KNYSNA
Municipality
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KNYSNA MUNICIPALITY

SEWER MASTER PLAN

December 2018

ELEMENT Consulting Engineers

gls consulting
an EOH company

KNYSNA
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LIST OF ABBREVIATIONS & ACRONYMS

AADD	-	Annual average daily demand
ADDWF	-	Average daily dry weather flow
AMP	-	Asset management plan
AR	-	Asset register
CAPEX	-	Capital expenditure
CF	-	Consequence of failure
CRC	-	Current replacement cost
d	-	Day
DRC	-	Depreciated replacement cost
ECE	-	Element consulting engineers
GIS	-	Geographic information system
GLS	-	GLS consulting engineers
h	-	Hour
Ha	-	Hectare
IMQS	-	Infrastructure management query station (software package)
IPDWF	-	Instantaneous peak dry weather flow
IPWWF	-	Instantaneous peak wet weather flow
kℓ	-	Kilolitre
kℓ/d	-	Kilolitre/day
km	-	Kilometre
kW	-	Kilowatt
kWh	-	Kilowatt-hour
KM		Knysna Municipality
ℓ	-	Litre
ℓ/day/UE	-	Litre/day/unit erf
ℓ/min	-	Litre/minute
ℓ/min/m pipe/m Ø	-	Litre/minute/meter pipe length/meter pipe diameter
ℓ/min/UE	-	Litre/minute/unit erf
ℓ/s	-	Litre/second
LF	-	Likelihood of failure
m	-	Metre
m a.s.l.	-	Metres above mean sea level
MISA	-	Municipal infrastructure support agent
m/s	-	Metres per second
Mℓ	-	Mega litre
mm	-	Millimetre

OPEX - Operational expenditure

P&G - Preliminary and general
PDDWF - Peak daily dry weather flow
PRP - Pipe replacement potential
PS - Pumping station

R - Rand

s - Second
SEWSAN - Sewer system analysis program (software)
SG - Surveyor general
SWIFT - Sewer water interface for treasury systems (software)

TWD - Total annual water demand

UAW - Unaccounted-for-water
UE - Unit erf
UH - Unit hydrographs
UWD - Unit water demand (e.g. ℓ/stand/d, or kℓ/ha/d)

v - Flow velocity (in m/s)
VAT - Value added tax

WWTP - Wastewater treatment plant (sewage)

1. INTRODUCTION

1.1 BRIEF

GLS consulting engineers (GLS) were appointed as sub-consultants to Element consulting engineers to update the master plan of the sewer distribution system for Knysna municipality (KM).

The project entails the verification of system data, updating of the existing computer model for the sanitation network, the linking of the model to updated land use information, evaluation and master planning of the sewerage networks to include expected future land use and resulting capital expenditure and the posting of all information to the Infrastructure Management Query Station (IMQS).

This master plan report lists the analyses and findings of the study on the sewer reticulation systems for all the towns within the KM.

1.2 STUDY AREA

The location of KM within the Western Cape is shown on Figure KMS1.1. The towns within the boundary of the KM are:

- Knysna town
- Sedgefield
- Belvidere
- Brenton on Lake
- Brenton on Sea
- Buffels Bay
- Karatara
- Rheenendal

Figure KMS1.2 shows the suburbs with suburb names entered during this investigation for all records in the geographic information system (GIS) database. The total area of these suburbs indicates the study area of this investigation.

1.3 PREVIOUS MASTER PLANNING

GLS conducted a sewer master plan study in December 2008 for the KM for the towns of Belvidere, Brenton on Lake, Brenton on Sea, Buffels Bay, Karatara, Knysna, Rheenendal and Sedgefield. The previous master plan was updated by GLS in 2016 and 2017.

These previous master plans where updated and are documented in this study.

1.4 DEFINITIONS

1.4.1 Stand

In this report *stand* is used to denote a piece of ground identified in the database of the surveyor general (SG) as a unique property. A stand could have one or more (or no) metered connections to the water supply system. The words property, site, erf (or erven), and lot are also sometimes used elsewhere to describe a stand.

1.4.2 Treasury record

A *treasury record* is a consumer's account that is recorded in the treasury database of the Municipality. Each treasury record normally represents a consumer's connection to the sewer distribution system. Some treasury records might not pertain to a sewer connection (or customer meter).

1.5 STRUCTURE AND SCOPE OF REPORT

This report addresses the disposal of sewage within the KM area. This study is confined to the sewerage networks and therefore the process and sufficiency of the wastewater treatment plants (WWTP's) are beyond the scope of this study.

The contents of each chapter is arranged so that all of the text is grouped together, followed by the tables and then the figures, if applicable to the chapter.

1.6 DISCLAIMER

The investigation has been performed and this report has been compiled based on the information made available to GLS. All efforts, within budget constraints, have been made during the gathering of information to ensure the highest degree of data integrity. The information supplied to GLS by the KM and other consultants at the outset of this master planning process is assumed to be the most accurate representation of the existing system up to date hereof.

Subsequent to the completion of the data capturing, the layout plans including the relevant attributes, were handed back to the Municipality so that the information could be verified by the Client. GLS can therefore under no circumstances be held accountable by any party for any direct, indirect, special or consequential damages as a result of inaccurate information received pertaining to the components of the existing system.

The information in this report is intended for use by the KM only.

Figure KMS1.1 **Locality plan -Knysna Municipality**

Figure KMS1.2a Towns and suburbs per treasury -Knysna, Belvidere, Brenton on Lake & Brenton on Sea

Figure KMS1.2b Towns and suburbs per treasury -Sedgefield

Figure KMS1.2c **Towns and suburbs per treasury -Buffels Bay**

Figure KMS1.2d **Towns and suburbs per treasury -Karatara**

Figure KMS1.2e **Towns and suburbs per treasury - Rheenendal**

2. EXISTING SYSTEM

2.1 SYSTEM LAYOUT AND OPERATION

The layouts of the KM sewer systems are shown on Figures KMS2.1 with a separate Figure for each area as follows:

- a - Knysna, Belvidere & Brenton
- b - Sedgefield
- c - Buffels Bay
- d - Karatara
- e - Rheenendal

This notation to distinguish between areas is used throughout this report for all Figures where appropriate.

Each system is operated in a main drainage area with a WWTP, which in turn could be sub-divided into several sub-drainage areas each as shown on Figures KMS2.2.

There are 68 pumping stations (PS's) in the Knysna system, 17 in the Sedgefield system, 1 in the Belvidere system, none in the Brenton on Lake system, 4 in the Brenton on Sea system, none in the Buffels Bay system, 1 in the Karatara system and 2 in the Rheenendal system, as indicated on Figures KMS2.1 and KMS2.2.

Tables KMS2.1a and KMS2.1b provide a summary of all the system components.

Table KMS2.2 lists the actual and potential fully occupied present peak daily dry weather flow's (PDDWF's) of the drainage areas.

2.2 DATA INTEGRITY

The data captured for the sewer model consists of a blend of as-built plans, design drawings, and GIS information. For some pipes only geographical information was available, and a default diameter of 150 mm Ø was assumed.

It is important that the integrity of the information be kept in mind when considering upgrades to the system. Figure KMS2.3 shows the integrity of the pipes in three categories:

- Pipes for which invert levels were available from the as-built drawings.
- Pipes for which invert levels were calculated based on minimum slopes.
- Pipes for which the slopeof the pipes were available from the as-built drawings.

