water by means of algal photosynthesis and the wind-powered mixers to maintain the DO level at 1.5 to 2.0mg/l, which will maintain aerobic conditions.

Figure 27. Installation of a Diffused Air aeration system in a pond

As soon as any raw sewage enters the pond, the Chemical Oxygen Demand of the raw sewage, will consume the available dissolved oxygen, causing the level to drop. Once this happens, the Diffused Aeration system will start up, and add the additional oxygen required to again achieve full aerobic conditions within the pond. In this manner, all organic matter entering the pond will be oxidised. When the oxygen requirements are being met naturally through photosynthetic activity, wind action and re-aeration supplemented by the wind/electric aerator/mixers, the diffused air system will automatically shut off; when the oxygen requirements increase, the diffused air system will automatically turn on. The auxiliary 0.5 kW electric motors are also activated automatically, based on wind speeds. These automatic operations not only reduce the onsite manpower requirements, but also maximise the energy savings of the system.

Algal uptake and nitrification-denitrification are the two main mechanisms dominating nitrogen removal in ponds. Under unfavourable conditions for algal growth, ammonium nitrogen would be mainly transformed into oxidised nitrogen species, and then permanently removed via the denitrification process. When conditions are more favourable for phytoplanktonic activity, ammonium nitrogen is predominantly, and more efficiently, removed by algal uptake simultaneous with the nitrification-denitrification process.

Given that an Aerated Facultative Pond system is a hybrid between an Activated Sludge WWTP and a conventional pond system, BVi is of opinion that this may be a feasible alternative for Kakamas. Such a system would have the benefits of relatively low construction cost, simple operation, and yet still have the ability to meet the requirements of the General Limit values.

An aerated facultative pond system for Kakamas would comprise the following:

- Conventional Inlet works with screens, grit removal and flow measurement;
- Two Aerated Facultative Ponds c/w six (6) wind-powered Aerator/Mixers and a Medium Bubble Diffuser supplied with a centrifugal fan for each pond.
- The facultative ponds would be followed by a series of three (3) maturation ponds downstream to ensure bacterial die-off.
- A conventional Chlorine contact tank, utilizing a Calcium Hypochlorite dosing system prior to discharge to the Orange River.

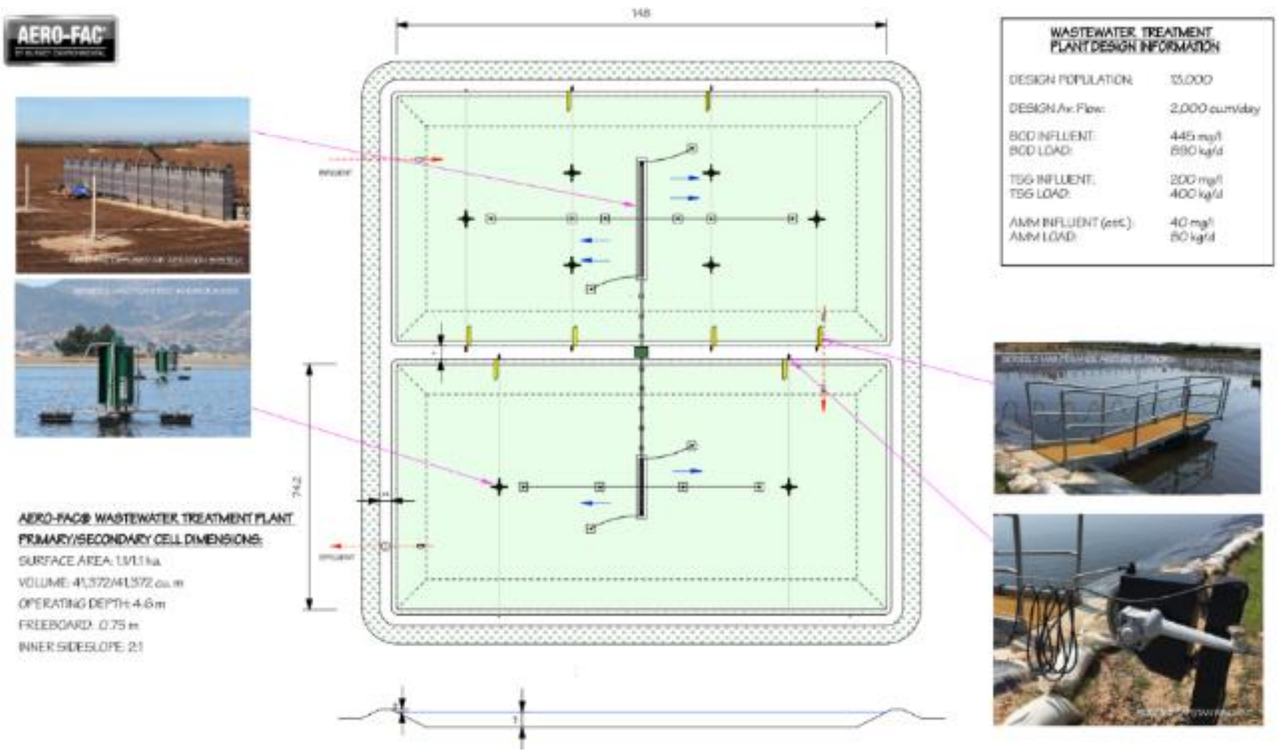


Figure 28. Proposed Aerated Facultative Pond layout for Kakamas WWTP

7.4 Rotating Biological Contactors

Rotating Biological Contactor or “rotating disc system” was developed in West Germany during the 1960’s for the biological treatment of domestic wastewater. Since then, hundreds of systems have been commissioned all over the world. The Rotating Biological Contactor (RBC) belongs to the family of aerobic biological attached-growth (fixed film) wastewater treatment systems. The RBC may also be referred to as a Rotating Disc Process, Rotating Biological Filter and Rotating Biological Surfaces.

The process/technology is based on circular corrugated/cupped high-density polyethylene disks (typically between 1 and 3 m in diameter) that are centre stacked. The stacked disks are then partially immersed in wastewater.

The shaft is mechanically rotated, allowing disks to revolve through untreated wastewater, bringing bacterial growth on the disks, in contact with untreated wastewater. Continuous rotation of disks through wastewater allows for intermittent exposure of bacterial biofilms to nutrients in the wastewater and oxygen in the air.

The vitality of the system rests on the prolonged microbial metabolic processes. Variations in wastewater composition has an influence on microbial activity and therefore effluent quality. Wastewater composition is of significant importance in engineering the size, number, and staging and rotation speeds of the disks. Like most wastewater treatment unit processes, a maintained system accomplishes the reduction of nutrient loads in domestic wastewater.

The treatment train would consist of primary sedimentation and anaerobic digestion (typically a septic tank with at least 48 hours retention time), primary reactors (rotating discs), followed by sedimentation to separate the biomass (humus) from the treated water. Conventional chlorination is then used for disinfection of the water and destruction of pathogens.

The septic tank serves to remove, retain and partially stabilise floatable and settleable solids introduced with the raw sewage and humus sludge. The latter is removed from the RBC effluent in the final sedimentation tank, and is normally returned to the septic tank. The return of humus sludge may result in limited denitrification. This can be further stimulated by recycling of the effluent from the final sedimentation tank to the septic tank by increasing the underflow rate, and also generally improves the treatment efficiency. If sufficiently conservatively designed the effluent after chlorination generally complies with the General Authorisation limits.

The process is illustrated in Figure 2 below.

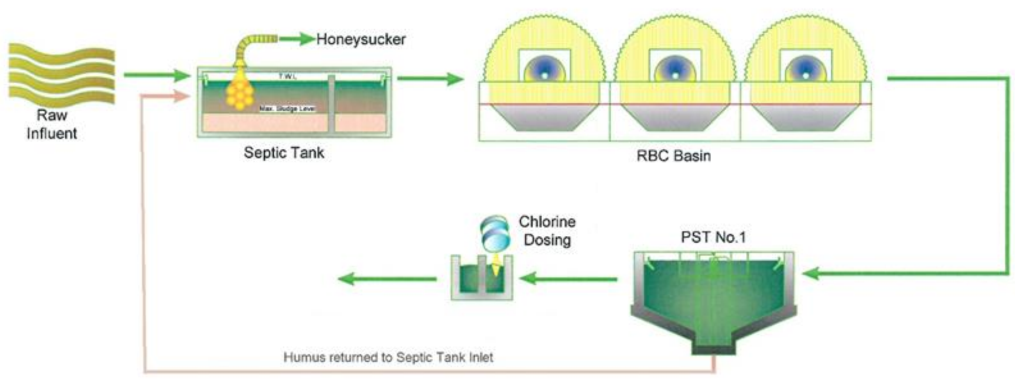


Figure 29. Typical process flow diagram for Rotating Biological Contactor plant

Rotating biological contactor plants are imminently suitable for small plants up to 500 m^3/day. They are used everywhere in South Africa where small installations are required with a relatively small footprint. Typically, the septic tank, bio rotor basin and humus tank are constructed from reinforced concrete. The Septic tank size is usually the major portion of the footprint.

RBC plants are easy to operate, typically, the primary operational activity being to desludge the humus tank a few times a day, and to top up the disinfection chemicals.

In terms of maintenance, RBC plants do require an electrician and a mechanical fitter from time to time to maintain the small electrical motors and gearboxes that power the Rotating discs. These are normally very small motors, seldom exceeding 0.5kW.

Typically, a disc area of 6 – 7m^2/person is required, when working at a load of 60mg BOD5 per person per day.

Advantages of the RBC WWTP system:

- Suited to high volume – low strength raw sewage
- Has a relatively small footprint for its rated treatment capacity
- Relatively small energy requirement, very few electrical components
- Provides a good quality effluent that complies with General Limit values if not overloaded.
- Cost effective, that is, relatively low cost for treatment capacity provided. Easy to maintain if required skills are available.
- Easy to operate, very little human intervention required.
- Relatively short construction period – determined by civil works

Disadvantages:

- Requires civil works such as septic tank, bar screen, grit trap as pre-treatment.
- Requires a clarifier to separate liquids and humus as secondary treatment step
- Requires an electrical connection to power bio disc and transfer pumps
- Maintenance is more intensive than that required for "natural" systems
- Requires regular attention from mechanical fitter and electrician due to electrical and mechanical components such switchgear, electrical motors, reduction gearbox and bearings.
- Requires a Process Controller to be present at least during daytime
- Not that effective at removing nitrogen, can nitrify, but not fully denitrify.
- Life time of some components are limited, for example plastic weather covers deteriorate due to UV radiation, bio discs become brittle over time due to temperature.

We have considered using the RBC wastewater treatment system for one or two of the villages, where the use of a natural system may be difficult due to lack of available space. Typically, one could construct a Tanker Discharge facility upstream of the Septic Tank, which would then allow vacuum tanker trucks to discharge their contents into such a system for treatment. Due to the quite small footprint, this is an attractive option where space is at a premium. RBC plants are not that expensive either, as there are some very reputable suppliers of this type of equipment in South Africa that produce everything locally and also provide the required back-up in terms of spares and after sales service.

Figure 30. Rotating Biological Contactors at a mine in the Northern Cape

Figure 31. Bio discs before installation at the plant

8 OPTION ANALYSIS

The following factors were considered in the option analysis for a suitable treatment process:

- Space limitations
- Technical complexity
- Operational requirements
- Maintenance requirements
- Capital Cost for construction
- Operations and Maintenance Costs

8.1 Single Large Activated Sludge WWTP at Kakamas

Using the following parameters, an activated sludge process was modelled to determine the basic sizes of the process units that would be required for:

Average Dry Weather Flow: 4 500 m^3/day

COD Concentration: 650 mg/l

TKN Concentration: 65 mg/l

Ammonia Concentration: 60 mg/l

Phosphate Concentration: 6 mg/l

MLSS Concentration: 4000 mg/l

Sludge Age: 25 days

Temperature: 25° C

<u>This returned the following process volumes for a single treatment plant at Kakamas:</u>

		Volumes						
Unsettled waste		Total	Aerobic	Anoxic	Peak O_2 Reqd			
		Process			COD	Nitrification	NO3 return	Total
Sludge age	Temp	Vol m^3	Vol m^3	Vol m^3	kg/d	kg/d	kg/d	kg/d
25	15	**4603.373**	**3452.529**	**1150.843**	976.1083	1305.987061	271.5733621	2010.522
25	25	**4375.831**	**3281.873**	**1093.958**	976.1083	1360.542406	273.5793447	**2063.071**

Anoxic Zone volume required: 1 151 m^3

Aerobic Reactor volume required: 3 453 m^3

Total Oxygen Required: 2 011 kg/day

Energy required: 4 x 75kW Aerators or 6 x 45kW Aerators

Clarifiers: 1 x 18m dia Clarifier, or 2 x 15m dia Clarifiers

Cost Estimates for an Activated Sludge WWTP at Kakamas is as follows:

Summary of Costs: Single Large Activated Sludge Plant: 4500 m^3/day	
Capital Cost:	**R135 650 456.56**
Operational Cost/annum **(Includes cost of transporting Sewage by truck)**	**R24 243 662.50**
Maintenance Cost / annum	**R1 803 505.00**
Unit Cost per m^3 treated	**R15.86 /m^3**

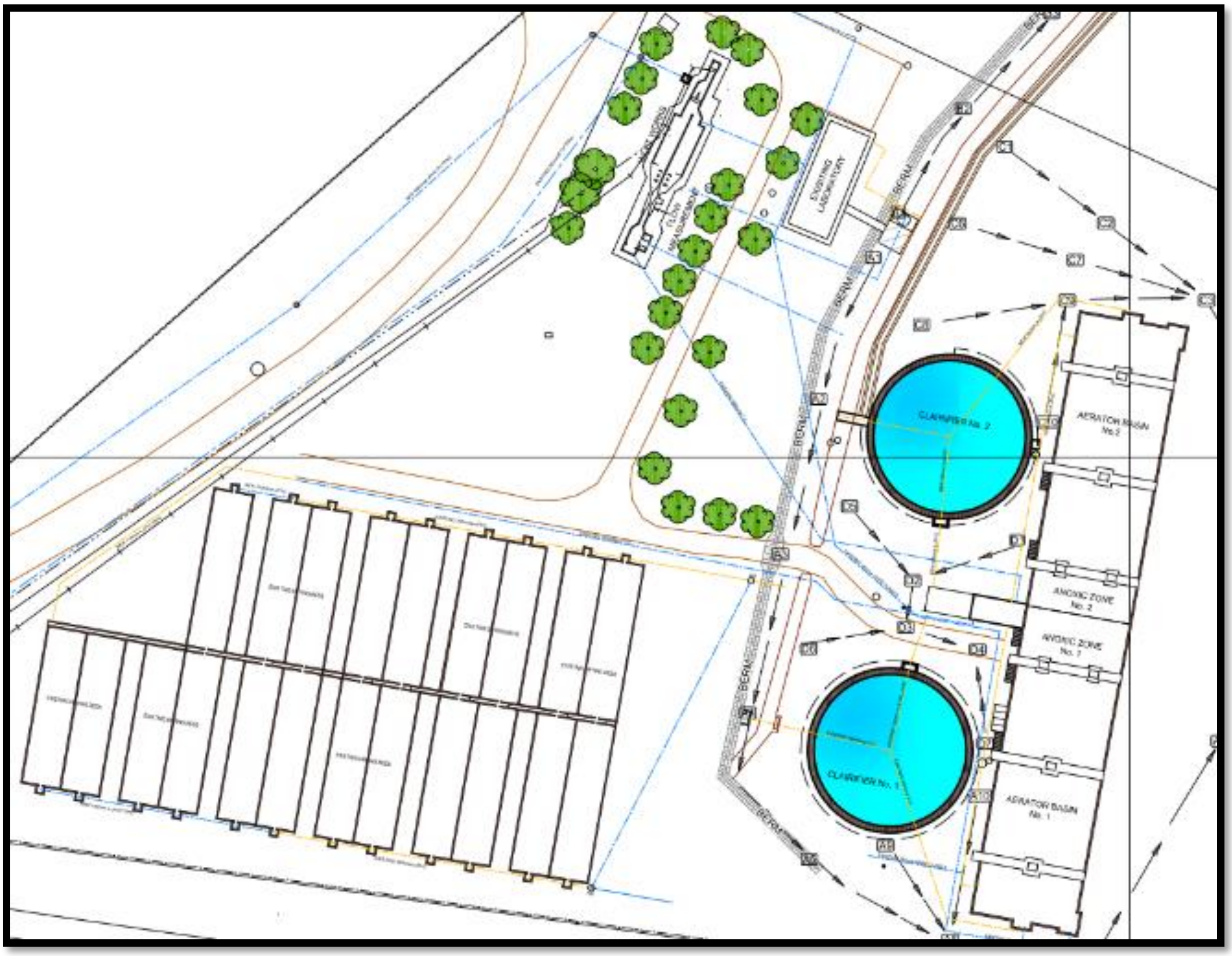


Figure 32. Typical layout drawing of a 4.50Ml/day Activated Sludge WWTP

8.2 Single conventional Oxidation Pond System at Kakamas

Using the following parameters, a conventional oxidation pond process was modelled to determine the basic sizes of the process units that would be required for:

Average Dry Weather Flow: 4 500 m^3/day

COD Concentration: 650 mg/l

Ammonia Concentration: 60 mg/l

This returned the following pond sizes:

Anaerobic Ponds x 2 3 000m^2 ea.

Facultative Ponds x 2 45 390 m^2 ea.

Aerobic Maturation Ponds x 3 10 084 m^2 ea.

Final Effluent Storage Pond x 1 22 404m^2 ea.

Total Pond Area required: 14.94 ha

Cost Estimates for a conventional Oxidation Pond system at Kakamas is as follows:

Summary of Costs: Single Large Oxidation Pond Plant: 4500 m^3/day	
Capital Cost:	**R68 469 522.57**
Operational Cost/annum **(Includes cost of transporting Sewage by truck)**	**R15 169 822.50**
Maintenance Cost / annum	**R567 398.12**
Unit Cost per m^3 treated	**R9.58 /m^3**

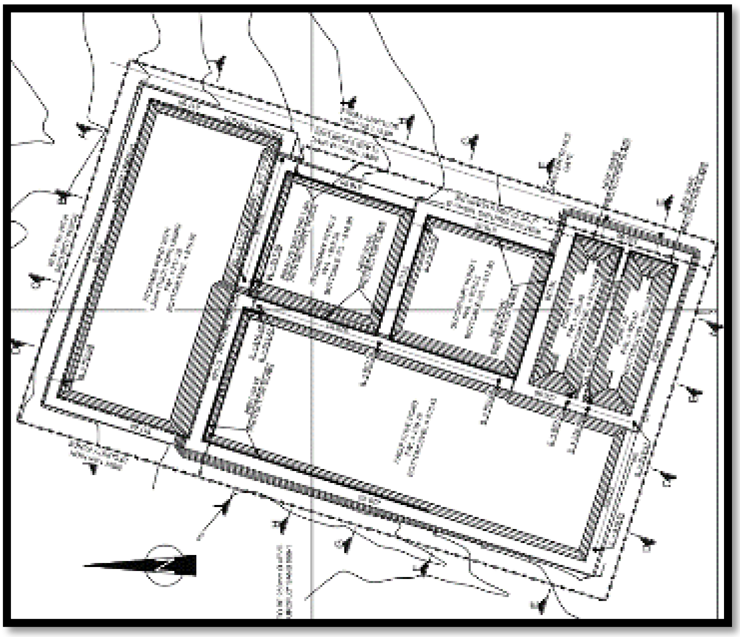


Figure 33. Typical Layout of a Conventional Oxidation Pond system

8.3 Single Aerated Facultative Pond system at Kakamas

Average Dry Weather Flow:	4 500 m^3/day
COD Concentration:	650 mg/l
TKN Concentration:	65 mg/l
Ammonia Concentration:	60 mg/l

This returned the following pond sizes:

Primary Diffused Air Aerated Ponds x 2	11 000m^2 ea.
Secondary Mixed Ponds x 2	11 000m^2 ea.
Maturation Ponds x 2	10 084 m^2 ea.