If this report is noted to have any discrepancies compared to alternative information, GLS should be contacted in this regard to ensure that the relevant sections of the system are verified as part of a future ongoing Bureau Service aimed at improving the data integrity in future.

2.3 DRAINAGE AREA, WATER DEMAND AND SEWER FLOWS

The total drainage area for each sewer system is shown on Figures KMS2.2.

2.3.1 Knysna

The present annual average daily demand (AADD) for the existing Knysna systemthat contributes to the domestic sewer flow is ± 8 245 kℓ/d, which includes unaccounted-for-water (UAW).

The PDDWF for the Knysna system is estimated at ± 7 790 kℓ/d, or roughly 94% of the AADD. Approximately 64% of this is a direct contribution from connections to the sewerage system, and the other 36% is contributed by groundwater infiltration.

2.3.2 Sedgefield

The present AADD for the existing Sedgefield system that contributes to the domestic sewer flow is ± 766 kℓ/d, which includes UAW.

The PDDWF for the Sedgefield system is estimated at ± 691 kℓ/d, or roughly 90% of the AADD. Approximately 66% of this is a direct contribution from connections to the sewerage system, and the other 34% is contributed by groundwater infiltration.

2.3.3 Belvidere

The present AADD for the existing Belvideresystemthat contributes to the domestic sewer flow is ± 191 kℓ/d, which includes UAW.

The PDDWF for the Belvidere system is estimated at ± 119 kℓ/d, or roughly 62% of the AADD. Approximately 93% of this is a direct contribution from connections to the sewerage system, and the other 7% is contributed by groundwater infiltration.

2.3.4 Brenton on Lake

Brenton on Lake is currently serviced by a septic tank and conservancy tank system and does not have a water borne sewage network and wastewater treatment facility for the area.

2.3.5 Brenton on Sea

The present AADD for the existing Brenton on Sea system that contributes to the domestic sewer flow is ± 301 kℓ/d, which includes UAW.

The PDDWF for the Brenton on Sea system is estimated at ± 100 kℓ/d, or roughly 33% of the AADD. Approximately 58% of this is a direct contribution from connections to the sewerage system, and the other 42% is contributed by groundwater infiltration.

2.3.6 Buffels Bay

Buffels Bay is currently serviced by a septic tank and conservancy tank system and does not have a water borne sewage network and wastewater treatment facility for the area.

2.3.7 Karatara

The present AADD for the existing Karatara system that contributes to the domestic sewer flow is ± 131 kℓ/d, which includes UAW.

The PDDWF for the Karatara system is estimated at ± 55 kℓ/d, or roughly 45% of the AADD. Approximately 50% of this is a direct contribution from connections to the sewerage system, and the other 50% is contributed by groundwater infiltration.

2.3.8 Rheenendal

The present AADD for the existing Rheenendal system that contributes to the domestic sewer flow is ± 152 kℓ/d, which includes UAW.

The PDDWF for the Rheenendal system is estimated at ± 133 kℓ/d, or roughly 88% of the AADD. Approximately 71% of this is a direct contribution from connections to the sewerage system, and the other 29% is contributed by groundwater infiltration.

2.4 WASTEWATER TREATMENT PLANTS

All the present PDDWF for each drainage area is treated at each town's WWTP.

2.5 SEWER FLOW MEASUREMENTS AND CALIBRATION

Daily sewer flow measurement data was available for the Knysna system to calibrate the existing Knysna sewer model. The data available was for sewer flow readings at the Knysna WWTP for the period January 2013 to December 2013.

The Sewer system analysis program (SEWSAN) models were populated with unit hydrographs (UH) as described in Figure KMS5.1, Chapter 5, which is based on the analysis of many flow recordings done for previous studies in the Western Cape Province.

From this data the dry weather flow was predicted from the SEWSAN models. The predicted flow volume from the KM SEWSAN models for each WWTP is shown on Figure KMS2.4

It is proposed that sewer flow measurements are taken at the WWTP of each town in order to verify the predicted flow volumes from the KM's SEWSAN models.

2.6 EXISTING OPERATIONAL PROBLEMS

The following operational problems were indicated by the operational staff:

- Blockages and overspill sometimes occur in the lower part of the Knysna CBD due to material lodged in manholes from roots and other solids transported from higher areas. This can be treated by normal pro-active cleaning and maintenance.
- Blockages due to root growth in some areas are experienced.
- The Knysna Main Pump Station is running at full capacity.
- Blockages at some pump stations occur due to solid material disposed in sewers.
- Pump failures sometimes occur due to mechanical and electrical failures or stuck float switches, but hydraulic capacity is satisfactory.
- Salt-water ingress in the areas around the Knysna lagoon is an ongoing concern.
- High stormwater ingress is an ongoing concern.

2.7 SPECIAL CONSIDERATIONS

2.7.1 General

Detailed drawings of the system are included in the plan book. The plan book should be used to indicate (by physical markings on the drawings) any additional information, or amendments, that would improve the quality of the final layout.

2.7.2 Information to be clarified

The duty points of the existing pumping stations are shown on Table KMS2.1a. The duty points of the most pumping stationsare however not available and it is recommended that field tests be carried out to verify pump duty points at all the PS’s.The unknown pipe diameters and invert levels should also be determined in order to improve the confidence in the models.

Table KMS2.1a Existing sewer system summary - WWTP’s and pumps

Table KMS2.1b Existing sewer system summary - Pipes

Table KMS2.2 Existing sewer drainage areas and PDDWF’s

Figure KMS2.1a Existing sewer system layout - Knysna, Belvidere & Brenton on Sea

Figure KMS2.1b Existing sewer system layout -Sedgefield

Figure KMS2.1c **Existing sewer system layout - Buffels Bay**

Figure KMS2.1d Existing sewer system layout -Karatara

Figure KMS2.1e **Existing sewer system layout - Rheenendal**

Figure KMS2.2a Existing drainage areas -Knysna, Belvidere & Brenton on Sea

Figure KMS2.2b Existing drainage areas -Sedgefield

Figure KMS2.2c Existing drainage areas - Buffels Bay

Figure KMS2.2d **Existing drainage areas -Karatara**

Figure KMS2.2e Existing drainage areas - Rheenendal

Figure KMS2.3a Existing data integrity -Knysna, Belvidere & Brenton on Sea

Figure KMS2.3b Existing data integrity -Sedgefield

Figure KMS2.3c Existing data integrity - Buffels Bay

Figure KMS2.3d **Existing data integrity -Karatara**

Figure KMS2.3e Existing data integrity - Rheenendal

Figure KMS2.4 Sewer flow measurements and calibration

3. PRESENT LAND USE, WATER DEMAND AND SEWAGE FLOW

3.1 METHODOLOGY

The SWIFT program is a link between treasury billing data, and water/sewer network models. (The name is derived from “Sewer Water Interface for Treasury systems”). The program was used to analyse the present land use and water demand situation in KM, as well as the projected potential water demand for a fully occupied existing system.

3.2 SWIFT ANALYSIS

A SWIFT analysis was conducted as part of this investigation. The KM has a R-Data treasury system, with a single treasury system for all the towns in the Municipal area. A data extraction routine for SWIFT was compiled as part of this investigation and will remain a standard part of the R-Data software suite in future.

The treasury records for the period September 2017 to August 2018 were used as the base information for the analysis.

3.3 LAND USE

With cognizance of the limited land use and zoning codes maintained in the treasury system being operated by the KM, the following land use categories were identified for this study:

- BUS_COMM - Business/Commercial
- CLUSTER - Town houses
- EDU - Educational
- FARM_AH - Farm/Agricultural holding
- FLATS - Flats
- GOVT_INST - Government/Institutional/Municipal
- IND - Industrial
- OTHER - All other categories
- INFORMAL - Informal
- RES - Residential stands

In order to account for the effect of stand size on residential water demand, the RES category is further subdivided into five sub-categories, based on stand size, as follows:

- RES 500 - smaller than 500 m^2
- RES 1 000 - 500 m^2 to 1 000 m^2
- RES 1 500 - 1 000 m^2 to 1 500 m^2
- RES 2 000 - 1 500 m^2 to 2 000 m^2
- RES 2 500 - 2 000 m^2 to 2 500 m^2
- RES >2 500 - larger than 2 500 m^2

The LARGE category is required to remove these special water consumers from their regular land use category, so as to prevent them from skewing the statistics for the specific category and to detach them from any theoretical unit water demand (UWD) that might not be applicable to them. The large water users are discussed later in this Chapter.

Figure KMS3.1 shows all the stands coloured in accordance with their land use.

3.4 SWIFT RESULTS AND RESULTING WATER DEMANDS

3.4.1 Suburb-by-suburb land use and water use statistics

All available treasury data in KM was analysed with the SWIFT program, in order to determine (for each stand/meter record) the suburb, the land use, whether it is occupied or vacant, its AADD and total annual water demand (TWD) for the base year. This information was then totalised and summarised by SWIFT per suburb, and broken down into the various land use categories. Average unit water demands (ℓ/stand/d) were also determined for each land use category in each suburb. The results are summarised in Table KMS3.2.

Figure KMS3.1 shows all the stands coloured in accordance with their land use according to the Swift analysis.

3.4.2 Unaccounted-for-water

The total water inputs for each area were compared with the total water sales, which resulted in UAW figures of 12,3% in Knysna, 27,8% in Sedgefield, 15,1% in Belvidere, 43,2% in Brenton on Lake & Brenton on Sea, unknown in Buffels Bay, 2,47% in Karatara and 75,6% in Rheenendal. The results are summarised in Table KMW3.3.

The large UAW figures of Brenton on Lake & Brenton on Sea and Rheenendal should be reduced by implementing a suitable Water Demand Management plan.

3.4.3 Rationalized (“theoretical”) unit water demands

The UWD’s per land use in each suburb were rationalised into rounded-up “theoretical” values. These values were calibrated by applying them to the total number of occupied stands in each land use category of each suburb, and comparing the resultant “theoretical” total water demand (excluding UAW) for each suburb with the actual water demand (excluding UAW) for the suburb. The results are summarised in Table KMS3.1.

3.4.4 Rationalized (“theoretical”) UAW

For planning and evaluation purposes, the UAW figures were also rationalised on a regional (wider-area) basis, as allowed by the sensibility of the results. After allowance was made for unmetered consumers and faulty bulk meters in the area, an UAW figure of 20% in Knysna, 28% in Sedgefield, 15% in Belvidere, 43% in Brenton on Lake & Brenton on Sea, 15% in Buffels Bay, 3% in Karatara and 75% in Rheenendal were applied for modelling purposes of the existing system.

For modelling of the future system an UAW figure of 20% in Knysna, 20% in Sedgefield, 20% in Belvidere, 25% in Brenton on Lake & Brenton on Sea, 15% in Buffels Bay, 15% in Karatara and 25% in Rheenendal were applied for modelling purposes of the existing systemwere applied.

3.4.5 Potential land use and AADD of existing developments

The Swift program determines the total number of vacant stands in each land use category for each suburb and each distribution zone. These vacant stands do not contribute to the present water demand calculations (actual or theoretical) as described above. However, the Swift program also determines from treasury data what the land use or zoning rights of vacant stands might be.

The rationalised theoretical UWD’s and UAW’s can therefore also be applied to these vacant stands in order to determine their potential water demand, should they become developed/occupied.

The theoretical present water demand model was therefore extended in Swift to include all vacant stands and a potential fully occupied present water demand (inc. UAW) for each suburb and distribution zone in KM was determined. The results are summarised per suburb in Table KMS3.1.

This potential future water demand so calculated is only for existing developments/ stands that have been proclaimed and exist. Potential future land developments and upgrading/relocation of informal areas were dealt with as described in Chapter 4.

3.4.6 Large water users

Table KMW3.2 is a list of all the stands defined as large users in SWIFT for KM. The table shows the large users (AADD > 10 kℓ/d) sorted per demand. The tabulated information for each user (e.g. owner, consumer, address) is unchanged as recorded in the treasury system.

The water demand for each of the large users recorded in the treasury database is interrogated by SWIFT. The AADD calculated by SWIFT for each large user is used to calculate the peak flow for the relevant consumer. The location of each large user is identified uniquely in view of its demand in the water system model.

3.4.7 Informal settlements

The treasury data does not contain information on informal settlements in the study area.

The following informal settlements were however reported to be present in the Western Cape Completed Service Levels (data provided by WorleyParsons for DWA) dated January 2014:

Informal housing with no access to basic services:

- 900 households in Knysna
- 50 households in Rheenendal

Informal housing with access to shared services:

- 3 287 households in Knysna
- 534 households in Sedgefield
- 50 households in Rheenendal

These settlements receive water from a number of yard taps/stand pipes in the adjacent areas. No meter readings are available for these taps, but estimates were however made in the water master plan for the consumption of these settlements.

Most of the informal settlements are linked to the existing sewer system and do therefore contribute to sewer flows in the system.

3.4.8 Present water demand summary

Table KMS3.4 is a summary of the present actual water demand in the various drainage areas.

3.5 PRESENT SEWER FLOW

3.5.1 Unit hydrograph types

After careful consideration of the various land uses and their unit water demands as established earlier in the chapter, it was decided to use 14 unit hydrographs for modelling the sewer flow contributions of typical erven. The 14 UH's are described in Figure KMS5.1, Chapter 5, and are based on the analysis of many flow recordings done for previous studies. Table KMS3.5 is a summary of how the various land uses in KM were mapped to these UH's. Figure KMS3.1 shows the stands coloured in accordance with their UH allocation.

3.5.2 Sewer flow components

Each UH contribution by a typical stand consists of a leakage (base flow) component, and a domestic flow component. The UH can be used as is in the sewer system analysis, or a more accurate approach can be taken where only the shape of the UH is used, and all the ordinates are adjusted so that the volume of the hydrograph represents a certain percentage (typically 50% to 60%) of the AADD for water.

In addition to the domestic flow and leakage component, there is another base flow component due to groundwater infiltration into pipes (typically ± 0,04 ℓ/min/m pipe/m Ø). This component typically increases the sewer flow to somewhere between 60% and 70% of the water AADD.

Stormwater ingress can also result in significant peaks in the sewer flow, even though the systems are ostensibly designed as “closed”. For this study, the systems are analysed and designed with a 30% allowance for stormwater ingress. Previous studies proved that accommodation of stormwater ingress in sewer systems is very expensive, and that funds should be applied to solving the problem, rather than treating the symptom and shifting the problem downstream to the WWTP.