Cost Estimates for an Aerated Facultative Pond system at Kakamas is as follows:

Summary of Costs: Aerated Faculative Pond Plant: 2000 m^3/day	
Capital Cost:	**R110 478 903.60**
Operational Cost/annum **(Includes cost of transporting Sewage by truck)**	**R13 082 431.30**
Maintenance Cost / annum	**R1 759 408.46**
Unit Cost per m^3 treated	**R9.04 /m^3**

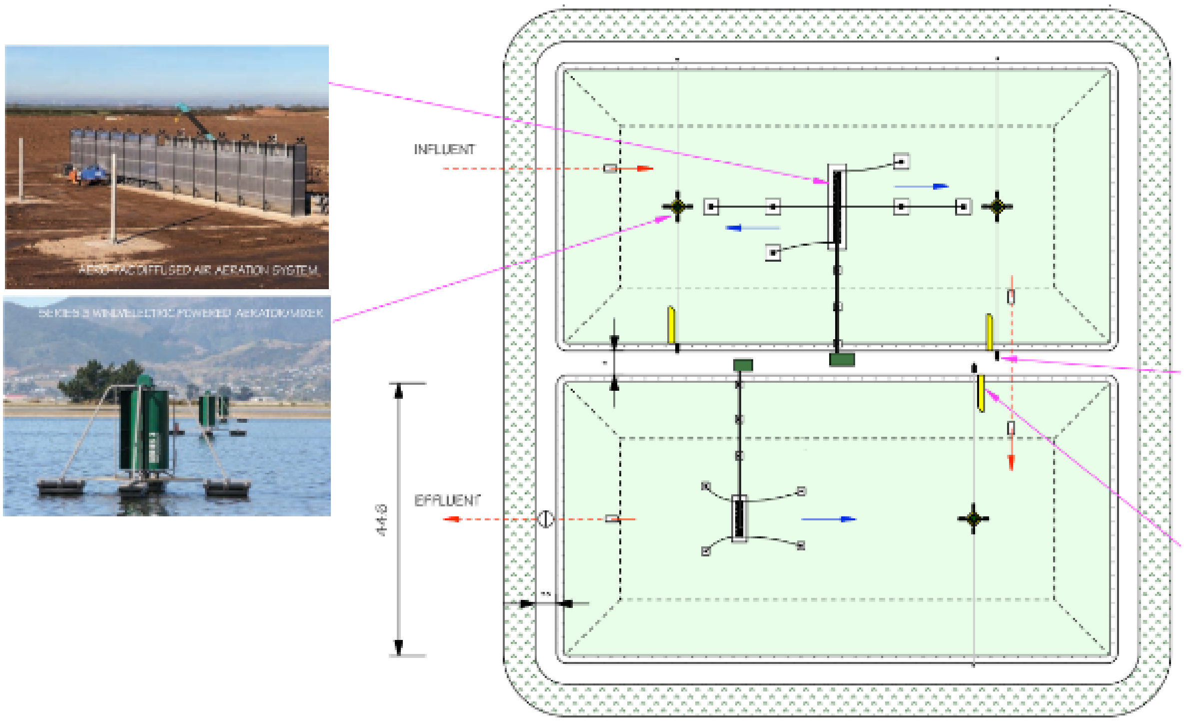


Figure 34. Typical Layout of a Aerated Facultative Pond system

8.4 Summary of options investigated for this approach (single WWTP at Kakamas)

Table 24. Summary of Approach A options

Approach A			
Option	**4.5Ml/d Activated Sludge Plant**	**4.5Ml/day Aerated Facultative Ponds**	**4.5Ml/d Oxidation Ponds**
Capital Cost	R135 650 456.56	R110 478 903.60	**R68 469 522.57**
O&M Cost	R26 047 167.50	**R14 841 839.76**	R15 737 220.62
Unit Cost	R15.86	**R9.04**	R9.58
Area Reqd (ha)	2.00	5.00	14.90
Water Quality	**General Limit**	**General Limit**	**General Limit (except TSS)**
Discharge to:	Orange River	Orange River	Orange River

8.5 Options investigated for Approach B

For the second approach, the use of a smaller treatment plant at Kakamas, in combination with several smaller decentralized wastewater treatment plants at the various villages were investigated.

The selected sizes of the various smaller treatment plants were as follows:

Kakamas: 2000 m^3/day

Alheit + Marchand 800 m^3/day

Augrabies & surrounds 500 m^3/day

Lutzburg & Cillie 450 m^3/day

Riemvasmaak Villages 250 m^3/day

All the farms in the area from Kakamas to Blouputz are taxed by the Kai !Garib Municipality, subsequently, the municipality is obliged to deliver a service when required. This typically entails the removal of wastewater from conservancy tanks. It was therefore decided to make an allowance for the treatment of farm wastewater at each of the smaller plants. This allowance for the farms, is included in the above plant sizes.

For each of the above WWTP's, a full cost analysis (Capital cost, Operational Cost, as well as Maintenance Cost and treatment Unit Cost) was done for the following treatment technology options:

- Conventional oxidation pond system with Final Effluent to be irrigated on sports fields
- Aerated facultative pond system with Final Effluent to be irrigated on sports fields
- Rotating Biological Contactor treatment plant with Final Effluent to be irrigated on sports fields

This was a strenuous exercise, entailing a multitude of calculations, and the summary of the Capital Cost findings are as follows:

Table 25. Summary of Approach B options

Approach B (Capital Cost only)			
Oxidation Ponds	**Aerated Ponds**	**Rot. Bio Contactors**	**Cost of Cheapest Option**
R50 377 289.12	R76 162 583.92	R76 162 583.92	R50 377 289.12
R25 589 824.70	**R30 573 738.08**	R43 454 825.10	R30 573 738.08
R23 590 679.99	**R26 922 497.01**	R39 332 835.59	R26 922 497.01
R12 622 183.96	R24 125 504.36	R36 447 442.93	R12 622 183.96
R7 089 291.96	R18 920 361.98	R24 905 872.29	R7 089 291.96
R119 269 269.75	**R176 704 685.36**	**R220 303 559.84**	**R127 585 000.14**

This analysis indicated that the cheapest option for each of the smaller wastewater treatment plants is to utilize Conventional Oxidation Ponds at each location.

There is however a legal requirement that oxidation ponds **should not be located closer than 500m from a residential area.** The reason for this being that conventional oxidation ponds utilize an Anaerobic (without oxygen) process as primary treatment. This process generates carbon dioxide, methane gas and hydrogen sulphide gas as by-product of the process. Especially hydrogen sulphide (H_2S), generates **noxious odours**, and is commonly known as "rotten egg" gas.

At both Alheit and Marchand, and at Augrabies Village, there is not sufficient municipal land available where the oxidation ponds can be placed, to comply with this requirement. There are also several private homes in the vicinity closer than 500m.

Subsequently, we have elected to go for the **Aerated Facultative Pond system at these two locations**. Being a fully aerobic treatment system, the generation of **odours will not be problematic**, and allow placement of the plants closer to the residential areas. This choice has a R6.5 million impact on the total cost of the project in terms of capital expenditure. The operational costs of Aerated Facultative Ponds are approximately R2-00 per kilolitre higher than for a conventional oxidation pond system.

From this table, it is clear that there is not a definitive answer to this problem. The reason for this being a phenomenon known as economy of scale. This means, that the larger a treatment plant becomes, the cost per unit of water treated actually declines. This factor is different for each of the various treatment options, and is not a linear relationship. It is in actual fact a declining exponential curve, and differs for each technology utilized.

In addition to the above, the operational requirements for each size and technology varies considerably. For example, when utilizing an Activated Sludge type plant, it is required that there be fulltime Process Controllers working shifts for 24 hours per day, while for an Oxidation Pond treatment plant, there is no point in doing this, as the Process Controller cannot control the process, and only need to look after the Inlet Works, removing screenings and grit, and topping up the disinfectant chemicals.

In a similar fashion, the chemical dosing of disinfectant for an Activated Sludge plant would entail dosing a lower concentration of chlorine, as the quality of the effluent is a lot better than the effluent from an Oxidation Pond system. This means that for the same treatment capacity, the chlorine usage of an Oxidation Pond system would be considerably higher than for an Activated Sludge plant due to the difference in chlorine demand of the treated effluent. This causes a significant difference in operational costs.

The cost calculations for all the possible options are included as Annexure.

Due to all the variations and permutations possible, it is pertinent that a Life Cycle Cost analysis be done for the various options.

8.6 Life Cycle Cost analysis

Subsequently, it is required that a comparison be done of what the costs would be for each of the options over a 30-year period. This calculation takes both the Capital Expenditure as well as the Operations and Maintenance costs into account over the 30-year period. A Nett Present value calculation is done over this period, using an interest rate of 6% (inflation) per annum.

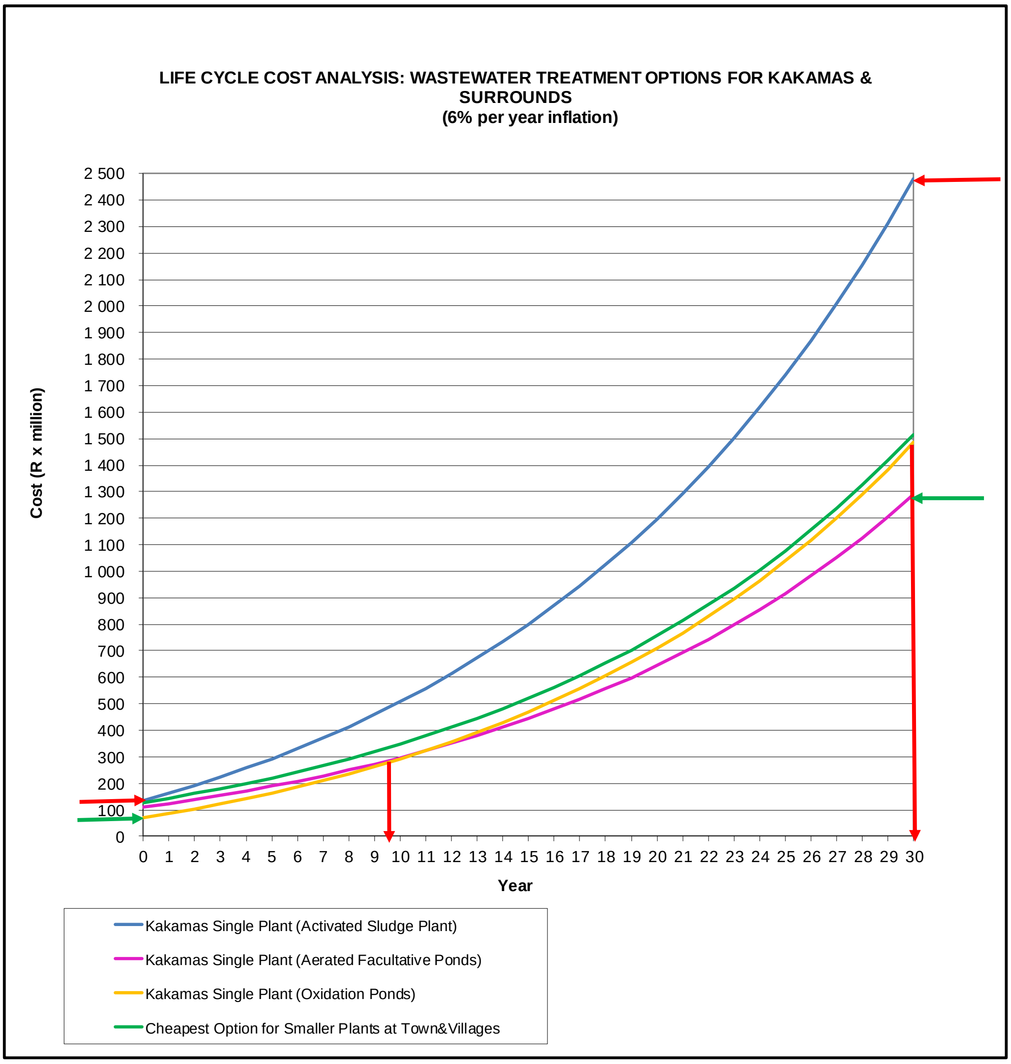
The options compared are as follows:

- The use of a single centralized 4.50Ml/day Activated Sludge Plant at Kakamas
- The use of a single 4.5 Ml/day conventional Oxidation Pond system at Kakamas
- The use of a single 4.5 Ml/day Aerated Facultative Pond system at Kakamas
- The use of a combination of smaller, decentralized treatment plants as follows:
    - 2.0 Ml/day conventional Oxidation Pond system for Kakamas town
    - 800 m^3/day Aerated Facultative Pond system for Alheit & Marchand villages
    - 500 m^3/day Aerated Facultative Pond system for Augrabies Village and surrounds
    - 450 m^3/day conventional Oxidation Pond system for Lutzburg & Cillie villages
    - 250 m^3/day conventional Oxidation Pond system for Riemvasmaak villages

The data returned by the Cost calculations for Capital Cost and Operation & Maintenance Cost utilized for the Life Cycle Cost analysis are as follows:

Approach A				Approach B
Option	**4.5Ml/d Activated Sludge Plant**	**4.5Ml/day Aerated Facultative Ponds**	**4.5Ml/d Oxidation Ponds**	**Lowest Cost Combination**
Capital Cost	R135 650 456.56	R122 781 639.26	**R91 467 143.15**	R127 585 000.14
O&M Cost	R26 047 167.50	**R15 191 745.54**	R15 919 019.99	R15 422 231.78
Unit Cost	R15.86	**R9.25**	R9.69	**R12.86**
Area Reqd (ha)	2.00	5.00	14.90	16.00
Water Quality	**General Limit**	**General Limit**	**General Limit (except TSS)**	**Varies**
Discharge to:	Orange River	Orange River	Orange River	Sportsfield Irrigation/ Orange River

The Life Cycle Costs are portrayed graphically as follows:



Analysis of Life Cycle Cost calculation:

- The single 4.50 Ml/day Activated Sludge WWTP at Kakamas has the highest Capital cost as well as the highest Operations & Maintenance costs
- The single 4.50 Ml/day Conventional Oxidation Pond system at Kakamas has the lowest Capital Cost of the options considered.
- The combined option, where smaller decentralized treatment plants are constructed at Kakamas and the various villages, has the 2nd highest Capital Cost. **Over a period of 30 years, the operational costs of the combination of small plants are comparable with the operational cost of a single 4.50 Ml/day Oxidation Pond at Kakamas.**
- Although the Capital costs for an Aerated Facultative Pond system is initially higher than that of the conventional Oxidation Pond system, the Operational Cost breaks even with that of the Oxidation Pond system after 9.5 years. The primary reason for this being the costs of Desludging of the Oxidation Ponds every 5 to 7 years, and also the lower chlorine demand due to the better quality of Treated Effluent produced by the Aerated Pond system.

  Subsequently, the Aerated Facultative Ponds have the lowest cost of ownership over the 30-year period due to lower Operational costs.
- From the land area requirement calculations for the various options, it is clear that the combination of smaller decentralized wastewater treatment plants has the largest requirement in terms of space. There is however sufficient municipal land area available at Kakamas as well as at the various smaller villages at relatively minimal cost to the project.

Given the above, there is no clear "cheap option".

For every selection of combinations made, there are advantages and disadvantages. The advantage of having a higher quality of effluent, is offset by the higher cost of treatment. Similarly, when water must be irrigated, there is a cost involved.

The reason for this being the complexity of the problem and the many possible permutations. It is however clear, that the large volume of wastewater currently being transported from the various villages all the way to the Kakamas WWTP, is not sustainable practically or financially over the long term.

We have done a cost analysis of this, but our analysis does not include the replacement of vacuum tanker trucks every 5 years. Subsequently, it is safe to make the assumption that **a large, single centralized wastewater treatment plant is NOT the optimum solution.**

The cheapest calculated combination of smaller, decentralized wastewater treatment plants, has the highest Capital Cost requirement, but the long-term cost of ownership (Operations and Maintenance cost) is comparable with that of the single 4.50 ML/day conventional Oxidation Pond system.

It is therefore recommended that the option of using smaller, decentralized wastewater treatment plants for Kakamas and surrounding villages be implemented, constructing the following units:

- 2.0 Ml/day conventional Oxidation Pond system for Kakamas town
- 800 m^3/day Aerated Facultative Pond system for Alheit & Marchand villages
- 500 m^3/day Aerated Facultative Pond system for Augrabies Village and surrounds
- 450 m^3/day conventional Oxidation Pond system for Lutzburg & Cillie villages
- 250 m^3/day conventional Oxidation Pond system for Riemvasmaak villages

8.7 Motivation for the selected scheme

The town of Kakamas has never been fully equipped with a waterborne sewer system, with most homes in the older parts of the town being reliant on conservancy tanks. Since 1994, several government-funded low-cost housing projects has led to the installation of waterborne sewers at all of these developments. Kakamas has always had an oxidation pond system, which was originally constructed to deal with the town's hospital effluent. At some point, the local municipality took over the oxidation ponds, and two or three extensions were done over time. The current calculated treatment capacity of the Kakamas oxidation ponds is 430 m^3/day.

After demarcation in 1997, the Kai !Garib Municipality was tasked to take over 10 villages, previously under the auspices of the then Benede-Oranje Regional Council, today known as the ZF Mgcau District Municipality. Seven of these villages, namely Alheit, Marchand, Lutzburg, Cillie, Augrabies, Riemvasmaak Mission and Riemvasmaak Vredesvallei are in close proximity (varies between 3km and 60km) to Kakamas. Subsequently, Kai !Garib Municipality became responsible for delivering a sanitation service in these areas as well.

Having limited infrastructure available at these villages, it was unavoidable that the wastewater from these villages is being carted by truck to the Kakamas WWTP, being the only disposal facility in the area.

This rapid accumulation of responsibilities, as well as organic growth of the town's population, has led to the Kakamas WWTP becoming totally overloaded both hydraulically and organically, as it was never designed to deal with the volumes now being received. The situation has now deteriorated to a point where untreated wastewater flows into the Orange River in an uncontrolled fashion. A formal directive was issued to the Kai !Garib Municipality in 2017 by the Department of Water & Sanitation to address the matter as soon as possible, or risk being criminally charged.