3.5.3 Present PDDWF

The present PDDWF of the drainage areas in Knysna Municipality are summarised in Table KMS2.2. These PDDWF's are based on the UH's, by applying their shapes to represent certain percentages of the water AADD, with additional groundwater infiltration.

The “Actual” PDDWF scenario varies between 88% to 62% of the actual present AADD for the towns in the Municipal area.

Table KMS3.1 Treasury water use per suburb and land use

Table KMS3.2 **Large water users (>10 kℓ/d AADD)**

Table KMS3.4 **Present water demand summary**

Table KMS3.5 Mapping of land uses to unit hydrographs

Figure KMS3.1a Land use per stand -Knysna, Belvidere,Brenton on Lake & Brenton on Sea

Figure KMS3.1b Land use per stand -Sedgefield

Figure KMS3.1c Land use per stand - Buffels Bay

Figure KMS3.1d Land use per stand -Karatara

Figure KMS3.1e Land use per stand - Rheenendal

4. FUTURE LAND USE, WATER DEMAND AND SEWER FLOW

4.1 FULL OCCUPATION OF EXISTING DEVELOPMENTS

For the future land use and sewer flow scenario, it was assumed that all existing but vacant stands in the area would become "occupied", i.e. start using water and discharging sewerage, as summarised in Table KMS2.2.

4.2 POTENTIAL FUTURE LAND DEVELOPMENTS

The potential areas for future developments were identified in consultation with the Municipality's town planning consultants. Each potential area was assigned an anticipated predominant land use, and will be phased in over a 20-year period.

The potential future land developments in KM are shown on Figure KMS4.1, coloured according to the land use.

Typical UWD's (per ha or per stand/unit) were estimated for the potential future areas based on previous experience and statistics obtained from the SWIFT analysis of the present water demands.

4.3 WATER DEMANDS OF FUTURE LAND DEVELOPMENTS

Typical UWD's (per ha or per stand/unit) were assumed for the future development areas, based on the statistics obtained from the analysis of the present water demands and in consultation with water services of KM, to determine their potential water demand. The results are listed in Table KMS4.1.

4.4 SEWER FLOWS OF FUTURE LAND DEVELOPMENTS

Table KMS4.1 also shows estimates for the PDDWF and Table KMS6.3 the UH allocations for the future land developments.

4.5 FUTURE WATER DEMAND

The future AADD (that contributes to the sewer flow) of the KM system studied for this report is ± 25 640 kℓ/d. The future AADD (modelled as the future system) represents an increase of ± 84% over the actual present AADD, and an increase of ± 54% over the potential fully occupied present AADD (after UAW is reduced to 20% in Knysna, 20% in Sedgefield, 20% in Belvidere, 25% in Brenton on Lake & Brenton on Sea, 15% in Buffels Bay, 15% in Karatara and 25% in Rheenendal).

4.6 FUTURE SEWER FLOW

The future PDDWF's of the drainage areas in KM are summarised in Table KMS4.2. The future PDDWF of ± 19 843 kℓ/d is ± 78% of the future AADD for the entire KM.

Table KMS4.1 Potential future land developments

Table KMS4.2 Present and future potential PDDWF's

Figure KMS4.1a **Potential future developments - Knysna, Belvidere, Brenton on Lake & Brenton on Sea**

Figure KMS4.1b Potential future developments -Sedgefield

Figure KMS4.1c Potential future developments - Buffels Bay

Figure KMS4.1d **Potential future developments -Karatara**

Figure KMS4.1e Potential future developments - Rheenendal

5. EVALUATION AND PLANNING CRITERIA

5.1 SEWER FLOW AND PEAK FACTORS

5.1.1 Planning

The major objectives pursued in the evaluation and planning of the sewer system in Knysna Municipality as presented in this report can be summarised as follows:

- Establishing a model of the sewer network that accurately reflects the existing system.
- Detailed water demand analysis based on data in the treasury system.
- Conformity with operational requirements and criteria adopted for this study.
- Optimal use of existing facilities with excess capacity.
- Optimisation with regards to capital - maintenance - and operational cost.

The study considered year 2035 (i.e. 20 years) as the horizon for planning purposes. The total PDDWF for the KM system can then potentially be ± 19 843 kℓ/d.

5.1.2 Present and future PDDWF's

Existing systems were evaluated on the basis of their maximum potential present PDDWF, i.e. as though all presently developed stands are occupied based on their land use. For planning of future systems, PDDWF's of all potential future developments were added.

5.1.3 Unit sewer flows

SEWSAN uses a UH for each erf linked to the model to simulate the leakage (base flow) and domestic contribution to sewer flow as a percentage of the AADD. The parameters of the unit hydrographs for the different types of erven are summarised in Figure KMS5.1. These are based on the analysis of many flow recordings, as performed for previous studies. In the analysis and planning of the system, the UH ordinates are adjusted to reflect the actual percentages of the AADD.

5.1.4 Total base flow (Infiltration and Leakage)

As part of the UH, each stand contributes a steady flow to the base sewage flow, in the form of leakage from cisterns and taps. The calibrated base flow rates for each UH type were calculated based on the assumption that domestic base flow accounts for ± 74% of the total base flow in the system. The base flow rates for each UH type is listed in Figure KMS5.1. The other ± 26% of the base flow is assumed to be groundwater infiltration through joints and cracks in the sewer pipe system. Based on flow measurements done for previous sewer system studies, a groundwater infiltration rate of 0,04 ℓ/min/m pipe/m Ø was assumed for the sewer system (see Table KMS5.3). The total base flow in the KMMunicipal systems is typically ± 29% of the PDDWF.

5.1.5 Stormwater Ingress

Based on simultaneous sewer flow and rainfall measurements undertaken for previous sewer system studies, it is estimated that ± 1,0% of all rainfall during heavy storms, which falls within 25 m of either side of a sewer pipe, typically ingresses into the sewer system. Storm and ingress criteria used for wet weather system analysis and planning (where applied) are shown in Table KMS5.3.

5.2 OPERATIONAL CRITERIA

5.2.1 Minimum gradients

The minimum gradient of gravity mains should be such that a minimum flow velocity of > 0,6 m/s at full flow capacity, can be maintained. Table KMS5.1 shows such minimum gradients for different diameter pipes.

5.2.2 Flow velocities - Gravity mains

A minimum of 0,6 m/s should be maintained in all gravity mains to ensure that sufficient scouring of the mains takes place. The maximum flow velocity under full flow conditions should be not more than 2,5 m/s to prevent damage to the pipelines, although a higher flow velocity of up to 4,0 m/s may be acceptable over short pipe lengths and for short periods. Flow velocity criteria are summarised in Table KMS5.2.

5.2.3 Flow velocities- Rising mains

Flow velocities must be limited in order to protect pipeline coatings and reduce the effects of water hammer. The preferred maximum allowed is 1,8 m/s, but an absolute maximum of 2,2 m/s is acceptable where only intermittent peak flows occur.

5.2.4 Pipe roughness coefficient

The Manning flow formula is used by the SEWSAN program and a Manning-n roughness coefficient of 0,012 was assumed for all the pipes in the model.