Having investigated the situation at hand, and considered various options in terms of treatment technologies and plant sizes, the calculations show that there is not a single, clear technical solution to the problem.

Subsequently, a compromise needs to be reached.

A single centralized wastewater treatment of 4.50 Ml/day constructed at Kakamas, is feasible, but has the disadvantage that all wastewater must be carted to the plant at an annual cost exceeding R8.9 million per annum. This option has the highest long-term cost of ownership due to the Operations and Maintenance cost of such a plant.

The use of several smaller, decentralized wastewater treatment plants, does not negate the requirement to use vacuum tanker trucks to transport the sewage. As long as conservancy tanks are used, in lieu of full waterborne sewage reticulation, this will be the case. The objective is therefore, to transport as little wastewater as possible, over as short a distance as possible, in order to reduce this enormous cost. This can only be achieved by constructing several decentralized wastewater treatment plants at or near the various villages.

Unfortunately, the capital cost requirement to construct several smaller decentralized wastewater treatment plants, is the highest of all the options investigated. This option does not have the lowest Operation & Maintenance Cost either, but it is very similar to the operational costs of the cheapest option.

At the various villages, there is definite potential for water re-use in the form of irrigation. All the villages in question, have at least one or more sports fields which can be irrigated with Treated Effluent.

A standard size soccer field has an area in excess of 7000 m^2 (105m x 68m). For such a field to receive 15mm of irrigation per day, which is quite low, a volume of 105 m^3 would be required, without any evaporation losses being taken into account. It would therefore be extremely feasible to irrigate at least 100m^3 per day in most villages, and even up to 300m^3 in the larger villages, where there are several such fields available.

It is proposed that provision be made, during the construction of the various wastewater treatment plants, to already provide irrigation infrastructure and planting of grass on the fields, which are currently bare. This will also assist in improving social issues among the young people of these villages by promoting outdoor sport as a pastime.

There are advantages and disadvantages for all possible options, with no clear winner meeting all criteria perfectly.

The recommended solution of constructing five (5) smaller decentralized wastewater treatment plants, using differing technologies is therefore the best compromise for the Kai! Garib Municipality, given the specific circumstances at Kakamas and surrounds.

It is therefore proposed that the technical solution to construct several smaller, decentralized wastewater treatment plants, to accommodate the wastewater generated at Kakamas, and the surrounding villages, be approved and accepted as the most feasible option.

9 VALUE DRIVERS AND TRADE-OFFS

9.1 Capital Costs of the Project

The project aims to construct several small, decentralized wastewater treatment plants at the town of Kakamas and surrounding villages at the following capital costs:

Item	Estimated Capital Cost
Kakamas 2.0 Ml/day Oxidation Pond system	R 50 377 289.12
Alheit & Marchand combined 0.8 Ml/day Aerated Facultative Ponds	R 30 573 738.08
Augrabies Village 0.5 Ml/day Aerated Facultative Ponds	R 26 922 497.01
Lutzburg & Cillie combined 0.45Ml/day Oxidation Pond system	R 12 622 183.96
Riemvasmaak Villages combined 0.25Ml/day Oxidation Pond system	R 7 089 291.96
Total Estimated Capital Cost Requirement:	**R127 585 000.14**

This cost includes 10% Contingencies and 15% VAT, but excludes any provision for escalation, environmental compliance monitoring or professional engineering fees.

9.2 Estimated Operational and Maintenance Costs

The Operation and Maintenance Cost were calculated separately for each of the wastewater treatment plants, as the operational requirements are different for each different technology used.

Operational Costs include:

- Cost to operate vacuum tanker trucks
- Personnel costs for Process Controllers & Supervisor
- Pumping Costs if applicable to the specific treatment plant
- Disinfection Chemicals

Maintenance Costs based on:

- Civil Works: 1% of capital value of structures, pipelines, etc
- Mechanical Works: 4% of capital value of mechanical equipment (pumps, valves, etc)
- Electrical Works: 4% of capital value of electrical equipment (powerlines, Switchgear)

Table 26. Summary of Operational and Maintenance Costs for each plant

Plant Name	Operational Cost	Maintenance Cost	Total O&M Costs per annum	Cost/m3 Treated
Kakamas 2Ml/day Oxidation Ponds	**R6 801 712.00**	**R289 682.41**	**R7 091 394.41**	**R9.71**
Alheit & Marchand 0.8Ml/day Aerated Facultative Ponds	**R3 109 489.28**	**R516 467.14**	**R3 625 956.42**	**R12.42**
Augrabies Village 0.5 Ml/day Aerated Facultative Ponds	**R2 514 136.05**	**R479 731.70**	**R2 993 867.75**	**R16.40**
Lutzburg & Cillie 0.45Ml/day Oxidation Ponds	**R1 749 454.58**	**R100 413.66**	**R1 849 868.23**	**R11.26**
Riemvasmaak Villages 0.25Ml/day Oxidation Ponds	**R1 247 439.88**	**R77 995.21**	**R1 325 435.09**	**R14.53**

The detail calculation sheet for these costs for each of the Treatment Plants are attached as Annexure.

9.3 Project Cost Summary

Taking into consideration the funding rules of the Regional Bulk Infrastructure Grant, it is estimated that this project be funded as follows:

Percentage of Indigent Households benefitting: **45% (Kakamas) & 71.0% (Villages)** (Census 2011)

Estimated Project Cost: **R 143 033 875.16**

	Kakamas WWTW	Population 2040	% indigent	Users 2040	Wastewater l/day	Wastewater Ml/day	WWTW Ml/day 2040	% Social Component
Kakamas	Indigents	15 245	45.00%	6 860	64	0.440	4.50	9.78%
	Non-indigents		55.00%	8 385	20	0.170	4.50	3.78%
Settlement	Indigents	37 075	71.00%	26 323	64	1.690	4.50	37.56%
	Non-indigents		29.00%	10 752	20	0.220	4.50	4.89%
Farms	Indigents	9 251	67.00%	6 198	64	0.400	4.50	8.89%
	Non-indigents		33.00%	3 053	20	0.070	4.50	1.56%
	Subtotal	*61 571*		*61 571*		*2.990*		*66.44%*
	Associated users	2017	Growth pa					
	Schools (day) learners	5 365	1.60%	7 729	16	0.130	4.50	2.89%
	Schools (boarding)	240	0.00%	240	112	0.030	4.50	0.67%
	Crèche learners	537	1.60%	773	16	0.020	4.50	0.44%
	Hospital beds	30	1.60%	43	240	0.020	4.50	0.44%
	Clinic outpatients (headcount)			215 499	3.5	0.760	4.50	16.89%
	Prison/police cells	20	1.60%	29	120	0.010	4.50	0.22%
	Community hall seats			1 539	20	0.040	4.50	0.89%
	Subtotal					1.010		22.44%
	TOTAL SOCIAL COMPONENT							88.89%

Total Cost of Project: R 143 033 875.16

RBIG Contribution to cover the Social Component: R 127 142 811.63

Co-funding required from Kai !Garib Municipality: R 15 891 063.53

These calculations are all based on estimates, which estimates are based on costs of recently completed projects of similar nature, quotations from specialist suppliers and the engineers' experience.

The fact of the matter is that the fluctuating value of the South African Rand, the slow growth of the national economy and the annual price hikes by ESKOM makes projects of this nature extremely expensive. Given the recent international geo-political happenings, the cost of diesel fuel is expected to increase dramatically in the foreseeable future, and will have a major impact on the costs of this project. In excess of 80% of the costs for this project is driven by earthworks, which are done by utilizing diesel-powered equipment such as excavators, tipper trucks and roller compactors.

Until this project has gone to tender, and the market has returned a firm price, any estimate will be of limited value.

In spite of these challenges, the people in Kakamas and surrounds, are guaranteed the same basic rights to dignified and acceptable sanitation facilities as all other citizens in South Africa.

10 STAKEHOLDERS INVOLVED IN THIS PROJECT

10.1 Kakamas, Villages & Farm Community

The communities of Kakamas, Alheit, Marchand, Augrabies, Lutzburg, Cillie and Riemvasmaak are the primary beneficiaries of this project. The residents in the area are mostly poor, with 71% of the residents classified as indigent. Although they are a poor community, with limited ability to pay for services, they still have the right to these basic services as enshrined in the Constitution.

It is estimated that some 140 temporary job opportunities will be created by this project for at least 18 months. There will also be a need for at least 14 permanent positions at the proposed new wastewater treatment plant to operate the systems efficiently.

10.2 Kai !Garib Municipality

Kai !Garib Municipality is the administrative local authority in whose area the proposed project is to be implemented. Kai !Garib Municipality are also responsible for providing a sanitation service in these villages and target areas.

10.3 ZF Mgcawu District Municipality

The Kai !Garib Municipality falls within the administrative area of the ZF Mgcawu District Municipality which has its seat in Upington. As the project is located within their administrative area, the ZF Mgcawu District Municipality is an Interested and Affected Party to the project.

10.4 Northern Cape Department of Environment and Nature Conservation

This provincial department is responsible for the issue of the Record of Decision regarding the Environmental Impact Assessment and therefore an important stakeholder to this project.

10.5 Department of Water and Sanitation

This department is responsible for the granting and issuing of the Water Use Licenses applicable to this project, as well as a primary funder of the project through the Regional Bulk Infrastructure Grant program.

10.6 Landowners affected by the project

There are no private landowners affected by this project. The project is located entirely in municipal property or within public road reserves for which wayleaves have been received.

11 DEVELOPMENT OF NEW WASTEWATER TREATMENT FACILITIES AT KAKAMAS & SURROUNDS: TECHNICAL DETAILS

11.1 Scope of the works

The proposed scope of works for this project entails the construction of the following components:

- **Construction of a new 2000m^3/day Conventional Oxidation Pond WWTP for the town of Kakamas, comprising the following:**
  - Operational Building/Shelter
  - Inlet Works (inclusive of Tanker Truck discharge facility)
  - Screenings Removal
  - Grit Channels
  - Flow measurement
  - Anaerobic Ponds x 2 (lined with HDPE membrane)
  - Facultative Ponds x 2 (lined with HDPE membrane)
  - Aerobic Ponds x 3 (lined with HDPE membrane)
  - Final Storage Pond (lined with HDPE membrane)
  - Horizontal Flow Reedbed (to filter out TSS to achieve General Limit)
  - Disinfection facility
  - 3.57km x 250mm dia Wastewater Rising Main pipeline
  - 3.87km x 300mm dia Treated Effluent Gravity Main from WWTP to Orange River
  - 22kV x 2.5km overhead Electrical Power supply line + Transformer
- **Construction of an 800 m^3/day Aerated Facultative Pond system for Alheit & Marchand villages, comprising the following:**
  - Operational Building/Shelter
  - Inlet Works (inclusive of Tanker Truck discharge facility)
  - Screenings Removal
  - Grit Channels
  - Flow measurement
  - Facultative Ponds x 2 (lined with HDPE membrane)
  - Wind powered Floating Aerator/Mixers
  - Medium Bubble Diffused Air aeration system Stainless Steel

- Low Pressure Centrifugal Fam c/w Motor
- Electrical Switchgear & DO Control System
- Aerobic Ponds x 2 (lined with HDPE membranes)
- Disinfection facility
- Irrigation equipment for disposal of Effluent on sports fields
- 22kV x 1.5km overhead Electrical Power supply line + Transformer

- **Construction of a 500 m³/day Aerated Facultative Pond system for Augrabies Village and surrounds, comprising the following:**
  - Operational Building/Shelter
  - Inlet Works (inclusive of Tanker Truck discharge facility)
  - Screenings Removal
  - Grit Channels
  - Flow measurement
  - Facultative Ponds x 2 (lined with HDPE membrane)
  - Wind powered Floating Aerator/Mixers
  - Medium Bubble Diffused Air aeration system Stainless Steel
  - Low Pressure Centrifugal Fam c/w Motor
  - Electrical Switchgear & DO Control System
  - Aerobic Ponds x 2 (lined with HDPE membranes)
  - Disinfection facility
  - Irrigation equipment for disposal of Effluent on sports fields
  - 22kV x 1.5km overhead Electrical Power supply line + Transformer

- **Construction of a 450 m³/day conventional Oxidation Pond system for Lutzburg & Cillie villages, comprising the following:**
  - Operational Building/Shelter
  - Inlet Works (inclusive of Tanker Truck discharge facility)
  - Screenings Removal
  - Grit Channels

  - Flow measurement
  - Anaerobic Ponds x 2 (lined with HDPE membrane)
  - Facultative Ponds x 1 (lined with HDPE membrane)
  - Aerobic Ponds x 3 (lined with HDPE membrane)
  - Final Storage Pond (lined with HDPE membrane)
  - Horizontal Flow Reedbed (to filter out TSS to achieve General Limit)
  - Disinfection facility
  - Irrigation equipment for disposal of Effluent on sports fields
  - 22kV x 2.5km overhead Electrical Power supply line + Transformer

- **Construction of a 250 m^3/day conventional Oxidation Pond system for Riemvasmaak villages, comprising the following:**
  - Operational Building/Shelter
  - Inlet Works (inclusive of Tanker Truck discharge facility)
  - Screenings Removal
  - Grit Channels
  - Flow measurement
  - Anaerobic Ponds x 2 (lined with HDPE membrane)
  - Facultative Ponds x 1 (lined with HDPE membrane)
  - Aerobic Ponds x 3 (lined with HDPE membrane)
  - Final Storage Pond (lined with HDPE membrane)
  - Horizontal Flow Reedbed (to filter out TSS to achieve General Limit)
  - Disinfection facility
  - Irrigation equipment for disposal of Effluent on sports fields
  - 22kV x 2.5km overhead Electrical Power supply line + Transformer

11.2 Survey and Investigation

A detailed topographical survey has been done already at the Kakamas site to facilitate the layout and design of the proposed new wastewater treatment works. The surveys of the smaller plants at the villages still need to be conducted to ensure accurate placement.

11.3 Environmental Issues

The following environmental legal requirements for the proposed project include:

- Environmental Impact Assessment application for environmental authorization in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA) Environmental Impact Assessment (EIA) Regulations 2014 (as amended - 07 April 2017 (GN No. 326)).

- Integrated Water Use Licensing application in terms of Section 40 of the National Water Act (Act 36 of 1998).

<u>The following activities may be triggered in terms of GN R 326:</u>

- **Activity no.10**: The development and related operation of infrastructure exceeding 1000 metres in length for the bulk transportation of sewage, effluent, process water, wastewater, return water, industrial discharge or slimes-
  - (i) With an internal diameter of 0.36 metres or more; or
  - (ii) With a peak throughput of 120 litres per second or more.

- **Activity no.12:** The development of;
  - (i) dams or weirs, where the dam or weir, including infrastructure and water surface area, exceeds 100 square metres;
  - (ii) infrastructure or structures with a physical footprint of 100 square metres or more;

  where such development occurs;

  (a) within a watercourse;

  (b) in front of a development setback; or

  (c) if no development setback exists, within 32 metres of a watercourse, measured from the edge of a watercourse;

- **Activity No. 19:** The infilling or depositing of any material of more than 10 cubic metres into, or the dredging, excavation, removal or moving of soil, sand, shells, shell grit, pebbles or rock of more than 10 cubic metres from a watercourse;
  - (a) will occur behind a development setback;
  - (b) is for maintenance purposes undertaken in accordance with a maintenance management plan; or
  - (c) falls within the ambit of activity 21 in this Notice, in which case that activity applies.
- **Activity No.25:** The development and related operation of facilities or infrastructure for the treatment of effluent, wastewater or sewage with a daily throughput capacity of more than 2000 cubic metres but less than 15000 cubic metres.
- **Activity no.27**: The clearance of an area of 1 hectare or more, but less than 20 hectares of indigenous vegetation, except where such clearance of indigenous vegetation is required for-
  - (i) The undertaking of a linear activity; or
  - (ii) Maintenance purposes undertaken in accordance with a maintenance management plan.
- **Activity no.31:** The decommissioning of existing facilities, structures or infrastructure for;
  - (i) any development and related operation activity or activities listed in this Notice, Listing Notice 2 of 2014 or Listing Notice 3 of 2014;
  - (ii) any expansion and related operation activity or activities listed in this Notice, Listing Notice 2 of 2014 or Listing Notice 3 of 2014;
  - (iv) any phased activity or activities for development and related operation activity or expansion or related operation activities listed in this Notice or Listing Notice 3 of 2014; or
  - (v) any activity regardless the time the activity was commenced with, where such activity:
    - (a) is similarly listed to an activity in (i) or (ii) above; and
    - (b) is still in operation or development is still in progress;

  excluding where;

  (aa) activity 22 of this notice applies; or

  (bb) the decommissioning is covered by part 8 of the National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008) in which case the National Environmental Management: Waste Act, 2008 applies.

To obtain environmental authorization for this proposed project, at least a basic assessment process needs to be followed addressing the issues, and their possible mitigation, listed above.

11.4 Water Use Licence Application

It will be required that an Integrated Water Use Licence application will need to be lodged for each of the proposed new wastewater treatment plants to be constructed.

The following activities will need to be licenced under Section 21 of the National Water Act (Act 36 of 1998):

- **Section 21 (c):** Impeding or diverting the flow of water in a watercourse. (Construction of pipelines)
- **Section 21 (e):** Engaging in a controlled activity identified as such in section 37(1) or declared under section 28(1) of the NWA. (Irrigation with water containing waste).
- **Section 21 (f):** Discharging waste or water containing waste into a water resource. Discharging of Treated Effluent into a surface water resource (Orange River).
- **Section 21 (g):** Disposing of waste in a manner which may detrimentally impact on a water resource. Disposal of effluent into a water containment facility (storage of wastewater in pond systems).

Given that the construction of the facilities as proposed in this study, has a direct bearing on the safe disposal of domestic wastewater, and the related quality of the Orange River, the municipality is confident that such water use licences will be readily forthcoming for this project.

11.5 Wayleaves and Consent Applications

All the construction activities are to take place on municipal commonage land.

The only exception being the Treated Effluent Gravity Pipeline at the Kakamas WWTP, which will cross private land, and where consent will be required from the individual landowners.

It is envisaged that the Treated Effluent pipeline will terminate at the head of an existing concrete-lined stormwater drainage canal, which is under control of the Kakamas Water Users Association. They will need to provide consent for this use as well.

Wayleaves will be obtained from ESKOM, as the construction of some activities will be in close proximity of ESKOM distribution powerlines running from the Taaipit Substation, which is located 2km from the proposed WWTP site at Kakamas.

11.6 Proposed Project Schedule

The construction schedule for this project is totally dependent on approval by the Department of Water and Sanitation and the availability of funding for the project.

A "best scenario" proposed schedule for the project is as follows:

Month	**Activity**
15 April 2022	Feasibility Study Complete
30 September 2022	Implementation Readiness Study Complete (EIA req.)
31 January 2023	Project Approval from DWS
31 May 2023	Detail design and tender documentation (6 weeks)
30 June 2023	Advertise tender for construction (4 weeks)
15 July 2023	Appointment of Contractor (2 weeks)
1 August 2023	Site Establishment and Commencement of construction
1 September 2025	Completion of Construction
2 September 2026	Retention Period expires and Final Completion Certificate

12 RISK REVIEW

The primary risk of this project is if nothing is done about the situation. Currently, the domestic wastewater is being disposed of at a wastewater treatment facility at Kakamas, which is woefully inadequate for the task.

This has the result that poorly treated effluent is occasionally spilt into the Orange River, which is both a public health risk, as well as a serious environmental hazard. The Orange River water quality has already deteriorated to such a degree over the past 20 years, that it is basically eutrophic for 9 months of the year due to primarily untreated sewage and agricultural drainage water discharged into the river as both point pollution sources (inadequate wastewater treatment plants) and diffuse sources (agricultural drainage). This has had the result that excessive quantities of both nitrogen and phosphorous have reached a point which is favourable for algal blooms to regularly occur.

Depending on which option is chosen, this is technically this is not an intensely complicated project.

If Option A (single 4.5Ml/day Activated Sludge WWTP) is chosen, then both the design, as well as the Operations and Maintenance become quite complex.

If Option B (several smaller pond-type treatment plants), are chosen, then design is relatively simple and construction will entail primarily bulk earthworks. Operations and Maintenance requirements for Option B are also a lot simpler, and the Kai !Garib Municipality should be able to deal with them satisfactorily.

Both the current financial status of Kai !Garib Municipality, and the serious lack of technical capacity to conduct Operations and Maintenance is a serious risk. One possible option to remedy this, is to investigate the possibility to let the Kakamas Water Users Association take over the Operations & Maintenance function for the proposed infrastructure in future. To achieve this, a Section 78 Investigation will need to be conducted as described in the Municipal Systems Act (Act No.32 of 2000), to determine the ability of the Kai !Garib Municipality to deliver such a service, and to investigate possible alternatives.

The Kai !Garib Municipality is fully committed to providing basic services to all its residents including those in Kakamas as well as the villages and farms along the Orange River. The Kai !Garib Municipality has also committed itself to the project in terms of ownership, operations and maintenance and counter funding. It is envisaged that the counter funding could be financed from the reclaimed Value Added Tax on the project.

The only remaining risk is therefore the availability of primary funding. Should funding not be forthcoming, the communities will continue to bear the public health risks and damage to the local environment.

13 ASSESSMENT OF STUDY RESULTS

The results of this study have shown that the most feasible option for establishment of a facility(s) for the treatment of wastewater at the town of Kakamas and surrounds, is a single 4 500m^3 Conventional Oxidation Pond system located at Kakamas. Practically, it is however problematic, as this option would rely on the road transportation of wastewater by tanker truck of 7 smaller villages in the vicinity of Kakamas. The cost of this transportation of the wastewater amounts to some R9 810 000-00 per annum, without taking the cost of the replacement of the tanker fleet into consideration.

Subsequently, the study included the establishment of several smaller capacity, decentralized wastewater treatment plants at Kakamas and the surrounding villages. The decentralized option returned the highest capital expenditure, as instead of constructing a single WWTP, it is now required to construct five (5) treatment facilities. In addition, this option does not negate the need for the transportation of sewage by truck, but it does reduce the distances and quantities that need to be transported. The reason for this, is the fact that all the villages, and at least 40% of the houses in Kakamas, are served by conservancy tanks, and not a waterborne sewage system. The Operational and Maintenance cost of having decentralized smaller plants, is slightly higher, but comparable to that of a single large Oxidation Pond system at Kakamas.

At two of the villages, Alheit/Marchand and Augrabies, it is not feasible to use conventional oxidation ponds. The reason for this being that the available free space is too close (less than 500m) from the residential area. Subsequently any anaerobic process would become problematic due to the generation of obnoxious odours caused by Hydrogen Sulphide gas. Therefore, a more expensive, but predominantly aerobic technology choice was favoured for these two treatment plants.

Therefore, the combination of a 2000m^3/day Conventional Oxidation Pond system at Kakamas plus the construction of four (4) smaller treatment plant, with sizes varying between 250m^3/day and 800m^3/day, at the surrounding villages is deemed the more practical technical solution for the Kai !Garib Municipality.

The town and surrounds are inhabited by more than 70% indigent persons, for which a suitable dignified sanitation service must be provided. The calculated social component for this project is in excess of 88%. It has therefore been endeavoured to try and keep the cost of the technology employed as simple and as cost effective as possible. Hopefully, the chosen technology options will allow the Kai !Garib Municipality to operate and maintain the proposed systems as efficiently as possible.

The treatment of wastewater is an expensive business, irrespective of how it is approached. We have analysed a multitude of technology options as well as combinations of different sizes of treatment plants to find the most suitable solution that is both practical from an operational point of view, easy to operate and as cost effective as possible. In spite of this, the unit cost of treatment varies between R9-04 and R14-53 per m^3. Wastewater treatment cost is highly dependent on economy of scale. A large treatment plant will always have a lower unit cost than a smaller plant, and the relationship is not linear.

In short, given sufficient funding, this project is deemed feasible in terms of technical possibility, economic feasibility and the subsequent social and environmental benefits to be derived. It is proposed that the option of constructing smaller capacity, decentralized wastewater treatment plants at Kakamas and surrounding villages be approved in order to commence with the Implementation Readiness Study as soon as possible.

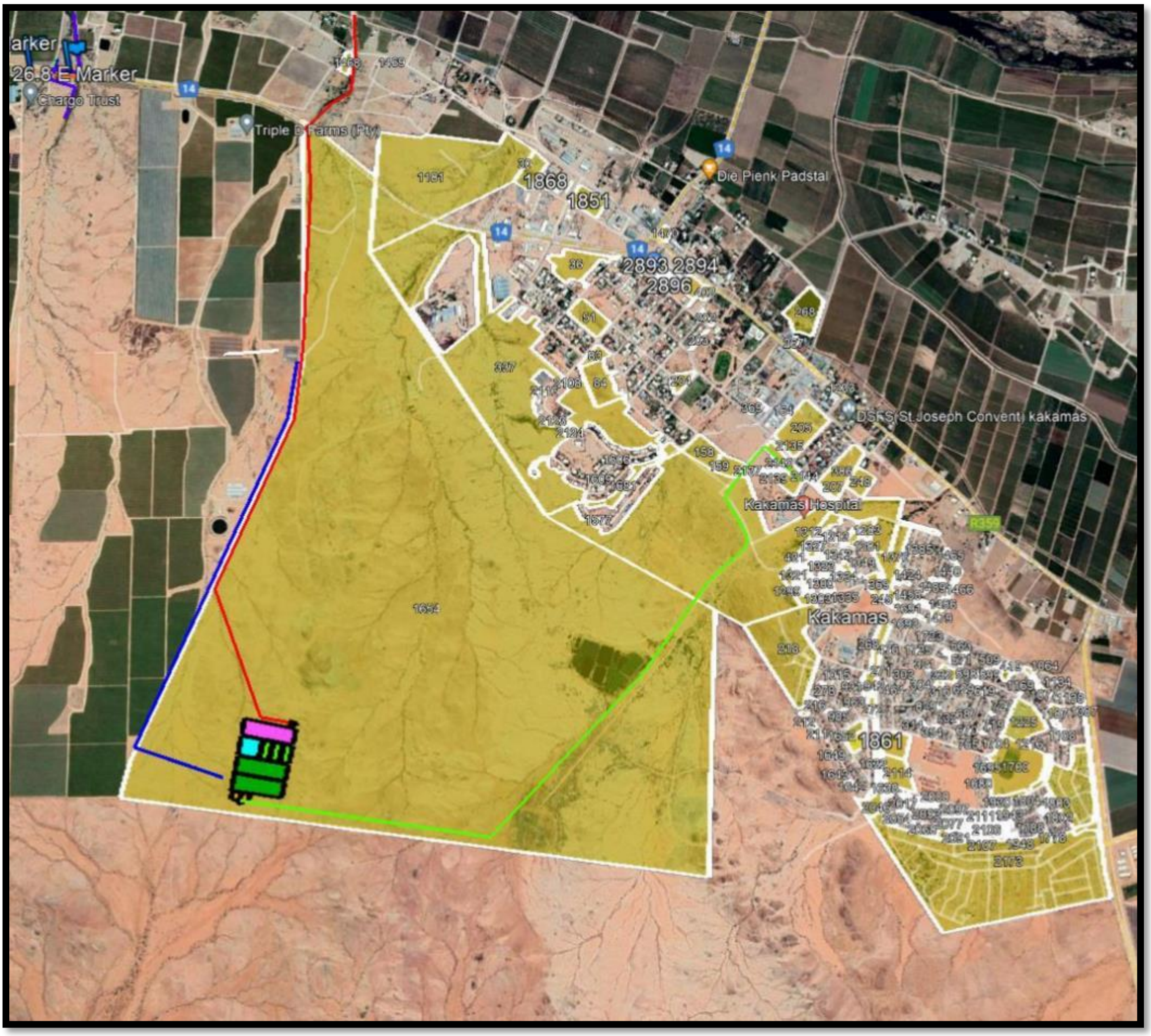
ANNEXURE A

LOCALITY MAP OF PROPOSED PROJECT


BOTSWANA
NAMIBIA
Kgalagadi Transfrontier Park
NORTH WEST
Kuruman
Kathu
N14
Richtersveld Transfrontier Conservation Park
Upington
Postmasburg
Alexander Bay
Kakamas
Keimoes
Vioolsdrif
Groblershoop
N8
KIMBERLEY
Port Nolloth
Pofadder
N7
N14
FREE STATE
Kleinsee
Springbok
Prieska
N12
Namaqua National Park
Orania
Kamieskroon
NORTHERN CAPE
N10
Hondeklipbaai
Garies
Britstown
De Aar
Colesberg
Carnarvon
Hanover
Victoria West
Calvinia
Loxton
Richmond
Three Sisters
ATLANTIC OCEAN
Fraserburg
N1
Sutherland
EASTERN CAPE
0 50 100 150 200 250km
WESTERN CAPE

ANNEXURE B

PROPOSED LAYOUTS FOR EACH WWTP



Proposed position of Kakamas WWTP

1 x Inlet Works

2 x Anaerobic Ponds

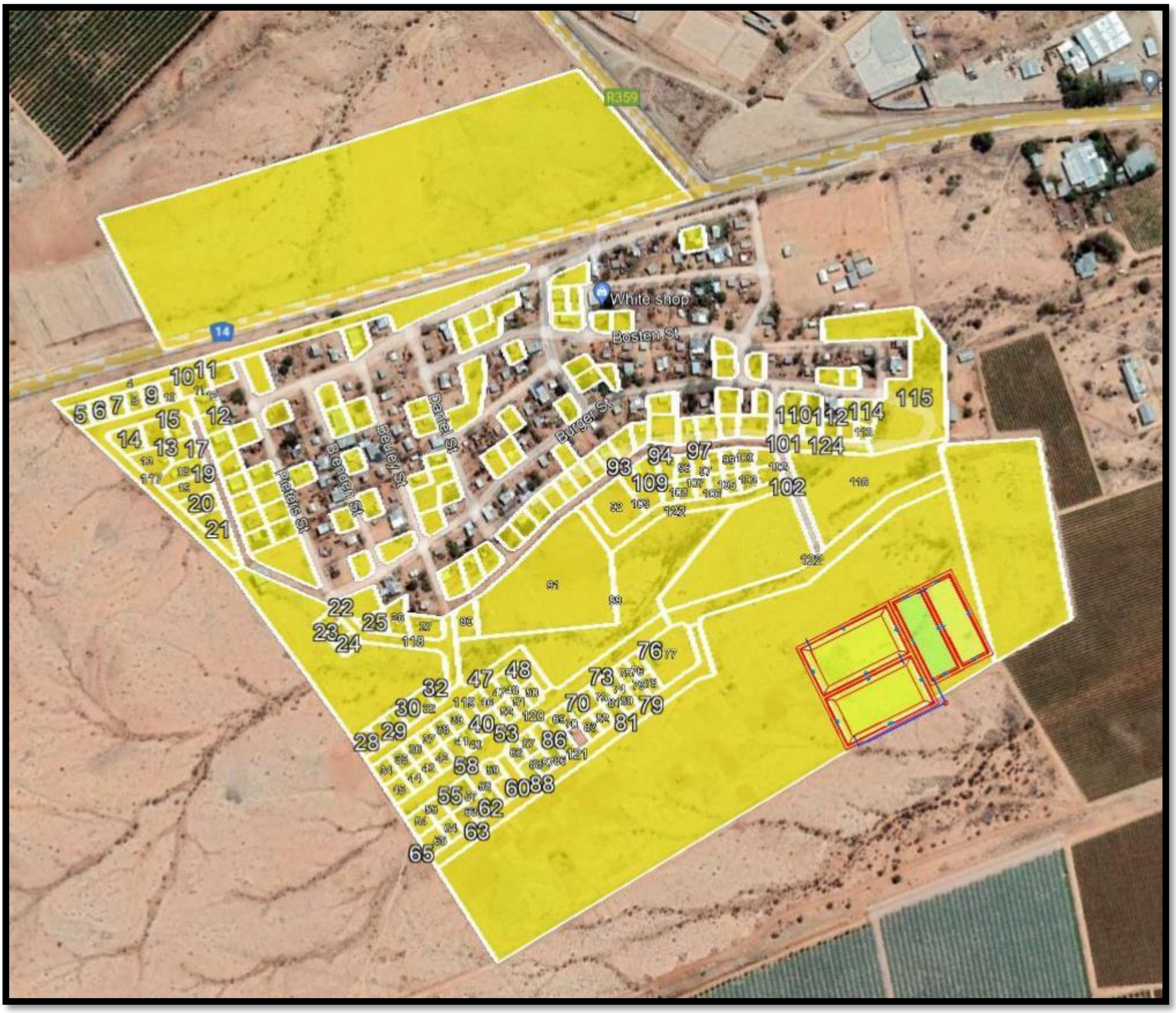
2 x Facultative Ponds

3 x Aerobic Maturation Ponds

1 x Treated Effluent Storage Pond

1 x Horizontal Flow Reedbed

1 x Chlorine Contact Tank



Proposed position of the Alheit/Marchand WWTP located at Alheit Village

1 x Inlet Works

2 x Aerated Facultative Ponds

2 x Aerobic Maturation Ponds

1 x Chlorine Contact Tank

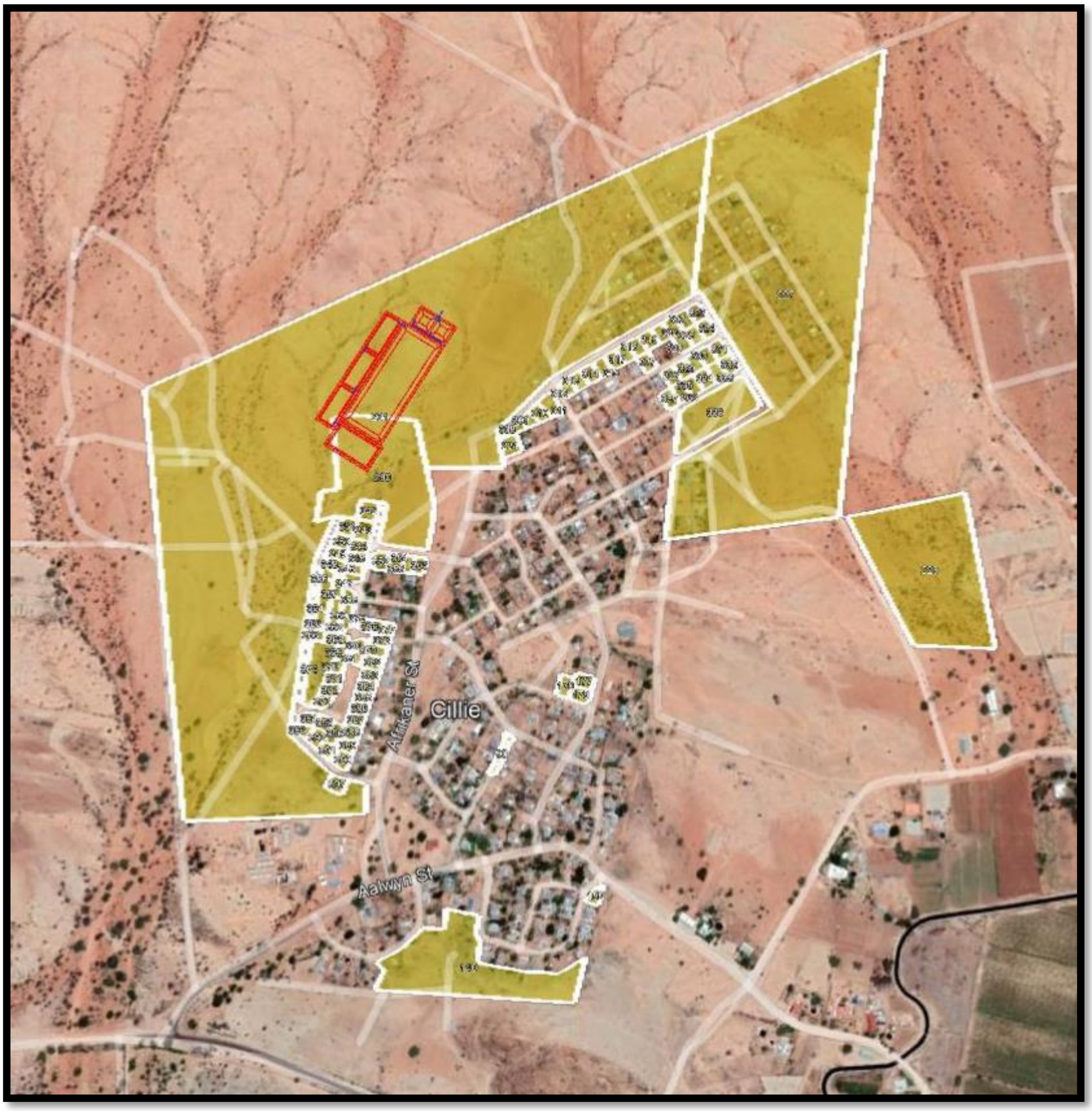
Proposed position of WWTP for Augrabies and surrounds located at Augrabies Village

1 x Inlet Works

2 x Aerated Facultative Ponds

2 x Aerobic Maturation Ponds

1 x Chlorine Contact Tank



Proposed position of the Lutzburg / Cillie WWTP to be located at Cillie Village

1 x Inlet Works

2 x Anaerobic Ponds

1 x Facultative Ponds

3 x Aerobic Maturation Ponds

1 x Treated Effluent Storage Pond

1 x Horizontal Flow Reedbed

1 x Chlorine Contact Tank

Proposed position of the Riemvasmaak WWTP to be located at Vredesvallei Village

1 x Inlet Works

2 x Anaerobic Ponds

1 x Facultative Ponds

3 x Aerobic Maturation Ponds

1 x Treated Effluent Storage Pond

1 x Horizontal Flow Reedbed

1 x Chlorine Contact Tank

ANNEXURE C

COST ESTIMATE OF THE TECHNOLOGY OPTIONS INVESTIGATED

(Capital Cost, Operational Cost, Maintenance Cost)