5.2.5 Hydraulic capacity of sewerage network

There are basically two design philosophies, which could be used for this planning study. These are the instantaneous peak dry weather flow (IPDWF) philosophy, with spare capacity allowed for stormwater ingress, and the instantaneous peak wet weather flow (IPWWF) philosophy, where the system is designed to accommodate stormwater ingress, but with pipes allowed to flow 100% full (see Table KMS5.2). It was found however that the effect of 1% stormwater ingress (see par. 5.1.5) is dramatic, resulting in very high IPWWF, and consequently very large and uneconomical pipes sizes. The IPDWF philosophy, as described below, was therefore used.

Pipe sizes in gravity mains should be such that the PDDWF can be accommodated in the pipeline whilst flowing 70% or less full. The remaining 30% of the flow area is for the accommodation of stormwater ingress. Should stormwater ingress cause this “spare capacity” to be exceeded, resulting in pipeline overflow, certain measures should be taken by the system manager to prevent ingress of stormwater into the sewer system.

The "spare capacity" for a regular gravity pipe which is unaffected by upstream pumps is defined as follows:

$$Spare\ capacity\,(\%) = \frac{Full\ \ flow\,capacity - IPDWF}{Full\ \ flow\,capacity}\ x\,100\%$$

If however there are upstream pump stations affecting the flow in a gravity pipe the "spare capacity" for of the pipe has to be redefined with cognisance of the pump flows, as follows:

$$Spare\,capacity\,(\%) = \frac{Full\ \ flow\,capacity - Upstream\ pump\ \ flow - IPDWF}{Full\ \ flow\,capacity - Upstream\ pump\ \ flow}\ x\,100\%$$

5.2.6 Pumping stations

The following criteria apply to the design and evaluation of PS:

- Pump configurations should be such that there is always at least one standby pump available for emergency purposes.
- PS capacity should be such that it equals or exceeds the IPWWF which arrives at the PS, or the IPDWF plus an allowance for stormwater ingress. In the case of a 30% allowance, the pump therefore must have a capacity equal to:

$$\frac{IPDWF}{(1-0{,}3)} = \frac{IPDWF}{0{,}7} = 1{,}43x\,IPDWF$$

- The sump at the PS should be sized to ensure that the pump does not switch on and off more than six times per hour.

5.2.7 Hydraulic influence of pump stations

Although sewer pump stations operate intermittently, their flows can influence the hydraulics of the downstream pipes at any time during the day. Pumps are therefore modelled as “continuous” pumps, which pump at specified capacity for 24 h per day.

5.3 OPTIMAL USE OF EXCESS CAPACITIES IN EXISTING FACILITIES

Many existing facilities may have excess capacity when measured in terms of the operational criteria described above. In whatever way it has come about, in the planning done for this study it was strived to utilise the excess capacities in existing facilities to its economically viable maximum.

5.4 ECONOMIC OPTIMISATION AND COST FUNCTIONS

All the strategic and technical alternatives studied were compared on mainly economic grounds, with a view to establishing a "master plan" which will result in the lowest present value of capital works, operations and maintenance.

The cost functions for cost estimates, cost comparisons and economic optimisation in general, are presented in Figure KMS5.2.

It should be noted that the proposed pipeline routes are indicated schematically on the master plan and that no detail topographical or geotechnical surveys have been conducted to verify these routes. The detail assessment of the routes are thus beyond the scope of this report and should be performed in the preliminary design stage during implementation. A variance of the cost estimates could therefore be experience typically due to the presence of hard rock in the substrata along the pipeline route, existing services of which the crossings appear to be problematic or for which ever reason the pipeline route has to be lengthened.

Table KMS5.1 **Minimum gradients for ± 0,65 m/s full flow velocity**

Table KMS5.2 **Operating min/max velocities and design spare capacities**

Table KMS5.3 Infiltration and stormwater ingress parameters

Figure KMS5.1 SEWSAN unit hydrographs

Figure KMS5.2 Cost functions (with tables)

6. EVALUATION AND MASTER PLAN

6.1 EXISTING SYSTEM

6.1.1 Replacement value

Table KMS6.1 provides an estimate of the replacement value of the existing KM system, based on the cost functions shown on Figure KMS5.2. It amounts to a total value of R 820,85 m and a PDDWF unit value of ± 85 571 R/kℓ/d.

6.1.2 External contributions to sewer flow

There are currently no external sources contributing to the sewer systems within the KM.

6.1.3 Existing drainage areas and sewer flows

Table KMS2.2 provides a summary of the existing PDDWF's for each sub-drainage area in KM.

6.1.4 Spare capacities

Figure KMS6.1 shows the relative spare capacities in the existing KM systems under IPDWF. The red and light blue lines indicate pipes where capacity problems (< 30% spare) may be experienced. A number of collector sewer pipes and bulk sewer pipes in Knysna town have spare capacities less than 30%. It should however be noted that limited information was available regarding the actual slope of the bulk and collector sewer pipes and that the actual capacities of these pipes could potentially be sufficient.

6.1.5 Flow velocities under peak demand

Figure KMS6.2 shows the flow velocities in the existing KM systems under full flow conditions. It can be noted that a minimum slope resulting in a velocity > 0,6 m/s was assumed for a number of pipes in the system, where insufficient information was available. See par. 2.2 and Figure KMS2.3.

6.1.6 Flow hydrographs

The present PDDWF hydrographs at each WWTP are shown on Figure KMS6.7.

6.1.7 Pumping stations and rising mains

All existing PS's and rising mains have sufficient capacity to accommodate the existing sewer flows.

It is recommended that the duty points of all the sewer PS's in KM are verified by field pumping tests.

6.2 FUTURE DRAINAGE AREAS AND SEWER FLOWS

6.2.1 Extended drainage areas

The proposed extended and new drainage areas for the future systems are shown on Figure KMS6.3.

6.2.2 Accommodation of future land developments

The future land developments are accommodated in the extended drainage areas. Table KMS6.3 is a summary of the future land development areas linking to the KM system; their PDDWF, land use and estimated additional pipe lengths. The connections of these future areas and sub-areas to the existing sewer system are indicated on Figure KMS6.4.

6.2.3 External contributors to sewer flow

No external sources will contribute to the future sewer systems within the KM.

6.2.4 Future sewer flow

Table KMS4.2 provides a summary of the future PDDWF's for each sub-drainage area in KM.

6.3 MASTER PLAN

The master planning for each of the towns in KM is discussed separately below. Items are identified to accommodate anticipated full development of each town, as provided by the Municipality's town planners.

The required works for the entire study area are shown on Figure KMS6.4. Details of the required items, cost estimates and phasing are also indicated in Tables KMS6.5a and these proposed master plan items are grouped together in proposed projects which are summarised in Table KMS6.5b. The proposed projects with the highest priority in KM are included in Table KMS6.5c.

Note that the internal network pipes in future developments were treated as schematic and are not included as master plan items. Table KMS6.6 shows the required pumping capacities for the future scenario.

6.3.1 Knysna

The existing drainage areas are increased and new drainage areas are proposed to accommodate future development areas and existing unserviced erven that fall within the drainage areas.

When overflow problems occur in the existing drainage areas the outfall sewers should be upgraded with larger diameters.

New gravity outfall sewers are required to collect the sewage from future development areas and the existing erven without a waterborne sanitation system, including new pumping stations and accompanying rising mains.

It is proposed that some existing pumping stations and rising mains are upgraded to accommodate the new development areas and their increased future flows.

Some of the major upgrades required in Knysna is the reinforcement of the existing bulk outfall sewers gravitating towards the Knysna WWTP, including upgrading of the existing pumping stations. It is however proposed that the capacities of the existing pumping stations in Knysna are verified before the pumping stations are upgraded. Where there is uncertainty over the actual slope or inside diameter of existing pipes it is proposed that the existing facilities must be investigated first, prior to implementing the master plan item.

It is proposed that the existing Concordia PS 3, Ethembeni PS 2, Ethembeni PS 3, Robololo PS 1, Robololo PS 2 and Robololo PS 3 are decommissioned and that sewage from their respective drainage areas is diverted to a lower lying Future PS K8 pumping station.

Two new flow diversions are proposed in the future Knysna sewer system to divert flow from outfall sewers with insufficient capacity to outfall sewers where sufficient spare capacity is available.

6.3.2 Sedgefield

The existing drainage areas are increased and new drainage areas are proposed to accommodate future development areas and existing un-serviced erven that fall within the drainage areas.

A number of existing outfall sewers require upgrading by replacement with enlarged future sewers.

New gravity outfall sewers are required to collect the sewage from future development areas and the existing erven without a waterborne sanitation system, including new pumping stations and accompanying rising mains.

Reinforcement of the existing bulk outfall sewer system from the Sedgefield PS 6 to the existing Sedgefield WWTP is proposed, including upgrading of the existing pumping stations, rising mains and main outfall sewers.

It is proposed that a number of existing pumping stations in Sedgefield are upgraded when the existing un-serviced erven in Sedgefield are accommodated within the existing sewer system. It is however proposed that the capacities of the existing pumping stations are verified before they are upgraded.

It is proposed that the existing Sedgefield pumping stations 1 & 3 are decommissioned when future area S12 develops and that sewage from the respective drainage areas are diverted to the proposed Future PS S3, which pumps sewage directly to the Sedgefield WWTP.

The existing Sedgefield WWTP is nearing capacity. It is proposed in the master plan that the existing WWTP is decommissioned and relocated to a new site. New bulk pumping stations and rising mains are proposed to transfer sewage from the existing WWTP and intercept sewage from existing Sedgefield PS 6 to the proposed new WWTP.

6.3.3 Belvidere

The existing drainage area is increased and a new drainage area is proposed in order to accommodate the existing erven in Belvidere without an existing water borne sanitation system.

New gravity outfall sewers and pumping station are required to collect the sewage from the existing erven without a water borne sanitation system.

It is proposed that the capacity of the existing Belvidere pumping station is verified by KM.

6.3.4 Brenton on Lake & Brenton on Sea

The existing drainage areas are increased and new drainage areas are proposed to accommodate future development areas and existing unserviced erven that fall within the drainage areas.

New gravity outfall sewers are required to collect the sewage from future development areas and the existing erven without a waterborne sanitation system, including new pumping stations and accompanying rising mains.

The capacities of the existing pumping stations in Brenton on Sea should be verified.

6.3.5 Buffels Bay

New outfall sewers, a new pumping station and an accompanying rising main are proposed to service the existing erven without a waterborne sanitation system in Buffels Bay. A new conservancy tank is proposed for Buffels Bay to collect the sewage for the town at a central point.

6.3.6 Karatara

The existing drainage areas are increased and a new drainage areas is proposed to accommodate future development areas and existing unserviced erven that fall within Karatara.

New gravity outfall sewers are required to collect the sewage from future development areas and the existing erven without a waterborne sanitation system, including a new pumping station and an accompanying rising main.

A number of existing outfall sewers require upgrading by replacement with enlarged future sewers to accommodate the future sewer flows.

It is proposed that the existing Karatara pumping station an accompanying rising main are upgraded to accommodate the increased future flows.

6.3.7 Rheenendal

A new drainage area is proposed to accommodate future development areas that fall within Rheenendal.

New outfall sewers, a new pumping station and accompanying rising main are proposed to service the proposed future development areas in Rheenendal.

It is proposed that the existing Rheenendal PS 1 and its accompanying rising main is upgraded to accommodate the increased future flows.

6.4 FUTURE SYSTEM

6.4.1 Spare capacities

Figure KMS6.5 shows the relative spare capacities in the future KM systems under IPDWF. All pipes were planned in accordance with the IPDWF philosophy for spare capacity > 30%.

6.4.2 Flow velocities under peak flow conditions

All future pipes were planned for a velocity > 0,6 m/s under full flow conditions. A few existing pipes with sufficient capacity but low velocities are however still present as indicated on Figure KMS6.2.

6.4.3 Flow hydrographs

The future PDDWF hydrographs are shown on Figure KMS6.6, for each WWTP.

6.4.4 Pumping stations and rising mains

Table KMS6.6 shows a summary of all the PS in the future system. The table shows which existing PS have sufficient capacity, which PS requires upgrading, which require downsizing, which should be decommissioned in the future and what new PS are required in future.

The existing PS's where duty points were not available were modelled with assumed scouring velocities in the accompanying rising mains. It is recommended that the duty points of these PS's be verified by field pumping tests.

The telemetry system whereby the PS's are closely monitored should also be upgraded and utilized to its full potential in order to assist with the operation of the systems.

All PS's should always have one standby pump available. Diesel-driven generators should be available for emergency conditions at all larger and strategically located (those which have high pollution risks) PS's.

6.4.5 Diversion structures

Two future diversion structures are proposed for the KM future system to alleviate high flows in the main sewers in Knysna. The proposed diversion structure parameters are shown in Table KMS6.7.

6.5 UPDATING AND MAINTENANCE OF THE COMPUTER MODEL AND MASTER PLAN

The calibrated computer model of the sewer distribution system is a handy tool for the day to day management of the system and can also be used as a basis for the calculation of services contributions by developers. The utility value of the model will however be lost if it is not properly maintained. The model should therefore be kept up to date with new developments and extensions to the system, and a link to the treasury water sales data.

Unknown or missing network information should be gathered or else surveyed in order to improve the data integrity of the hydraulic model. It is recommended that a survey programme be implemented at the soonest opportunity, with a view to establishing the correct diameters and invert levels of the uncertain elements of the sewer network components. The survey should be prioritized by commencing with the largest diameters and thus focusing on the main outfall sewers. Field tests should also be performed in order to determine the duty points of the PS that are not known. During this investigation the diameters of the rising mains should also be recorded in order to verify the system data.

6.6 MONITORING OF THE SYSTEM

A continuous flow monitoring programme, mainly through an extension of the already established telemetry system, is suggested as it will greatly enhance future calibration and planning studies performed with the model as basis. In addition, its results can be used with a view to identifying those drainage areas where the most stormwater ingress occurs, so that these can be prioritized in terms of the proposed investigation into the causes of the problem.

6.7 STORMWATER INGRESS AND GROUNDWATER INFILTRATION

The impact of stormwater ingress and groundwater infiltration on the operation and performance of a sewer network is in many cases hugely underestimated. In other municipalities in the Western Cape stormwater ingress measured at the inlet works of WWTP's has been recorded to be as high as 300% of the dry weather sewer flows while groundwater infiltration due to rising water tables in wet winter months have been recorded to be as high as 50% of the dry weather sewer flows. These high flows clearly have a negative impact on the hydraulic performance of a sewer network and also the functioning of the WWTP downstream of the network.