Plant Size: 4.5 Megalitre

Capital Costs: Activated Sludge: Single Centralized Plant at Kakamas			
		Unit Cost/Ml	
Preliminary & General Costs:	0.175	R14 171 062.50	
Wastewater Rising Main (3 820m x 250mm uPVC)		R5 730 000.00	
Treated Effluent Discharge Gravity Main (3 870m x 350mm)		R5 805 000.00	
Civil Works:	0.6	R48 586 500.00	
Mechanical Equipment	0.3	R24 293 250.00	
Electrical Equipment	0.1	R8 097 750.00	R17 995 000.00
Electrical Power Supply Line 22kV from Substation (2.5km + Trf)		R550 000.00	
Subtotal:		**R107 233 562.50**	
10% Contingency		R10 723 356.25	
Subtotal:		**R117 956 918.75**	
VAT @15%		R17 693 537.81	
Total Expected Project Costs:		**R135 650 456.56**	

Operational Costs:

Cost to operate fleet of Vacuum Tanker Trucks:			100%	R9 801 000.00
Personnel Costs: 4 x Process Controllers + Supervizor				
Operateur: Klas 0 tot Klas I	T4 x 2		R126 192.00	R252 384.00
Proseskontroleur: Klas II & III	T7 x 2		R175 848.00	R351 696.00
Voorman: Klas IV	T10 x 1		R250 932.00	R250 932.00
Superintendent: Klas V	T12 x 1		R358 116.00	R358 116.00

Electricity:	Size	Oper. Hours	kW.h/Annum	
Aeration: (kW)	300	24	2628000	
Mixers: (kW)	100	24	876000	
RAS Pumps	150	24	1314000	
A-Recyle Pumps	100	24	876000	
Pump costs from	100	16	584000	
Total:			6278000	
Rate:	R1.85 R/kW.h			R11 614 300.00
Chemicals:		Tons/Annum		
Chlorine Dose:	3 mg/l			
Liters	45000000			
kg/day	135		49.275	
Unit price Cl.	R32.78			R1 615 234.50
Estimated Annual Operational Costs:				**R24 243 662.50**

Maintenance Costs:

Civil Works:	1%	R48 586 500.00	R485 865.00
Mechanical Work	4%	R24 293 250.00	R971 730.00
Electrical Works	4%	R8 647 750.00	R345 910.00
Total Annual Maintenance Costs:			**R1 803 505.00**
Total Operations and Maintenance Cost:			**R26 047 167.50**
Total annual Volume Treated:			1 642 500.00 m^3/ annum
Unit Cost:			R15.86 /m^3

Summary of Costs: Single Large Activated Sludge Plant: 4500 m^3/day	
Capital Cost:	**R135 650 456.56**
Operational Cost/annum **(Includes cost of transporting Sewage by truck)**	**R24 243 662.50**
Maintenance Cost / annum	**R1 803 505.00**
Unit Cost per m^3 treated	R15.86 /m^3

Plant Size: 4.50 Megalitre

Capital Cost: Oxidation Pond System: Single Centralized Plant at Kakamas					
					Unit Cost/Ml
Preliminary & General Costs:			0.175	R7 953 722.53	
Wastewater Rising Main (3 820m x 250mm uPVC)				R5 730 000.00	
Treated Effluent Discharge Gravity Main (3 870m x 350mm)				R5 805 000.00	
Civil Works:			0.6	R27 269 905.82	
Mechanical Equipment			0.05	R2 272 492.15	
Electrical Equipment			0.1	R4 544 984.30	R7 574 973.84
Electrical Power Supply Line 22kV from Substation (2.5km + Trf)				R550 000.00	
Subtotal:				**R54 126 104.80**	
10% Contingency				R5 412 610.48	
Subtotal:				**R59 538 715.28**	
VAT @15%				R8 930 807.29	
Total Expected Project Costs:				**R68 469 522.57**	
Operational Costs:					
Cost to operate fleet of Vacuum Tanker Trucks:			100%	R9 801 000.00	
Personnel Costs: 4 x Process Controllers + Supervizor					
Operateur: Klas 0 tot Klas I	T4 x 2		R126 192.00	R252 384.00	
Proseskontroleur: Klas II & III	T7 x 0			R0.00	
Voorman: Klas IV	T10 x 0			R0.00	
Superintendent: Klas V	T12		R358 116.00	R358 116.00	
Electricity:					
	Size	Oper. Hours	kW.h/Annum		
Pumping Costs from Main Pump Station to Plant					
	55	12	240900		
A-Recyle Pumps	100	24	876000		
Total:			1116900		
Rate:	R1.85 R/kW.h			R2 066 265.00	
Chemicals:			Tons/Annum		
Chlorine Dose:	5 mg/l				
Liters	45000000				
kg/day	225		82.125		
Unit price Cl.	R32.78			R2 692 057.50	
Estimated Annual Operational Costs:				**R15 169 822.50**	
Maintenance Costs:					
Civil Works:	1%	R27 269 905.82		R272 699.06	
Mechanical Work:	4%	R2 272 492.15		R90 899.69	
Electrical Works	4%	R5 094 984.30		R203 799.37	
Total Annual Maintenance Costs:				**R567 398.12**	
Total Operations and Maintenance Cost:				**R15 737 220.62**	
Total annual Volume Treated:				1 642 500.00	m^3/ annum
Unit Cost:				**R9.58**	**/m^3**

Summary of Costs: Single Large Oxidation Pond Plant: 4500 m^3/day	
Capital Cost:	**R68 469 522.57**
Operational Cost/annum **(Includes cost of transporting Sewage by truck)**	**R15 169 822.50**
Maintenance Cost / annum	**R567 398.12**
Unit Cost per m^3 treated	**R9.58 /m^3**

Plant Size:			4.50 Megalitre		
Capital Cost: Single centralized Aerated Facultative Pond System: 4.50 Megalitre/Day at Kakamas					
					Unit Cost/Ml
Preliminary & General Costs:			0.175	R7 953 722.53	
Wastewater Rising Main (3 820m x 250mm uPVC)				R5 730 000.00	
Treated Effluent Discharge Gravity Main (3 870m x 350mm)				R5 805 000.00	
Civil Works:				R31 814 890.12	
Mechanical Equipment (Mixers + Diffused Air)				R32 300 000.00	
Electrical Equipment				R3 181 489.01	
Electrical Power Supply Line 22kV from Substation (2.5km + Trf)				R550 000.00	R8 006 997.56
Subtotal:				**R87 335 101.66**	
10% Contingency				R8 733 510.17	
Subtotal:				**R96 068 611.83**	
VAT @15%				R14 410 291.77	
Total Expected Project Costs:				**R110 478 903.60**	
Operational Costs:					
Cost to operate fleet of Vacuum Tanker Trucks:			100%	R9 801 000.00	
Personnel Costs: 4 x Process Controllers + Supervizor					
Operateur: Klas 0 tot Klas I	T4 x 2		R126 192.00	R252 384.00	
Proseskontroleur: Klas II & III	T7 x 0			R0.00	
Voorman: Klas IV	T10 x 0			R0.00	
Superintendent: Klas V	T12		R358 116.00	R358 116.00	
Electricity:					
	Size	Oper. Hours	kW.h/Annum		
Pumping Costs from Main Pump Station to Plant					
	55	12	240900		
Mixer/Aerators x	32	8	93440		
Diffused Air Fans	120	24	1051200		
Total:			1385540		
Rate:	R1.85 R/kW.h			R2 563 249.00	
Chemicals:		Tons/Annum			
Chlorine Dose:	2 mg/l				
Liters	4500000				
kg/day	9		3.285		
Unit price Cl.	R32.78			R107 682.30	
Estimated Annual Operational Costs:				**R13 082 431.30**	
Maintenance Costs:					
Civil Works:	1%	R31 814 890.12		R318 148.90	
Mechanical Work:	4%	R32 300 000.00		R1 292 000.00	
Electrical Works	4%	R3 731 489.01		R149 259.56	
Total Annual Maintenance Costs:				**R1 759 408.46**	
Total Operations and Maintenance Cost:				**R14 841 839.76**	
Total annual Volume Treated:				1 642 500.00 m^3/ annum	
Unit Cost:				R9.04 /m^3	
Summary of Costs: Aerated Faculative Pond Plant: 2000 m^3/day					
Capital Cost:				**R110 478 903.60**	
Operational Cost/annum				**R13 082 431.30**	
(Includes cost of transporting Sewage by truck)					
Maintenance Cost / annum				**R1 759 408.46**	
Unit Cost per m^3 treated				R9.04 /m^3	

Plant Size: 2.00 Megalitre

Capital Cost: Activated Sludge System: 2.00 Megalitre/Day for Kakamas only

			Unit Cost/Ml
Preliminary & General Costs:	0.175	R6 298 250.00	
Wastewater Rising Main (3 820m x 250mm uPVC)		R5 730 000.00	
Treated Effluent Discharge Gravity Main (3 870m x 350mm)		R5 805 000.00	
Civil Works:	0.6	R21 594 000.00	
Mechanical Equipment	0.3	R10 797 000.00	
Electrical Equipment	0.1	R3 599 000.00	R17 995 000.00
Electrical Power Supply Line 22kV from Substation (2.5km + Trf)		R550 000.00	
Subtotal:		**R54 373 250.00**	
10% Contingency		R5 437 325.00	
Subtotal:		**R59 810 575.00**	
VAT @15%		R8 971 586.25	
Total Expected Project Costs:		**R68 782 161.25**	

Operational Costs:

Cost to operate fleet of Vacuum Tanker Trucks:			45%	R4 410 450.00
Personnel Costs: 4 x Process Controllers + Supervizor				
Operateur: Klas 0 tot Klas I	T4 x 2		R126 192.00	R252 384.00
Proseskontroleur: Klas II & III	T7 x 2		R175 848.00	R351 696.00
Voorman: Klas IV	T10 x 1		R250 932.00	R250 932.00
Superintendent: Klas V	T12 x 1		R358 116.00	R358 116.00
Electricity:				
	Size	Oper. Hours	kW.h/Annum	
Aeration: (kW)	220	24	1927200	
Mixers: (kW)	85	24	744600	
RAS Pumps	75	24	657000	
A-Recyle Pumps	50	24	438000	
General other:	50	16	292000	
Total:			4058800	
Rate:	R1.85 R/kW.h			R7 508 780.00
Chemicals:			Tons/Annum	
Chlorine Dose:	3 mg/l			
Liters	2000000			
kg/day	6		2.19	
Unit price Cl.	R32.78			R71 788.20
Estimated Annual Operational Costs:				**R13 204 146.20**

Maintenance Costs:

Civil Works:	1%	R21 594 000.00	R215 940.00
Mechanical Works	4%	R10 797 000.00	R431 880.00
Electrical Works	4%	R4 149 000.00	R165 960.00
Total Annual Maintenance Costs:			**R813 780.00**
Total Operations and Maintenance Cost:			**R14 017 926.20**
Total annual Volume Treated:			730 000.00 m^3/ annum
Unit Cost:			**R19.20 /m^3**

Summary of Costs: Single Large Activated Sludge Plant: 4500 m^3/day

Capital Cost:	**R68 782 161.25**
Operational Cost/annum (Includes cost of transporting Sewage by truck)	**R13 204 146.20**
Maintenance Cost / annum	**R813 780.00**
Unit Cost per m^3 treated	**R19.20 /m^3**

Plant Size:	2.00 Megalitre

Capital Cost: Oxidation Pond System: 2.00 Megalitre/Day for Kakamas only

			Unit Cost/Ml
Preliminary & General Costs:	0.175	R7 953 722.53	
Wastewater Rising Main (3 820m x 250mm uPVC)		R5 730 000.00	
Treated Effluent Discharge Gravity Main (3 870m x 350mm)		R5 805 000.00	
Civil Works:	0.6	R17 457 548.33	
Mechanical Equipment	0.05	R1 454 795.69	
Electrical Equipment	0.03	R872 877.42	R9 892 610.72
Electrical Power Supply Line 22kV from Substation (2.5km + Trf)		R550 000.00	
Subtotal:		**R39 823 943.97**	
10% Contingency		R3 982 394.40	
Subtotal:		**R43 806 338.37**	
VAT @15%		R6 570 950.76	
Total Expected Project Costs:		**R50 377 289.12**	

Operational Costs:

Cost to operate fleet of Vacuum Tanker Trucks:			45%	R4 410 450.00
Personnel Costs: 4 x Process Controllers + Supervizor				
Operateur: Klas 0 tot Klas I	T4 x 2		R126 192.00	R252 384.00
Proseskontroleur: Klas II & III	T7 x 0			R0.00
Voorman: Klas IV	T10 x 0			R0.00
Superintendent: Klas V	T12		R358 116.00	R358 116.00
Electricity:				
	Size	Oper. Hours	kW.h/Annum	
Pumping Costs from Main Pump Station to Plant				
	55	12	240900	
A-Recyle Pumps	75	24	657000	
Total:			897900	
Rate:	R1.85 R/kW.h			R1 661 115.00
Chemicals:			Tons/Annum	
Chlorine Dose:	5 mg/l			
Liters	2000000			
kg/day	10		3.65	
Unit price Cl.	R32.78			R119 647.00
Estimated Annual Operational Costs:				**R6 801 712.00**

Maintenance Costs:

Civil Works:	1%	R17 457 548.33	R174 575.48
Mechanical Works	4%	R1 454 795.69	R58 191.83
Electrical Works	4%	R1 422 877.42	R56 915.10
Total Annual Maintenance Costs:			**R289 682.41**
Total Operations and Maintenance Cost:			**R7 091 394.41**
Total annual Volume Treated:			730 000.00 m^3/ annum
Unit Cost:			**R9.71 /m^3**

Summary of Costs: Single Oxidation Pond Plant: 2000 m^3/day

Capital Cost:	**R50 377 289.12**
Operational Cost/annum **(Includes cost of transporting Sewage by truck)**	**R6 801 712.00**
Maintenance Cost / annum	**R289 682.41**
Unit Cost per m^3 treated	**R9.71 /m^3**

Plant Size: **2.00 Megalitre**

Capital Cost: Aerated Facultative Pond System: 2.00 Megalitre/Day for Kakamas only					
					Unit Cost/Ml
Preliminary & General Costs:			0.175	R7 953 722.53	
Wastewater Rising Main (3 820m x 250mm uPVC)				R5 730 000.00	
Treated Effluent Discharge Gravity Main (3 870m x 350mm)				R5 805 000.00	
Civil Works:				R20 367 139.72	
Mechanical Equipment (Mixers + Diffused Air)				R16 150 000.00	
Electrical Equipment				R3 651 713.97	
Electrical Power Supply Line 22kV from Substation (2.5km + Trf)				R550 000.00	**R10 175 856.99**
Subtotal:				**R60 207 576.22**	
10% Contingency				R6 020 757.62	
Subtotal:				**R66 228 333.84**	
VAT @15%				R9 934 250.08	
Total Expected Project Costs:				**R76 162 583.92**	
Operational Costs:					
Cost to operate fleet of Vacuum Tanker Trucks:			45%	R4 410 450.00	
Personnel Costs: 4 x Process Controllers + Supervizor					
Operateur: Klas 0 tot Klas I	T4 x 2		R126 192.00	R252 384.00	
Proseskontroleur: Klas II & III	T7 x 0			R0.00	
Voorman: Klas IV	T10 x 0			R0.00	
Superintendent: Klas V	T12		R358 116.00	R358 116.00	
Electricity:					
	Size	Oper. Hours	kW.h/Annum		
Pumping Costs from Main Pump Station to Plant					
	55	12	240900		
Mixer/Aerators x	4	8	11680		
Diffused Air Fans	45	24	394200		
Total:			646780		
Rate:	R1.85 R/kW.h			R1 196 543.00	
Chemicals:			Tons/Annum		
Chlorine Dose:	2 mg/l				
Liters	2000000				
kg/day	4		1.46		
Unit price Cl.	R32.78			R47 858.80	
Estimated Annual Operational Costs:				**R6 265 351.80**	
Maintenance Costs:					
Civil Works:	1%	R20 367 139.72		R203 671.40	
Mechanical Works	4%	R16 150 000.00		R646 000.00	
Electrical Works	4%	R4 201 713.97		R168 068.56	
Total Annual Maintenance Costs:				**R1 017 739.96**	
Total Operations and Maintenance Cost:				**R7 283 091.76**	
Total annual Volume Treated:				730 000.00	m^3/ annum
Unit Cost:					**R9.98 /m^3**

Summary of Costs: Aerated Faculative Pond Plant: 2000 m^3/day		
Capital Cost:	**R76 162 583.92**	
Operational Cost/annum (Includes cost of transporting Sewage by truck)	**R6 265 351.80**	
Maintenance Cost / annum	**R1 017 739.96**	
Unit Cost per m^3 treated		**R9.98 /m^3**

Plant Size: 0.80 Megalitre

Capital Cost: Aerated Facultative Pond System: 800m³/Day for Alheit & Marchand					
				Unit Cost/Ml	
Preliminary & General Costs:			0.175	R2 617 973.10	
Civil Works:				R11 519 081.64	
Mechanical Equipment (Mixers + Diffused Air)				R8 550 000.00	
Electrical Equipment				R1 151 908.16	
Electrical Power Supply Line 22kV from Substation (1.5km + Trf)				R330 000.00	R12 539 885.21
Subtotal:				**R24 168 962.91**	
10% Contingency				R2 416 896.29	
Subtotal:				**R26 585 859.20**	
VAT @15%				R3 987 878.88	
Total Expected Project Costs:				**R30 573 738.08**	
Operational Costs:					
Cost to operate fleet of Vacuum Tanker Trucks:			25%	R2 450 250.00	
Personnel Costs: 4 x Process Controllers + Supervizor					
Operateur: Klas 0 tot Klas I	T4 x 2		R126 192.00	R252 384.00	
Proseskontroleur: Klas II & III	T7 x 0			R0.00	
Voorman: Klas IV	T10 x 0			R0.00	
Superintendent: Klas V	T12 x 0			R0.00	
Electricity:					
	Size	Oper. Hours	kW.h/Annum		
			0		
Mixer/Aerators x 8	10	8	29200		
Diffused Air Fans x 2	20	24	175200		
Total:			204400		
Rate:	R1.85 R/kW.h			R378 140.00	
Chemicals:		Tons/Annum			
Chlorine Dose:	3 mg/l				
Liters	800000				
kg/day	2.4		0.876		
Unit price Cl.	R32.78			R28 715.28	
Estimated Annual Operational Costs:				**R3 109 489.28**	
Maintenance Costs:					
Civil Works:	1%	R11 519 081.64		R115 190.82	
Mechanical Works	4%	R8 550 000.00		R342 000.00	
Electrical Works	4%	R1 481 908.16		R59 276.33	
Total Annual Maintenance Costs:				**R516 467.14**	
Total Operations and Maintenance Cost:				**R3 625 956.42**	
Total annual Volume Treated:				292 000.00 m³/ annum	
Unit Cost:				R12.42 /m³	