A programme whereby sewer flows at strategic points in the network (WWTP's and PS) are monitored, via telemetry, is recommended. Results from these loggings could be used to identify the areas which pose the greatest problems in this regard. A strategy to address these problems should be adopted which could inter alia include a house-to-house investigation in order to eliminate illegal stormwater ingress from private properties.

6.8 ASSET MANAGEMENT

It is recommended that the current data bases as well as hydraulic analyses and master planning results be extended and applied to support the asset register (AR) and asset management plan (AMP). The following aspects are of importance in this respect:

- The data bases must be revisited to ensure compliance with the AR with respect to componentization and hierarchy. Due to the process followed in compiling the data bases it is not expected that this will be a major task, but the specific rules for componentization, hierarchy and continuous update of the AR within e.g. a unique numbering system were not available at the time.
- Similarly the master plan projects should be aligned with the format stipulated in the AMP.
- The data integrity allocation during the establishment of the data base should be applied to inform the data improvement plan which is a subset of the AMP.
- The results of the hydraulic analyses should be applied to assist in determining important component attributes in the AR, such as criticality, utilization, performance and remaining useful lifetime.
- Attributes that will assist in performing AMP related actions, such as risk based pipe replacement prioritization, should be captured. These would e.g. include geological environment, location with respect to areas or consumers sensitive to spillages or flooding etc.
- The units and unit rates used should be checked and adjusted to be consistent for the determination of asset valuations (current replacement cost - CRC), fair values (depreciated replacement cost - DRC) and budgets which includes maintenance (OPEX), and future works planning (CAPEX).

6.9 PIPE REPLACEMENT PRIORITIZATION

The risk associated with replacing infrastructure can be quantified in monetary terms by the product of the probability of failure and the consequence of failure. Intervention to replace infrastructure before failure, reduces risk, but finding useable statistical information to perform such an analysis is difficult.

An analysis based on fundamentally independent factors could be performed to assess the pipe replacement potential (PRP) for any one modelled pipe in the water distribution or sewer reticulation model by combining the two critical factors -likelihood of failure (LF) and consequence of failure (CF).

Various independent variables contribute to each of these factors using a simplified scoring system from 0 to 5. The contributing variables are then summated using different weights to give total LF and CF factors. The total PRP is then calculated for each pipe as the product of these factors:

PRP = LF x CF (in the range of 1 to 25)

Which is then ranked for all pipes in the model to give the PRP% (in the range of 0 to 100%). In addition the actual replacement cost for every pipe is calculated. The pipes with high PRP% can then be visualized graphically. The pipes can be aggregated in various ways to provide the weighted average, maximum or minimum PRP for various collections, such as per region or supply zone. The analysis is performed as an add-in to the SEWSAN GIS-based hydraulic analysis software. Results are reported in generic GIS format or in a dedicated module of IMQS.

It is recommended that a pipe replacement prioritization analysis be performed for the entire KM sewer network in order to ensure that upgrades and replacements of infrastructure are planned and implemented in an efficient and cost effective manner.

Table KMS6.1 **Sewer system replacement value - Existing system**

Table KMS6.3 Sewer flows and connections for development areas - Future system

Table KMS6.5a Proposed works, cost estimates and phasing

Table KMS6.5b **Proposed projects, cost estimates and phasing**

Table KMS6.5c Priority sewer projects - Knysna Municipality

Table KMS6.6 Pumping station parameters - Future system

Table KMS6.7 Diversion structure parameters - Future system

Figure KMS6.1a **Existing spare capacities at IPDWF -Knysna, Belvidere, Brenton on Lake & Brenton on Sea**

Figure KMS6.1b Existing spare capacities at IPDWF -Sedgefield

Figure KMS6.1c **Existing spare capacities at IPDWF - Buffels Bay**

Figure KMS6.1d **Existing spare capacities at IPDWF - Karatara**

Figure KMS6.1e Existing spare capacities at IPDWF - Rheenendal

Figure KMS6.2a **Existing full flow velocities - Knysna, Belvidere, Brenton on Lake & Brenton on Sea**

Figure KMS6.2b **Existing full flow velocities - Sedgefield**

Figure KMS6.2c Existing full flow velocities - Buffels Bay

Figure KMS6.2d Existing full flow velocities -Karatara

Figure KMS6.2e **Existing full flow velocities - Rheenendal**

Figure KMS6.3a **Future drainage areas - Knysna, Belvidere, Brenton on Lake & Brenton on Sea**

Figure KMS6.3b **Future drainage areas - Sedgefield**

Figure KMS6.3c **Future drainage areas - Buffels Bay**

Figure KMS6.3d **Future drainage areas - Karatara**

Figure KMS6.3e **Future drainage areas - Rheenendal**

Figure KMS6.4a Required works - Knysna, Belvidere, Brenton on Lake & Brenton on Sea

Figure KMS6.4b Required works - Sedgefield

Figure KMS6.4c **Required works - Buffels Bay**

Figure KMS6.4d **Required works - Karatara**

Figure KMS6.4e Required works - Rheenendal

Figure KMS6.6 SEWSAN flow hydrographs - Knysna Municipality system

7. SUMMARY

This report describes the study undertaken with respect to the updating of the master plan for the sewer distribution system of the Knysna Municipality (KM). The initial sewer master plan was compiled by GLS consulting engineers (GLS) and documented in a report, dated December 2008.This master plan was subsequently updated by GLS in 2016 and 2017 with the 2018 update documented in a report, dated December 2018.

7.1 SCOPE OF SEWER MASTER PLAN STUDY

The scope of this update study was briefly defined as the following:

- Verification and updating of existing computer models for the KM sanitation networks.
- The linking of these models to updated land use information.
- Evaluation and master planning of the sewerage networks.
- Present all information electronically in geographic information system (GIS) format.

7.2 STUDY AREA

The Engineering Services department of the KM is responsible for the operation and maintenance of the sewer reticulation systems of the towns within the boundary of the KM, which are:

- Knysna
- Sedgefield
- Belvidere
- Brenton on Lake & Brenton on Sea
- Buffels Bay
- Karatara
- Rheenendal

Figure KMS1.2 shows the suburbs with suburb names entered during this investigation for all records in the GIS database. The total area of these suburbs indicates the study area of this investigation.

7.3 SYSTEM LAYOUT AND OPERATION

Figure KMS2.1 shows the Belvidere, Brenton on Lake, Brenton on Sea, Buffels Bay, Karatara, Knysna, Rheenendal and Sedgefield systems as operated by the KM.

Each system is operated in a main drainage area with a wastewater treatment plant (WWTP), which in turn could be sub-divided into several sub-drainage areas each as shown on Figure KMS2.2.

7.3.1 Pumping stations

There are 68 pumping stations (PS's) in the Knysna system, 4 in Brenton on Sea, 1 in Belvidere, 2 in Rheenendal, 18 in Sedgefield and 1 in the Karatara system as indicated on Figures KMS2.1 and KMS2.2.

7.3.2 Pipe network

The total KM system consists of ± 318,3 km of gravity sewers and ± 46,7 km of rising mains.

7.4 WATER DEMAND AND SEWER FLOWS

Knysna

The present annual average daily demand (AADD) for the existing Knysna system that contributes to the domestic sewer flow is ± 8 245 kℓ/d, which includes unaccounted-for-water (UAW).

The peak daily dry weather flow (PDDWF) for the Knysna system is estimated at ± 7 790 kℓ/d, or roughly 94% of the AADD.