Summary of Costs: Aerated Faculative Pond Plant: 800 m³/day	
Capital Cost:	**R30 573 738.08**
Operational Cost/annum **(Includes cost of transporting Sewage by truck)**	**R3 109 489.28**
Maintenance Cost / annum	**R516 467.14**
Unit Cost per m³ treated	**R12.42 /m³**

Plant Size: **0.80 Megalitre**

Capital Cost: Oxidation Pond System: 800m^3/Day for Alheit & Marchand						
						Unit Cost/Ml
Preliminary & General Costs:				0.175	R7 953 722.53	
Horizontal Flow Reedbed to Filter Algae					R617 093.66	
Civil Works:				0.6	R9 873 498.55	
Mechanical Equipment				0.05	R1 454 795.69	
Electrical Equipment				0	R0.00	R14 160 367.81
Electrical Power Supply Line 22kV from Substation (1.5km + Trf)					R330 000.00	
Subtotal:					**R20 229 110.44**	
10% Contingency					R2 022 911.04	
Subtotal:					**R22 252 021.48**	
VAT @15%					R3 337 803.22	
Total Expected Project Costs:					**R25 589 824.70**	
Operational Costs:						
Cost to operate fleet of Vacuum Tanker Trucks:				25%	R2 450 250.00	
Personnel Costs: 4 x Process Controllers + Supervizor						
Operateur: Klas 0 tot Klas I		T4 x 2		R126 192.00	R252 384.00	
Proseskontroleur: Klas II & III		T7 x 0			R0.00	
Voorman: Klas IV		T10 x 0			R0.00	
Superintendent: Klas V		T12 x 0			R0.00	
Electricity:						
	Size	Oper. Hours	kW.h/Annum			
				0		
				0		
Total:				0		
Rate:		R1.85 R/kW.h			R0.00	
Chemicals:			Tons/Annum			
Chlorine Dose:		5 mg/l				
Liters		800000				
kg/day		4		1.46		
Unit price Cl.		R32.78			R47 858.80	
Estimated Annual Operational Costs:					**R2 750 492.80**	
Maintenance Costs:						
Civil Works:		1%	R9 873 498.55		R98 734.99	
Mechanical Works		4%	R1 454 795.69		R58 191.83	
Electrical Works		4%	R330 000.00		R13 200.00	
Total Annual Maintenance Costs:					**R170 126.81**	
Total Operations and Maintenance Cost:					**R2 920 619.61**	
Total annual Volume Treated:					292 000.00	m^3/ annum
Unit Cost:					**R10.00**	**/m^3**

Summary of Costs: Single Oxidation Pond Plant: 800 m^3/day		
Capital Cost:	**R25 589 824.70**	
Operational Cost/annum **(Includes cost of transporting Sewage by truck)**	**R2 750 492.80**	
Maintenance Cost / annum	**R170 126.81**	
Unit Cost per m^3 treated	**R10.00**	**/m^3**

Plant Size: **0.80 Megalitre**

Capital Cost: RBC Plant System: 800m³/Day for Alheit & Marchand					
					Unit Cost/Ml
Preliminary & General Costs:			0.175	R7 953 722.53	
Civil Works:				R15 640 750.72	
Mechanical Equipment			0.3	R7 820 375.36	
Electrical Equipment			0.1	R2 606 791.79	R32 584 897.33
Electrical Power Supply Line 22kV from Substation (1.5km + Trf)				R330 000.00	
Subtotal:				**R34 351 640.40**	
10% Contingency				R3 435 164.04	
Subtotal:				**R37 786 804.44**	
VAT @15%				R5 668 020.67	
Total Expected Project Costs:				**R43 454 825.10**	
Operational Costs:					
Cost to operate fleet of Vacuum Tanker Trucks:			25%	R2 450 250.00	
Personnel Costs: 4 x Process Controllers + Supervizor					
Operateur: Klas 0 tot Klas I	T4 x 2		R126 192.00	R252 384.00	
Proseskontroleur: Klas II & III	T7 x 0			R0.00	
Voorman: Klas IV	T10 x 0			R0.00	
Superintendent: Klas V	T12 x 0			R0.00	
Electricity:					
Size		Oper. Hours	kW.h/Annum		
Transfer Pump	7.5	12	32850		
Bio Rotors	4	24	35040		
Total:			67890		
Rate:	R1.85 R/kW.h			R125 596.50	
Chemicals:		Tons/Annum			
Chlorine Dose:	3 mg/l				
Liters	800000				
kg/day	2.4		0.876		
Unit price Cl.	R32.78			R28 715.28	
Estimated Annual Operational Costs:				**R2 856 945.78**	
Maintenance Costs:					
Civil Works:	1%	R15 640 750.72		R156 407.51	
Mechanical Works	4%	R7 820 375.36		R312 815.01	
Electrical Works	4%	R2 936 791.79		R117 471.67	
Total Annual Maintenance Costs:				**R586 694.19**	
Total Operations and Maintenance Cost:				**R3 443 639.97**	
Total annual Volume Treated:				292 000.00	m³/ annum
Unit Cost:				**R11.79**	**/m³**

Summary of Costs: Single Oxidation Pond Plant: 800 m³/day		
Capital Cost:	**R43 454 825.10**	
Operational Cost/annum **(Includes cost of transporting Sewage by truck)**	**R2 856 945.78**	
Maintenance Cost / annum	**R586 694.19**	
Unit Cost per m³ treated	**R11.79**	**/m³**

Plant Size: 0.50 Megalitre

Capital Cost: Aerated Facultative Pond System: 500m^3/Day for Augrabies					
				Unit Cost/Ml	
Preliminary & General Costs:			0.175	R2 617 973.10	
Civil Works:				R8 895 121.12	
Mechanical Equipment (Mixers + Diffused Air)				R8 550 000.00	
Electrical Equipment				R889 512.11	
Electrical Power Supply Line 22kV from Substation (1.5km + Trf)				R330 000.00	R19 539 024.22
Subtotal:				**R21 282 606.33**	
10% Contingency				R2 128 260.63	
Subtotal:				**R23 410 866.97**	
VAT @15%				R3 511 630.04	
Total Expected Project Costs:				**R26 922 497.01**	
Operational Costs:					
Cost to operate fleet of Vacuum Tanker Trucks:			20%	R1 960 200.00	
Personnel Costs: 4 x Process Controllers + Supervizor					
Operateur: Klas 0 tot Klas I	T4 x 2		R126 192.00	R252 384.00	
Proseskontroleur: Klas II & III	T7 x 0			R0.00	
Voorman: Klas IV	T10 x 0			R0.00	
Superintendent: Klas V	T12 x 0			R0.00	
Electricity:					
	Size	Oper. Hours	kW.h/Annum		
			0		
Mixer/Aerators x 8	7.5	8	21900		
Diffused Air Fans x 2	15	24	131400		
Total:			153300		
Rate:	R1.85 R/kW.h			R283 605.00	
Chemicals:		Tons/Annum			
Chlorine Dose:	3 mg/l				
Liters	500000				
kg/day	1.5		0.5475		
Unit price Cl.	R32.78			R17 947.05	
Estimated Annual Operational Costs:				**R2 514 136.05**	
Maintenance Costs:					
Civil Works:	1%	R8 895 121.12		R88 951.21	
Mechanical Works	4%	R8 550 000.00		R342 000.00	
Electrical Works	4%	R1 219 512.11		R48 780.48	
Total Annual Maintenance Costs:				**R479 731.70**	
Total Operations and Maintenance Cost:				**R2 993 867.75**	
Total annual Volume Treated:				182 500.00 m^3/ annum	
Unit Cost:				R16.40 /m^3	

Summary of Costs: Aerated Faculative Pond Plant: 800 m^3/day	
Capital Cost:	**R26 922 497.01**
Operational Cost/annum (Includes cost of transporting Sewage by truck)	**R2 514 136.05**
Maintenance Cost / annum	**R479 731.70**
Unit Cost per m^3 treated	R16.40 /m^3

Plant Size: **0.50 Megalitre**

Capital Cost: Oxidation Pond System: 500m³/Day for Augrabies				
				Unit Cost/Ml
Preliminary & General Costs:		0.175	R7 953 722.53	
Horizontal Flow Reedbed to Filter Algae			R641 136.27	
Civil Works:		0.6	R8 975 907.77	
Mechanical Equipment		0.05	R747 992.31	
Electrical Equipment		0	R0.00	**R19 447 800.18**
Electrical Power Supply Line 22kV from Substation (1.5km + Trf)			R330 000.00	
Subtotal:			**R18 648 758.89**	
10% Contingency			R1 864 875.89	
Subtotal:			**R20 513 634.78**	
VAT @15%			R3 077 045.22	
Total Expected Project Costs:			**R23 590 679.99**	

Operational Costs:

Cost to operate fleet of Vacuum Tanker Trucks:			20%	R1 960 200.00
Personnel Costs: 4 x Process Controllers + Supervizor				
Operateur: Klas 0 tot Klas I	T4 x 2		R126 192.00	R252 384.00
Proseskontroleur: Klas II & III	T7 x 0			R0.00
Voorman: Klas IV	T10 x 0			R0.00
Superintendent: Klas V	T12 x 0			R0.00
Electricity:				
Size	Oper. Hours	kW.h/Annum		
			0	
			0	
Total:			0	
Rate:	R1.85 R/kW.h			R0.00
Chemicals:		Tons/Annum		
Chlorine Dose:	5 mg/l			
Liters	500000			
kg/day	2.5		0.9125	
Unit price Cl.	R32.78			R29 911.75
Estimated Annual Operational Costs:				**R2 242 495.75**

Maintenance Costs:

Civil Works:	1%	R8 975 907.77	R89 759.08
Mechanical Works	4%	R747 992.31	R29 919.69
Electrical Works	4%	R330 000.00	R13 200.00
Total Annual Maintenance Costs:			**R132 878.77**
Total Operations and Maintenance Cost:			**R2 375 374.52**
Total annual Volume Treated:			182 500.00 m³/ annum
Unit Cost:			**R13.02 /m³**

Summary of Costs: Single Oxidation Pond Plant: 800 m³/day	
Capital Cost:	**R23 590 679.99**
Operational Cost/annum **(Includes cost of transporting Sewage by truck)**	**R2 242 495.75**
Maintenance Cost / annum	**R132 878.77**
Unit Cost per m³ treated	**R13.02 /m³**

Plant Size: **0.50 Megalitre**

Capital Cost: RBC Plant System: 500m³/Day for Augrabies				
			Unit Cost/Ml	
Preliminary & General Costs:	0.175	R7 953 722.53		
Civil Works:		R16 292 448.67		
Mechanical Equipment	0.3	R4 887 734.60		
Electrical Equipment	0.1	R1 629 244.87	R45 618 856.27	
Electrical Power Supply Line 22kV from Substation (1.5km + Trf)		R330 000.00		
Subtotal:		**R31 093 150.66**		
10% Contingency		R3 109 315.07		
Subtotal:		**R34 202 465.73**		
VAT @15%		R5 130 369.86		
Total Expected Project Costs:		**R39 332 835.59**		

Operational Costs:

Cost to operate fleet of Vacuum Tanker Trucks:			20%	R1 960 200.00
Personnel Costs: 4 x Process Controllers + Supervizor				
Operateur: Klas 0 tot Klas I	T4 x 2		R126 192.00	R252 384.00
Proseskontroleur: Klas II & III	T7 x 0			R0.00
Voorman: Klas IV	T10 x 0			R0.00
Superintendent: Klas V	T12 x 0			R0.00
Electricity:				
Size	Oper. Hours	kW.h/Annum		
Transfer Pump	5	12	21900	
Bio Rotors	2	24	17520	
Total:			39420	
Rate:	R1.85 R/kW.h			R72 927.00
Chemicals:		Tons/Annum		
Chlorine Dose:	3 mg/l			
Liters	500000			
kg/day	1.5		0.5475	
Unit price Cl.	R32.78			R17 947.05
Estimated Annual Operational Costs:				**R2 303 458.05**

Maintenance Costs:

Civil Works:	1%	R16 292 448.67	R162 924.49
Mechanical Works	4%	R4 887 734.60	R195 509.38
Electrical Works	4%	R1 959 244.87	R78 369.79
Total Annual Maintenance Costs:			**R436 803.67**
Total Operations and Maintenance Cost:			**R2 740 261.72**
Total annual Volume Treated:			182 500.00 m³/ annum
Unit Cost:			**R15.02 /m³**

Summary of Costs: Single Oxidation Pond Plant: 800 m³/day	
Capital Cost:	**R39 332 835.59**
Operational Cost/annum **(Includes cost of transporting Sewage by truck)**	**R2 303 458.05**
Maintenance Cost / annum	**R436 803.67**
Unit Cost per m³ treated	**R15.02 /m³**

Plant Size: 0.45 Megalitre

Capital Cost: Aerated Facultative Pond System: 450m^3/Day for Lutzburg & Cillie				
				Unit Cost/Ml
Preliminary & General Costs:		0.175	R1 907 798.79	
Civil Works:			R8 394 314.69	
Mechanical Equipment (Mixers + Diffused Air)			R7 600 000.00	
Electrical Equipment			R839 431.47	
Electrical Power Supply Line 22kV from Substation (1.5km + Trf)			R330 000.00	R19 487 625.49
Subtotal:			**R19 071 544.95**	
10% Contingency			R1 907 154.50	
Subtotal:			**R20 978 699.45**	
VAT @15%			R3 146 804.92	
Total Expected Project Costs:			**R24 125 504.36**	

Operational Costs:

Cost to operate fleet of Vacuum Tanker Trucks:			15%	R1 470 150.00
Personnel Costs: 4 x Process Controllers + Supervizor				
Operateur: Klas 0 tot Klas I	T4 x 2		R126 192.00	R252 384.00
Proseskontroleur: Klas II & III	T7 x 0			R0.00
Voorman: Klas IV	T10 x 0			R0.00
Superintendent: Klas V	T12 x 0			R0.00
Electricity:				
	Size	Oper. Hours	kW.h/Annum	
			0	
Mixer/Aerators x 8	7.5	8	21900	
Diffused Air Fans x 2	15	24	131400	
Total:			153300	
Rate:	R1.85 R/kW.h			R283 605.00
Chemicals:		Tons/Annum		
Chlorine Dose:	3 mg/l			
Liters	450000			
kg/day	1.35		0.49275	
Unit price Cl.	R32.78			R16 152.35
Estimated Annual Operational Costs:				**R2 022 291.35**

Maintenance Costs:

Civil Works:	1%	R8 394 314.69	R83 943.15
Mechanical Works	4%	R7 600 000.00	R304 000.00
Electrical Works	4%	R1 169 431.47	R46 777.26
Total Annual Maintenance Costs:			**R434 720.41**
Total Operations and Maintenance Cost:			**R2 457 011.75**
Total annual Volume Treated:			164 250.00 m^3/ annum
Unit Cost:			**R14.96 /m^3**

Summary of Costs: Aerated Faculative Pond Plant: 800 m^3/day	
Capital Cost:	**R24 125 504.36**
Operational Cost/annum **(Includes cost of transporting Sewage by truck)**	**R2 022 291.35**
Maintenance Cost / annum	**R434 720.41**
Unit Cost per m^3 treated	**R14.96 /m^3**

Plant Size: **0.45 Megalitre**

Capital Cost: Oxidation Pond System: 450m³/Day for Lutzburg & Cilie				
				Unit Cost/Ml
Preliminary & General Costs:		0.175	R1 907 798.79	
Horizontal Flow Reedbed to Filter Algae			R654 102.44	
Civil Works:		0.6	R6 541 024.43	
Mechanical Equipment		0.05	R545 085.37	
Electrical Equipment		0	R0.00	R15 746 910.67
Electrical Power Supply Line 22kV from Substation (1.5km + Trf)			R330 000.00	
Subtotal:			**R9 978 011.04**	
10% Contingency			R997 801.10	
Subtotal:			**R10 975 812.14**	
VAT @15%			R1 646 371.82	
Total Expected Project Costs:			**R12 622 183.96**	

Operational Costs:					
Cost to operate fleet of Vacuum Tanker Trucks:				15%	R1 470 150.00
Personnel Costs: 4 x Process Controllers + Supervizor					
Operateur: Klas 0 tot Klas I	T4 x 2			R126 192.00	R252 384.00
Proseskontroleur: Klas II & III	T7 x 0				R0.00
Voorman: Klas IV	T10 x 0				R0.00
Superintendent: Klas V	T12 x 0				R0.00
Electricity:					
	Size	Oper. Hours	kW.h/Annum		
				0	
				0	
Total:				0	
Rate:	R1.85 R/kW.h				R0.00
Chemicals:			Tons/Annum		
Chlorine Dose:	5 mg/l				
Liters	450000				
kg/day	2.25			0.82125	
Unit price Cl.	R32.78				R26 920.58
Estimated Annual Operational Costs:					**R1 749 454.58**

Maintenance Costs:			
Civil Works:	1%	R6 541 024.43	R65 410.24
Mechanical Works	4%	R545 085.37	R21 803.41
Electrical Works	4%	R330 000.00	R13 200.00
Total Annual Maintenance Costs:			**R100 413.66**
Total Operations and Maintenance Cost:			**R1 849 868.23**
Total annual Volume Treated:			164 250.00 m³/ annum
Unit Cost:			**R11.26 /m³**

Summary of Costs: Single Oxidation Pond Plant: 800 m³/day	
Capital Cost:	**R12 622 183.96**
Operational Cost/annum (Includes cost of transporting Sewage by truck)	**R1 749 454.58**
Maintenance Cost / annum	**R100 413.66**
Unit Cost per m³ treated	**R11.26 /m³**

Plant Size: **0.45 Megalitre**

Capital Cost: RBC Plant System: 450m³/Day for Lutzburg & Cillie					
					Unit Cost/Ml
Preliminary & General Costs:			0.175	R7 953 722.53	
Civil Works:				R14 663 203.80	
Mechanical Equipment			0.3	R4 398 961.14	
Electrical Equipment			0.1	R1 466 320.38	R45 618 856.27
Electrical Power Supply Line 22kV from Substation (1.5km + Trf)				R330 000.00	
Subtotal:				**R28 812 207.85**	
10% Contingency				R2 881 220.79	
Subtotal:				**R31 693 428.64**	
VAT @15%				R4 754 014.30	
Total Expected Project Costs:				**R36 447 442.93**	
Operational Costs:					
Cost to operate fleet of Vacuum Tanker Trucks:			15%	R1 470 150.00	
Personnel Costs: 4 x Process Controllers + Supervizor					
Operateur: Klas 0 tot Klas I	T4 x 2		R126 192.00	R252 384.00	
Proseskontroleur: Klas II & III	T7 x 0			R0.00	
Voorman: Klas IV	T10 x 0			R0.00	
Superintendent: Klas V	T12 x 0			R0.00	
Electricity:					
	Size	Oper. Hours	kW.h/Annum		
Transfer Pump	5	12	21900		
Bio Rotors	2	24	17520		
Total:			39420		
Rate:	R1.85 R/kW.h			R72 927.00	
Chemicals:		Tons/Annum			
Chlorine Dose:	3 mg/l				
Liters	450000				
kg/day	1.35		0.49275		
Unit price Cl.	R32.78			R16 152.35	
Estimated Annual Operational Costs:				**R1 811 613.35**	
Maintenance Costs:					
Civil Works:	1%	R14 663 203.80		R146 632.04	
Mechanical Works	4%	R4 398 961.14		R175 958.45	
Electrical Works	4%	R1 796 320.38		R71 852.82	
Total Annual Maintenance Costs:				**R394 443.30**	
Total Operations and Maintenance Cost:				**R2 206 056.64**	
Total annual Volume Treated:				164 250.00	m³/ annum
Unit Cost:				**R13.43**	**/m³**

Summary of Costs: Single Oxidation Pond Plant: 800 m³/day		
Capital Cost:	**R36 447 442.93**	
Operational Cost/annum **(Includes cost of transporting Sewage by truck)**	**R1 811 613.35**	
Maintenance Cost / annum	**R394 443.30**	
Unit Cost per m³ treated	**R13.43**	**/m³**

Plant Size: **0.25 Megalitre**

Capital Cost: Aerated Facultative Pond System: 250m³/Day for Riemvasmaak Villages					
					Unit Cost/Ml
Preliminary & General Costs:			0.175	R1 907 798.79	
Civil Works:				R5 517 281.00	
Mechanical Equipment (Mixers + Diffused Air)				R6 650 000.00	
Electrical Equipment				R551 728.10	
Electrical Power Supply Line 22kV from Substation (1.5km + Trf)				R330 000.00	R30 126 912.40
Subtotal:				**R14 956 807.89**	
10% Contingency				R1 495 680.79	
Subtotal:				**R16 452 488.68**	
VAT @15%				R2 467 873.30	
Total Expected Project Costs:				**R18 920 361.98**	
Operational Costs:					
Cost to operate fleet of Vacuum Tanker Trucks:			10%	R980 100.00	
Personnel Costs: 4 x Process Controllers + Supervizor					
Operateur: Klas 0 tot Klas I	T4 x 2		R126 192.00	R252 384.00	
Proseskontroleur: Klas II & III	T7 x 0			R0.00	
Voorman: Klas IV	T10 x 0			R0.00	
Superintendent: Klas V	T12 x 0			R0.00	
Electricity:					
	Size	Oper. Hours	kW.h/Annum		
			0		
Mixer/Aerators x 8	4	8	11680		
Diffused Air Fans x 2	8	24	70080		
Total:			81760		
Rate:	R1.85 R/kW.h			R151 256.00	
Chemicals:		Tons/Annum			
Chlorine Dose:	3 mg/l				
Liters	250000				
kg/day	0.75		0.27375		
Unit price Cl.	R32.78			R8 973.53	
Estimated Annual Operational Costs:				**R1 392 713.53**	
Maintenance Costs:					
Civil Works:	1%	R5 517 281.00		R55 172.81	
Mechanical Works	4%	R6 650 000.00		R266 000.00	
Electrical Works	4%	R881 728.10		R35 269.12	
Total Annual Maintenance Costs:				**R356 441.93**	
Total Operations and Maintenance Cost:				**R1 749 155.46**	
Total annual Volume Treated:				91 250.00	m³/ annum
Unit Cost:				R19.17	/m³

Summary of Costs: Aerated Faculative Pond Plant: 800 m³/day	
Capital Cost:	**R18 920 361.98**
Operational Cost/annum	**R1 392 713.53**
(Includes cost of transporting Sewage by truck)	
Maintenance Cost / annum	**R356 441.93**
Unit Cost per m³ treated	R19.17 /m³

Plant Size: **0.25 Megalitre**

Capital Cost: Oxidation Pond System: 250m³/Day for Riemvasmaak Villages					
					Unit Cost/Ml
Preliminary & General Costs:			0	R0.00	
Horizontal Flow Reedbed to Filter Algae				R429 918.00	
Civil Works:			0.6	R4 299 180.00	
Mechanical Equipment			0.05	R545 085.37	
Electrical Equipment			0	R0.00	**R19 377 061.48**
Electrical Power Supply Line 22kV from Substation (1.5km + Trf)				R330 000.00	
Subtotal:				**R5 604 183.37**	
10% Contingency				R560 418.34	
Subtotal:				**R6 164 601.71**	
VAT @15%				R924 690.26	
Total Expected Project Costs:				**R7 089 291.96**	
Operational Costs:					
Cost to operate fleet of Vacuum Tanker Trucks:			10%	R980 100.00	
Personnel Costs: 4 x Process Controllers + Supervizor					
Operateur: Klas 0 tot Klas I	T4 x 2		R126 192.00	R252 384.00	
Proseskontroleur: Klas II & III	T7 x 0			R0.00	
Voorman: Klas IV	T10 x 0			R0.00	
Superintendent: Klas V	T12 x 0			R0.00	
Electricity:					
	Size	Oper. Hours	kW.h/Annum		
			0		
			0		
Total:			0		
Rate:	R1.85 R/kW.h			R0.00	
Chemicals:		Tons/Annum			
Chlorine Dose:	5 mg/l				
Liters	250000				
kg/day	1.25		0.45625		
Unit price Cl.	R32.78			R14 955.88	
Estimated Annual Operational Costs:				**R1 247 439.88**	
Maintenance Costs:					
Civil Works:	1%	R4 299 180.00		R42 991.80	
Mechanical Works	4%	R545 085.37		R21 803.41	
Electrical Works	4%	R330 000.00		R13 200.00	
Total Annual Maintenance Costs:				**R77 995.21**	
Total Operations and Maintenance Cost:				**R1 325 435.09**	
Total annual Volume Treated:				91 250.00	m³/ annum
Unit Cost:				**R14.53**	**/m³**

Summary of Costs: Single Oxidation Pond Plant: 800 m³/day		
Capital Cost:	**R7 089 291.96**	
Operational Cost/annum (Includes cost of transporting Sewage by truck)	**R1 247 439.88**	
Maintenance Cost / annum	**R77 995.21**	
Unit Cost per m³ treated	**R14.53**	**/m³**

Plant Size: **0.25 Megalitre**

Capital Cost: RBC Plant System: 250m^3/Day for Riemvasmaak Villages					
					Unit Cost/Ml
Preliminary & General Costs:			0.175	R7 953 722.53	
Civil Works:				R8 146 224.33	
Mechanical Equipment			0.3	R2 443 867.30	
Electrical Equipment			0.1	R814 622.43	**R45 618 856.27**
Electrical Power Supply Line 22kV from Substation (1.5km + Trf)				R330 000.00	
Subtotal:				**R19 688 436.60**	
10% Contingency				R1 968 843.66	
Subtotal:				**R21 657 280.26**	
VAT @15%				R3 248 592.04	
Total Expected Project Costs:				**R24 905 872.29**	
Operational Costs:					
Cost to operate fleet of Vacuum Tanker Trucks:			10%	R980 100.00	
Personnel Costs: 4 x Process Controllers + Supervizor					
Operateur: Klas 0 tot Klas I	T4 x 2		R126 192.00	R252 384.00	
Proseskontroleur: Klas II & III	T7 x 0			R0.00	
Voorman: Klas IV	T10 x 0			R0.00	
Superintendent: Klas V	T12 x 0			R0.00	
Electricity:					
Size		Oper. Hours	kW.h/Annum		
Transfer Pump	3	12	13140		
Bio Rotors	2	24	17520		
Total:			30660		
Rate:	R1.85 R/kW.h			R56 721.00	
Chemicals:		Tons/Annum			
Chlorine Dose:	3 mg/l				
Liters	250000				
kg/day	0.75		0.27375		
Unit price Cl.	R32.78			R8 973.53	
Estimated Annual Operational Costs:				**R1 298 178.53**	
Maintenance Costs:					
Civil Works:	1%	R8 146 224.33		R81 462.24	
Mechanical Works	4%	R2 443 867.30		R97 754.69	
Electrical Works	4%	R1 144 622.43		R45 784.90	
Total Annual Maintenance Costs:				**R225 001.83**	
Total Operations and Maintenance Cost:				**R1 523 180.36**	
Total annual Volume Treated:				91 250.00	m^3/ annum
Unit Cost:				**R16.69**	**/m^3**

Summary of Costs: Single Oxidation Pond Plant: 800 m^3/day		
Capital Cost:	**R24 905 872.29**	
Operational Cost/annum (Includes cost of transporting Sewage by truck)	**R1 298 178.53**	
Maintenance Cost / annum	**R225 001.83**	
Unit Cost per m^3 treated	**R16.69**	**/m^3**

ANNEXURE D

DETAIL COST ESTIMATE OF THE CHOSEN OPTION

(Project Construction Cost)

COST ESTIMATE: KAKAMAS & SURROUNDS WASTEWATER TREATMENT PROJECT

								Cost	
PRELIMINARY AND GENERAL COSTS									
Taken as 17.5% of Construction Value								R 12 669 578.93	**R 12 669 578.93**
KAKAMAS 2.0 Ml/day CONVENTIONAL OXIDATION POND SYSTEM									
				Unit	Qty	**Rate**		**Cost:**	
Operational Building/Shelter									
Converted Shipping Container for Shelter/Ablution Facility				Ea.	1	R 149 855.00		R 149 855.00	
Structural Steel Canopy over Inlet Works				Ea.	1	R 38 466.00		R 38 466.00	
Inlet Works									
Screenings Removal - Hand-Raked Screen				No.	1	R 9 631.00		R 9 631.00	
- Mechanical Screen				No.	1	R 281 770.00		R 281 770.00	
Grit Channels				No.	1	R 119 558.00		R 119 558.00	
Parshall Flume				No.	1	R 75 000.00		R 75 000.00	
Ultrasonic Open Channel Flowmeter				No.	1	R 29 885.00		R 29 885.00	
Splitterbox				No.	1	R 25 895.00		R 25 895.00	
Anaerobic Ponds	Earthworks Factor:		1.62%						
Earthworks: Cut to Fill				m^3	4312	R 55.00		R 237 160.00	
Hard Rock excavation				m^3	647	R 650.00		R 420 420.00	
HDPE Linings				m^2	4173	R 72.00		R 300 456.00	
Inlet Structures				No.	1	R 9 500.00		R 9 500.00	
Outlet Structures				No.	1	R 12 850.00		R 12 850.00	
Recycle Pumps (Circulate Top to Bottom of Pond) Ratio - 1:1				No.	1	R 126 859.00		R 126 859.00	
Facultative Ponds									
Earthworks: Cut to Fill				m^3	38185	R 55.00		R 2 100 175.00	
Hard Rock excavation				m^3	3819	R 650.00		R 2 482 025.00	
HDPE Linings				m^2	31007	R 72.00		R 2 232 504.00	
Inlet Structures				No.	2	R 9 500.00		R 19 000.00	
Outlet Structures				No.	2	R 12 850.00		R 25 700.00	
Aerobic Ponds									
Earthworks: Cut to Fill				m^3	14666	R 55.00		R 806 630.00	
Hard Rock excavation				m^3	2200	R 650.00		R 1 429 935.00	
HDPE Linings				m^2	12831	R 72.00		R 923 832.00	
Inlet Structures				No.	3	R 9 500.00		R 28 500.00	
Outlet Structures				No.	3	R 12 850.00		R 38 550.00	
Final Storage Pond									
Earthworks: Cut to Fill				m^3	12040	R 55.00		R 662 200.00	
Hard Rock excavation				m^3	1806	R 650.00		R 1 173 900.00	
HDPE Linings				m^2	31007	R 72.00		R 2 232 504.00	
Inlet Structures				No.	1	R 9 500.00		R 9 500.00	
Outlet Structures				No.	1	R 12 850.00		R 12 850.00	
Recycle Pumps: (Recycle back to Facultative Pond) Ratio- 1:6				No.	1	R 126 859.00		R 126 859.00	
Horizontal Flow Reedbed									
Earthworks: Cut to Fill				m^3	19055	R 55.00		R 1 048 025.00	
HDPE Linings				m^3	5717	R 74.67		R 426 851.06	
Hard Rock excavation				m^2	1143	R 650.00		R 743 145.00	
Gabion Inlet & Outlet Structures				No.	1	R 37 650.00		R 37 650.00	
Outlet Structures				No.	1	R 19 925.00		R 19 925.00	
Planting of reeds				m^2	23950	R 45.00		R 1 077 750.00	
Disinfection	Conc Volume	Rate							
Chlorine Contact Tank		27.5	R 4 800.00	Ea.	1	R 132 000.00		R 132 000.00	
Dosing Pumps (1 Duty + 1 Standby) & Day Tanks				No.	1	R 90 870.00		R 90 870.00	
Flow Measurement (Ultrasonic + Logger & V-Notch Weir)				No.	1	R 48 950.00		R 48 950.00	
Interconnecting Pipework between Ponds: (160mm dia uPVC Cl.6)				m	527	R 176.55		R 93 041.85	
									R 19 860 176.91
KAKAMAS HOSPITAL TO WWTP WASTEWATER RISING MAIN:									
		Qty		Rate	Cost:				
Clear and Grub and stockpile topsoil		3840 10	38400	R 6.40	R 245 760.00			R 1 572 864.00	
Pipes:									
250mm PVC Class 6			340	R 396.00	R 134 640.00				
250mm PVC Class 9			3500	R 451.00	R 1 578 500.00				
		3840			R 1 713 140.00			R 1 713 140.00	
Valves:			**No.**	**Price:**					
Air Valves			8	19254				R 154 032.00	
Scour Valves			3	22230				R 66 690.00	
Isolating Valves:			2	33320				R 66 640.00	
VALVE CHAMBERS			**No.**	**Price:**					
Air Valve			8	8259				R 66 072.00	
Scour Valve			3	3420				R 10 260.00	
Isolating Valve			2	4831				R 9 662.00	
Excavation			**Length**	**Width**	**Volume**	**R/ m**	**R/m³**		
Normal:			3840	0.85	4080	R 65.00		R 249 600.00	
Intermediate:					1020		R 450.00	R 459 000.00	
Rock:					2040		R 650.00	R 1 326 000.00	
									R 5 693 960.00

WWTP TO ORANGE RIVER: TREATED EFFLUENT GRAVITY MAIN:								
		Qty	Rate	Cost:				
Clear and Grub and stockpile topsoil	3870	38700	R 6.40	R 247 680.00			R 1 585 152.00	
	10							
Pipes:		**Length**	**R/m**	**Cost:**				
300mm PVC Class 9		3870	R 630.50	R 2 440 035.00			R 2 440 035.00	
	3870							
Valves:		**No.**	**Price:**					
Air Valves		8	19254				R 154 032.00	
Scour Valves		2	22230				R 44 460.00	
Isolating Valves:		2	33320				R 66 640.00	
VALVE CHAMBERS		**No.**	**Price:**					
Air Valve		8	8259				R 66 072.00	
Scour Valve		2	3420				R 6 840.00	
Isolating Valve		2	4831				R 9 662.00	
Excavation		**Length**	**Width**	**Volume**	**R/ m**	**R/m^3**		
Normal:		3870	0.9	4353.75	R 65.00		R 251 550.00	
Intermediate:				653.0625		R 450.00	R 293 878.13	
Rock:				1306.125		R 650.00	R 848 981.25	
								R 5 767 302.38
ELECTRICAL POWER SUPPLY LINE								
	2500	Qty	Rate	Cost:				
Wooden Pole Structures								
11m, 160-180mm top diameter		34	R 2 480.00	R84 320.00			R 84 320.00	
A-frame/steel cross arm		34	R 1 720.00	R58 480.00			R 58 480.00	
H-Pole Structures		4	R 17 500.00	R70 000.00			R 70 000.00	
Drilling of pole holes		34	R 1 500.00	R51 000.00			R 51 000.00	
Stays & Anchors		72	R 1 080.00	R77 760.00			R 77 760.00	
Conductors								
Fox Conductor		7500	R 20.00	R150 000.00			R 150 000.00	
Section links cut-outs or disconnectors		2	R 5 120.00	R10 240.00			R 10 240.00	
Expulsion fuses (set of 3) for above		2	R 6 650.00	R13 300.00			R 13 300.00	
Pole Mounted Transformers								
50 kVA 11kV/420V Dyn11		1	R 35 000.00	R35 000.00				
LV Cables		**Length**	**Width**	**Volume**	**R/ m**	**R/m^3**		
LV cable trench: 500mm wide x 900mm deep		75	0.5	34	R 65.00		R4 875.00	
Intermediate:				5.1		R 450.00	R 2 295.00	
Rock:				10.2		R 650.00	R 6 630.00	
Pole Mounted Distribution Kiosk		1	R 15 400.00	R15 400.00			R 15 400.00	
Maximum Demand and Consumption Metering		1	R 5 500.00	R5 500.00			R 5 500.00	
								R 549 800.00
Subtotal for Kakamas WWTP							**R 31 871 239.28**	

ALHEIT & MARCHAND 0.8 Ml/day AERATED FACULTATIVE POND SYSTEM			Unit	Qty	Unit Cost:	Cost:	
Operational Building/Shelter							
Converted Shipping Container for Shelter/Ablution Facility			Ea.	1	R 149 855.00	R 149 855.00	
Structural Steel Canopy over Inlet Works			Ea.	1	R 38 466.00	R 38 466.00	
Inlet Works							
Screenings Removal - Hand-Raked Screen			No.	1	R 7 635.00	R 7 635.00	
- Mechanical Screen			No.	1	R 251 775.00	R 251 775.00	
Grit Channels			No.	2	R 219 558.00	R 439 116.00	
Parshall Flume			No.	1	R 75 000.00	R 75 000.00	
Ultrasonic Open Channel Flowmeter			No.	1	R 29 885.00	R 29 885.00	
Facultative Ponds	Earthworks Factor:	14.60%					
Earthworks: Cut to Fill			m^3	44034	R 55.00	R 2 421 870.00	
Hard Rock excavation			m^3	6605	R 650.00	R 4 293 315.00	
HDPE Linings			m^2	11418	R 72.00	R 822 096.00	
Inlet Structures			No.	2	R 9 500.00	R 19 000.00	
Outlet Structures			No.	2	R 12 850.00	R 25 700.00	
Mechanical Equipment							
Wind powered Floating Aerator/Mixers			No.	4	R 589 825.00	R 2 359 300.00	
Medium Bubble Diffused Air aeration system Stainless Steel			No.	2	R 2 268 980.00	R 4 537 960.00	
Low Pressure Centrifugal Fam c/w Motor			No.	2	R 385 722.00	R 771 444.00	
Floating curtians to direct flow			No.	4	R 229 801.00	R 919 204.00	
Maintenance Access Platform			No.	2	R 161 046.00	R 322 092.00	
Electrical Switchgear & DO Control Syste			No.	1	R 1 645 583.09	R 1 645 583.09	
Aerobic Ponds							
Earthworks: Cut to Fill			m^3	8544	R 55.00	R 469 920.00	
Hard Rock excavation			m^3	1282	R 650.00	R 833 040.00	
HDPE Linings			m^2	5714	R 72.00	R 411 408.00	
Inlet Structures			No.	2	R 9 500.00	R 19 000.00	
Outlet Structures			No.	2	R 12 850.00	R 25 700.00	
Disinfection	Conc Volume	Rate					
Chlorine Contact Tank	25	R 4 800.00	Ea.	1	R 120 000.00	R 120 000.00	
Dosing Pumps (1 Duty + 1 Standby) & Day Tanks			No.	1	R 90 870.00	R 90 870.00	
Flow Measurement (Ultrasonic + Logger & V-Notch Weir)			No.	1	R 48 950.00	R 48 950.00	
Interconnecting Pipework between Ponds: (160mm dia uPVC Cl.6)			m	413	R 176.55	R 72 968.12	
							R 21 221 152.21

ELECTRICAL POWER SUPPLY LINE (ALHEIT & MARCHAND)	1500	Qty	Rate	Cost:				
Wooden Pole Structures								
11m, 160-180mm top diameter		20	R 2 480.00	R49 600.00			R 49 600.00	
A-frame/steel cross arm		20	R 1 720.00	R34 400.00			R 34 400.00	
H-Pole Structures		2	R 17 500.00	R35 000.00			R 35 000.00	
Drilling of pole holes		34	R 1 500.00	R51 000.00			R 51 000.00	
Stays & Anchors		22	R 1 080.00	R23 760.00			R 23 760.00	
Conductors								
Fox Conductor		4500	R 20.00	R90 000.00			R 90 000.00	
Section links cut-outs or disconnectors		1	R 5 120.00	R5 120.00			R 5 120.00	
Expulsion fuses (set of 3) for above		1	R 6 650.00	R6 650.00			R 6 650.00	
Pole Mounted Transformers								
16 kVA 11kV/420V Dyn11		1	R 16 200.00	R16 200.00				
LV Cables		**Length**	**Width**	**Volume**	**R/ m**	**R/m³**		
LV cable trench: 500mm wide x 900mm deep		73	0.5	33	R 65.00		R4 745.00	
Intermediate:				4.95		R 450.00	R 2 227.50	
Rock:				9.9		R 650.00	R 6 435.00	
Pole Mounted Distribution Kiosk		1	R 15 400.00	R15 400.00			R 15 400.00	
Maximum Demand and Consumption Metering		1	R 5 500.00	R5 500.00			R 5 500.00	
								R 329 837.50
Subtotal for Alheit + Marchand WWTP							**R21 550 989.71**	

AUGRABIES VILLAGE 0.5 Ml/day AERATED FACULTATIVE POND SYSTEM

			Unit	Qty	Unit Cost:	Cost:	
Operational Building/Shelter							
Converted Shipping Container for Shelter/Ablution Facility			Ea.	1	R 149 855.00	R 149 855.00	
Structural Steel Canopy over Inlet Works			Ea.	1	R 38 466.00	R 38 466.00	
Inlet Works							
Screenings Removal - Hand-Raked Screen			No.	1	R 7 635.00	R 7 635.00	
- Mechanical Screen			No.	1	R 241 775.00	R 241 775.00	
Grit Channels			No.	2	R 219 558.00	R 439 116.00	
Parshall Flume			No.	1	R 75 000.00	R 75 000.00	
Ultrasonic Open Channel Flowmeter			No.	1	R 29 885.00	R 29 885.00	
Facultative Ponds	Earthworks Factor:	6.93%					
Earthworks: Cut to Fill			m^3	27442	R 55.00	R 1 509 310.00	
Hard Rock excavation			m^3	7547	R 650.00	R 4 905 257.50	
HDPE Linings			m^2	8192	R 72.00	R 589 824.00	
Inlet Structures			No.	2	R 9 500.00	R 19 000.00	
Outlet Structures			No.	2	R 12 850.00	R 25 700.00	
Mechanical Equipment							
Wind powered Floating Aerator/Mixers			No.	4	R 589 825.00	R 2 359 300.00	
Medium Bubble Diffused Air aeration system Stainless Steel			No.	2	R 2 268 980.00	R 4 537 960.00	
Low Pressure Centrifugal Fam c/w Motor			No.	2	R 385 722.00	R 771 444.00	
Floating curtians to direct flow			No.	4	R 229 801.00	R 919 204.00	
Maintenance Access Platform			No.	2	R 161 046.00	R 322 092.00	
Electrical Switchgear & DO Control Syste			No.	1	R 1 270 731.59	R 1 270 731.59	
Aerobic Ponds							
Earthworks: Cut to Fill			m^3	5094	R 55.00	R 280 170.00	
Hard Rock excavation			m^3	1630	R 650.00	R 1 059 552.00	
HDPE Linings			m^2	3762	R 72.00	R 270 864.00	
Inlet Structures			No.	2	R 9 500.00	R 19 000.00	
Outlet Structures			No.	2	R 12 850.00	R 25 700.00	
Disinfection	Conc Volume	Rate					
Chlorine Contact Tank	25	R 4 800.00	Ea.	1	R 120 000.00	R 120 000.00	
Dosing Pumps (1 Duty + 1 Standby) & Day Tanks			No.	1	R 90 870.00	R 90 870.00	
Flow Measurement (Ultrasonic + Logger & V-Notch Weir)			No.	1	R 48 950.00	R 48 950.00	
Interconnecting Pipework between Ponds: (160mm dia uPVC Cl.6)			m	418	R 176.55	R 73 797.90	
							R 20 200 458.99

ELECTRICAL POWER SUPPLY LINE (AUGRABIES VILLAGE)								
	1500	Qty	Rate	Cost:				
Wooden Pole Structures								
11m, 160-180mm top diameter		20	R 2 480.00	R49 600.00			R 49 600.00	
A-frame/steel cross arm		20	R 1 720.00	R34 400.00			R 34 400.00	
H-Pole Structures		2	R 17 500.00	R35 000.00			R 35 000.00	
Drilling of pole holes		34	R 1 500.00	R51 000.00			R 51 000.00	
Stays & Anchors		22	R 1 080.00	R23 760.00			R 23 760.00	
Conductors								
Fox Conductor		4500	R 20.00	R90 000.00			R 90 000.00	
Section links cut-outs or disconnectors		1	R 5 120.00	R5 120.00			R 5 120.00	
Expulsion fuses (set of 3) for above		1	R 6 650.00	R6 650.00			R 6 650.00	
Pole Mounted Transformers								
16 kVA 11kV/420V Dyn11		1	R 16 200.00	R16 200.00				
LV Cables		**Length**	**Width**	**Volume**	**R/ m**	**R/m^3**		
LV cable trench: 500mm wide x 900mm deep		77	0.5	35	R 65.00		R5 005.00	
Intermediate:				5.25		R 450.00	R 2 362.50	
Rock:				10.5		R 650.00	R 6 825.00	
Pole Mounted Distribution Kiosk		1	R 15 400.00	R15 400.00			R 15 400.00	
Maximum Demand and Consumption Metering		1	R 5 500.00	R5 500.00			R 5 500.00	
								R 330 622.50
Subtotal for Augrabies Village WWTP							**R20 531 081.49**	

LUTZBURG & CILLIE VILLAGES: 0.45 Ml/day CONVENTIONAL OXIDATION POND SYSTEM

			Unit	Qty	Rate	Cost:	
Operational Building/Shelter							
Converted Shipping Container for Shelter/Ablution Facility			Ea.	1	R 149 855.00	R 149 855.00	
Structural Steel Canopy over Inlet Works			Ea.	1	R 38 466.00	R 38 466.00	
Inlet Works							
Screenings Removal - Hand-Raked Screen			No.	1	R 9 631.00	R 9 631.00	
- Mechanical Screen			No.	1	R 281 770.00	R 281 770.00	
Grit Channels			No.	2	R 219 558.00	R 439 116.00	
Parshall Flume			No.	1	R 75 000.00	R 75 000.00	
Ultrasonic Open Channel Flowmeter			No.	1	R 29 885.00	R 29 885.00	
Splitterbox			No.	1	R 25 895.00	R 25 895.00	
Anaerobic Ponds	Earthworks Factor:	6.50%					
Earthworks: Cut to Fill			m^3	3885	R 60.00	R 233 100.00	
Hard Rock excavation			m^3	583	R 650.00	R 378 787.50	
HDPE Linings			m^2	1198	R 74.67	R 89 459.57	
Inlet Structures			No.	2	R 9 500.00	R 19 000.00	
Outlet Structures			No.	2	R 12 850.00	R 25 700.00	
Recycle Pumps (Circulate Top to Bottom of Pond) Ratio - 1:1			No.	2	R 126 859.00	R 253 718.00	
Facultative Ponds							
Earthworks: Cut to Fill			m^3	11820	R 60.00	R 709 200.00	
Hard Rock excavation			m^3	1773	R 650.00	R 1 152 450.00	
HDPE Linings			m^2	8812	R 74.67	R 658 028.17	
Inlet Structures			No.	1	R 9 500.00	R 9 500.00	
Outlet Structures			No.	1	R 12 850.00	R 12 850.00	
Aerobic Ponds							
Earthworks: Cut to Fill			m^3	4614	R 60.00	R 276 840.00	
Hard Rock excavation			m^3	692	R 650.00	R 449 865.00	
HDPE Linings			m^2	3753	R 74.67	R 280 251.90	
Inlet Structures			No.	3	R 9 500.00	R 28 500.00	
Outlet Structures			No.	3	R 12 850.00	R 38 550.00	
Final Storage Pond							
Earthworks: Cut to Fill			m^3	3790	R 60.00	R 227 400.00	
Hard Rock excavation			m^3	569	R 650.00	R 369 525.00	
HDPE Linings			m^2	2687	R 74.67	R 200 649.31	
Inlet Structures			No.	1	R 9 500.00	R 9 500.00	
Outlet Structures			No.	1	R 12 850.00	R 12 850.00	
Recycle Pumps: (Recycle back to Facultative Pond) Ratio- 1:6			No.	1	R 126 859.00	R 126 859.00	
Horizontal Flow Reedbed							
Earthworks: Cut to Fill			m^3	4793	R 60.00	R 287 580.00	
HDPE Linings			m^3	1438	R 74.67	R 107 367.99	
Hard Rock excavation			m^2	216	R 650.00	R 140 195.25	
Gabion Inlet & Outlet Structures			No.	1	R 37 650.00	R 37 650.00	
Outlet Structures			No.	1	R 19 925.00	R 19 925.00	
Planting of reeds			m^2	4500	R 45.00	R 202 500.00	
Disinfection	Conc Volume	Rate					
Chlorine Contact Tank	25	R 4 800.00	Ea.	1	R 120 000.00	R 120 000.00	
Dosing Pumps (1 Duty + 1 Standby) & Day Tanks			No.	1	R 90 870.00	R 90 870.00	
Flow Measurement (Ultrasonic + Logger & V-Notch Weir)			No.	1	R 48 950.00	R 48 950.00	
Interconnecting Pipework between Ponds: (160mm dia uPVC Cl.6)			m	410	R 176.55	R 72 385.50	
							R 7 739 625.19

ELECTRICAL POWER SUPPLY LINE (LUTZBURG & CILLIE VILLAGE)								
	1500	Qty	Rate	Cost:				
Wooden Pole Structures								
11m, 160-180mm top diameter		20	R 2 480.00	R49 600.00			R 49 600.00	
A-frame/steel cross arm		20	R 1 720.00	R34 400.00			R 34 400.00	
H-Pole Structures		2	R 17 500.00	R35 000.00			R 35 000.00	
Drilling of pole holes		34	R 1 500.00	R51 000.00			R 51 000.00	
Stays & Anchors		22	R 1 080.00	R23 760.00			R 23 760.00	
Conductors								
Fox Conductor		4500	R 20.00	R90 000.00			R 90 000.00	
Section links cut-outs or disconnectors		1	R 5 120.00	R5 120.00			R 5 120.00	
Expulsion fuses (set of 3) for above		1	R 6 650.00	R6 650.00			R 6 650.00	
Pole Mounted Transformers								
16 kVA 11kV/420V Dyn11		1	R 16 200.00	R16 200.00				
LV Cables		**Length**	**Width**	**Volume**	**R/ m**	**R/m³**		
LV cable trench: 500mm wide x 900mm deep		77	0.5	35	R 65.00		R5 005.00	
Intermediate:				5.25		R 450.00	R 2 362.50	
Rock:				10.5		R 650.00	R 6 825.00	
Pole Mounted Distribution Kiosk		1	R 15 400.00	R15 400.00			R 15 400.00	
Maximum Demand and Consumption Metering		1	R 5 500.00	R5 500.00			R 5 500.00	
								R 330 622.50
Subtotal for Lutzburg & Cillie Villages WWTP							**R8 070 247.69**	

RIEMVASMAAK VILLAGES: 0.25 Ml/day CONVENTIONAL OXIDATION POND SYSTEM

Item			Unit	Qty	Rate	Cost:	
Operational Building/Shelter							
Converted Shipping Container for Shelter/Ablution Facility			Ea.	1	R 149 855.00	R 149 855.00	
Structural Steel Canopy over Inlet Works			Ea.	1	R 38 466.00	R 38 466.00	
Inlet Works							
Screenings Removal - Hand-Raked Screen			No.	1	R 9 631.00	R 9 631.00	
- Mechanical Screen			No.	1	R 281 770.00	R 281 770.00	
Grit Channels			No.	2	R 219 558.00	R 439 116.00	
Parshall Flume			No.	1	R 75 000.00	R 75 000.00	
Ultrasonic Open Channel Flowmeter			No.	1	R 29 885.00	R 29 885.00	
Splitterbox			No.	1	R 25 895.00	R 25 895.00	
Anaerobic Ponds	Earthworks Factor:	4.00%					
Earthworks: Cut to Fill			m^3	2769	R 60.00	R 166 140.00	
Hard Rock excavation			m^3	969	R 650.00	R 629 947.50	
HDPE Linings			m^2	482	R 74.67	R 35 992.92	
Inlet Structures			No.	2	R 9 500.00	R 19 000.00	
Outlet Structures			No.	2	R 12 850.00	R 25 700.00	
Recycle Pumps (Circulate Top to Bottom of Pond) Ratio - 1:1			No.	2	R 126 859.00	R 253 718.00	
Facultative Ponds							
Earthworks: Cut to Fill			m^3	3815	R 60.00	R 228 900.00	
Hard Rock excavation			m^3	954	R 650.00	R 619 937.50	
HDPE Linings			m^2	2404	R 74.67	R 179 516.54	
Inlet Structures			No.	1	R 9 500.00	R 9 500.00	
Outlet Structures			No.	1	R 12 850.00	R 12 850.00	
Aerobic Ponds							
Earthworks: Cut to Fill			m^3	2633	R 60.00	R 157 980.00	
Hard Rock excavation			m^3	658	R 650.00	R 427 862.50	
HDPE Linings			m^2	716	R 74.67	R 53 466.66	
Inlet Structures			No.	3	R 9 500.00	R 28 500.00	
Outlet Structures			No.	3	R 12 850.00	R 38 550.00	
Final Storage Pond							
Earthworks: Cut to Fill			m^3	2141	R 60.00	R 128 460.00	
Hard Rock excavation			m^3	642	R 650.00	R 417 495.00	
HDPE Linings			m^2	1619	R 74.67	R 120 897.37	
Inlet Structures			No.	1	R 9 500.00	R 9 500.00	
Outlet Structures			No.	1	R 12 850.00	R 12 850.00	
Recycle Pumps: (Recycle back to Facultative Pond) Ratio- 1:6			No.	1	R 126 859.00	R 126 859.00	
Horizontal Flow Reedbed							
Earthworks: Cut to Fill			m^3	2600	R 60.00	R 156 000.00	
HDPE Linings			m^3	780	R 74.67	R 58 242.60	
Hard Rock excavation			m^2	585	R 650.00	R 380 250.00	
Gabion Inlet & Outlet Structures			No.	1	R 37 650.00	R 37 650.00	
Outlet Structures			No.	1	R 19 925.00	R 19 925.00	
Planting of reeds			m^2	2500	R 45.00	R 112 500.00	
Disinfection	Conc Volume	Rate					
Chlorine Contact Tank	25	R 4 800.00	Ea.	1	R 120 000.00	R 120 000.00	
Dosing Pumps (1 Duty + 1 Standby) & Day Tanks			No.	1	R 90 870.00	R 90 870.00	
Flow Measurement (Ultrasonic + Logger & V-Notch Weir)			No.	1	R 48 950.00	R 48 950.00	
Interconnecting Pipework between Ponds: (160mm dia uPVC Cl.6)			m	319	R 176.55	R 56 319.45	
							R 5 833 948.03

ELECTRICAL POWER SUPPLY LINE (LUTZBURG & CILLIE VILLAGE)	1500	Qty	Rate	Cost:				
Wooden Pole Structures								
11m, 160-180mm top diameter		20	R 2 480.00	R49 600.00			R 49 600.00	
A-frame/steel cross arm		20	R 1 720.00	R34 400.00			R 34 400.00	
H-Pole Structures		2	R 17 500.00	R35 000.00			R 35 000.00	
Drilling of pole holes		34	R 1 500.00	R51 000.00			R 51 000.00	
Stays & Anchors		22	R 1 080.00	R23 760.00			R 23 760.00	
Conductors								
Fox Conductor		4500	R 20.00	R90 000.00			R 90 000.00	
Section links cut-outs or disconnectors		1	R 5 120.00	R5 120.00			R 5 120.00	
Expulsion fuses (set of 3) for above		1	R 6 650.00	R6 650.00			R 6 650.00	
Pole Mounted Transformers								
16 kVA 11kV/420V Dyn11		1	R 16 200.00	R16 200.00				
LV Cables		Length	Width	Volume	R/ m	R/m^3		
LV cable trench: 500mm wide x 900mm deep		77	0.5	35	R 65.00		R5 005.00	
Intermediate:				5.25		R 450.00	R 2 362.50	
Rock:				10.5		R 650.00	R 6 825.00	
Pole Mounted Distribution Kiosk		1	R 15 400.00	R15 400.00			R 15 400.00	
Maximum Demand and Consumption Metering		1	R 5 500.00	R5 500.00			R 5 500.00	
								R 330 622.50

Subtotal for Riemvasmaak Villages WWTP **R6 164 570.53**

Project Subtotal:							**R 100 857 707.62**
10% CONTINGENCIES							**R 10 085 770.76**
Project Subtotal:							**R 110 943 478.38**
Escalation Costs: (6% per annum)							**R 6 656 608.70**
Project Subtotal:							**R 117 600 087.08**
Professional Engineering Fees:	Primary Fee:			R2 620 900.00	R4 175 195.66		
	and	4.50%	of R15 983 478.38	R719 256.53			**R 4 175 195.66**
	Multiplier for Water & Wastewater Tretament Works		1.25	R3 340 156.53			
Disbursements					R1 200 000.00		**R 1 200 000.00**
Professional Fees for Environmental Control Officer:							
Environmental Site Agent: Full Time for 14 days per month for 18 months							
Environmental Control Officer: fortnightly visits to site for the duration of the contract + attendance of site meetings							**R 1 250 000.00**
Environmental Audit at project closure as per ROD conditions:							**R 152 000.00**
Subtotal:							**R 124 377 282.74**
VAT at 15%							**R 18 656 592.41**
TOTAL ESTIMATED EXPENDITURE:							**R 143 033 875.16**