Sedgefield

The present AADD for the existing erven in the Sedgefield system that contributes to the domestic sewer flow is ± 766 kℓ/d, which includes UAW.

The PDDWF for the Sedgefield system is estimated at ± 691 kℓ/d, or roughly 90% of the AADD.

Belvidere

The present AADD for the existing Belvidere system that contributes to the domestic sewer flow is ± 191 kℓ/d, which includes UAW.

The PDDWF for the Belvidere system is estimated at ± 119 kℓ/d, or roughly 62% of the AADD.

Brenton on Lake

Brenton on Lake is currently serviced by a septic tank and conservancy tank system and does not have a water borne sewage network and wastewater treatment facility for the area.

Brenton on Sea

The present AADD for the existing Brenton on Sea system that contributes to the domestic sewer flow is ± 301 kℓ/d, which includes UAW.

The PDDWF for the Brenton on Sea system is estimated at ± 100 kℓ/d, or roughly 58% of the AADD.

Buffels Bay

Buffalo Bay is currently serviced by a septic tank and conservancy tank system and does not have a water borne sewage network and wastewater treatment facility for the area.

Karatara

The present AADD for the existing erven in the Karatara system that contributes to the domestic sewer flow is ± 99 kℓ/d, which includes UAW.

The PDDWF for the Karatara system is estimated at ± 99 kℓ/d, or roughly 99% of the AADD.

Rheenendal

The present AADD for the existing erven in the Rheenendal system that contributes to the domestic sewer flow is ± 152 kℓ/d, which includes UAW.

The PDDWF for the Rheenendal system is estimated at ± 133 kℓ/d, or roughly 88% of the AADD.

7.5 SEWER FLOW MEASUREMENTS AND CALIBRATION

Daily sewer flow measurement data was available for the Knysna system to calibrate the existing Knysna sewer model. The data available was for sewer flow readings at the Knysna WWTP for the period January 2013 to December 2013.

The Sewer system analysis program (SEWSAN) models were populated with unit hydrographs (UH) as described in Figure KMS5.1, Chapter 5, which is based on the analysis of many flow recordings done for previous studies in the Western Cape Province.

From this data the dry weather flow was predicted from the SEWSAN models. The predicted flow volume from the KM SEWSAN models for each WWTP's is shown on Figure KMS2.4

It is proposed that sewer flow measurements are taken at the WWTP's of each town in order to verify the predicted flow volumes from the Knysna Municipality SEWSAN models.

7.6 WASTEWATER TREATMENT PLANTS

All the present PDDWF for each drainage area is treated at each town's WWTP:

• Knysna	- Capacity	6,00Mℓ/d
• Sedgefield	- Capacity	0,75Mℓ/d
• Belvidere	- Capacity	0,29 Mℓ/d
• Brenton on Sea	- Capacity	0,16Mℓ/d
• Karatara	- Capacity	0,17Mℓ/d
• Rheenendal	- Capacity	0,35Mℓ/d
Total Capacity		**7,72 Mℓ/d**

The total capacity for the existing WWTP's in KM is roughly equal to 0,81 x the present PDDWF of 9,6 Mℓ/d.

The analysis of the capacities of the existing KM WWTP's is however beyond the scope of this study.

7.7 Replacement value

The year 2018/19 replacement value of the system (excluding wastewater treatment plants) is estimated as follows:

Knysna	R	660,34 m
Sedgefield	R	92,77 m
Belvidere	R	18,64 m
Brenton on Sea	R	17,94 m
Karatara	R	16,40 m
Rheenendal	R	15,31 m
Total	R	820,85 m

7.8 FUTURE LAND USE, WATER DEMAND AND SEWER FLOW

7.8.1 Future Land use

For the future scenario pertaining to land use in KM it was assumed that all presently unoccupied erven will become occupied. In addition, certain areas in KM have been identified for future developments in consultation with the Municipality's town planning consultants. Each potential area was assigned an anticipated predominant land use, and will be phased in over a 20-year period.

The potential future land developments in KM are shown on Figure KMS4.1, coloured according to the land use.

7.8.2 Future water demand

The future AADD (that contributes to the sewer flow) of the KM systems studied for this report is ± 25 641 kℓ/d. The future AADD represents an increase of ± 54% over the present fully occupied AADD that contributes to the sewer flow. The potential future developments account for ± 79% of the future AADD.

7.8.3 Future sewer flow

The future PDDWF's of the drainage areas in KM are summarised in Table KMS4.2. The future PDDWF of ± 19 843 kℓ/d is ± 78% of the future AADD for the entire KM.

7.9 OPERATIONAL CRITERIA

For this planning study the instantaneous peak dry weather flow (IPDWF) philosophy was used, where spare capacities in the pipes were reserved to allow for stormwater ingress.

Pipe sizes in gravity mains should therefore be such that the peak dry weather flow can be accommodated in the pipeline whilst flowing 70% or less full. The remaining 30% of the flow area is for the accommodation of stormwater ingress. Should stormwater ingress cause this "spare capacity" to be exceeded, resulting in pipeline overflow, certain measures should be taken by the system manager to prevent ingress of stormwater into the sewer system.

7.10 COMPUTER MODEL ANALYSIS AND EVALUATION OF EXISTING SYSTEM

The existing computer model of the existing sewer system was updated with the latest as-built information and calibrated based on sewer flow readings measured at the WWTP's, using the SEWSAN software. The model is complete, detailed, and geographically accurate, and can therefore also serve as the GIS "as-built" record of the system.

The model was subjected to a typical IPDDWF scenario, and evaluated with respect to:

- Spare capacities in outfall sewers
- Spare capacities at PS
- Flow velocities in outfall sewers
- Flow velocities in rising mains

Presently the sewer systems operates and functions without major problems, and this was reflected in the computer model analysis.

A few bulk pipelines KM are however currently near or at capacity and requires upgrading outfall bulk sewers in Knysna have capacities less than 30%.

7.11 MASTER PLAN FOR SYSTEM EXTENSIONS/AUGMENTATION

A master plan for future extensions to the sewerage system, based on the anticipated future land use in KM was compiled with the use of computer models. The master plan was compiled for a total PDDWF of 19 843 kℓ/d from the system. Pipeline capacities were planned so as to have 30% spare capacity over and above the IPDWF which may occur in a pipe. Proposed works were determined on an economically optimal basis and should be implemented in phases, firstly to ameliorate problems in the existing system and after that as demanded by an increase in sewer flow and the incorporation of new areas into the system.

The proposed works are discussed in detail in the report and only the most important aspects are mentioned in this summary

7.11.1 Drainage areas

The proposed future drainage areas to accommodate future developments within the KM boundaries are, in most cases, extensions of the present drainage areas. Where gravity flow into the existing systems were not possible, PS drainage areas were added.

7.11.2 Wastewater treatment plants

The analysis of the capacities of the existing KM WWTP's is beyond the scope of this study.

7.11.3 Required works

An extended computer model representing the future scenario was set up to plan and size the components of the future sewer system. The motivation for the works, and a detailed description for each component, is provided in the main body of the report.

The required works to reinforce the system for existing and potential future deficiencies are shown on Figure KMS6.4 and listed with short descriptions in Table KMS6.4a. These proposed master plan items are grouped together in proposed projects which are summarised in Table KMS6.4b.

The major new sewer projects with the highest priorities are summarized below:

- Improve integrity of existing sewer models: Survey diameters & slopes of existing main outfall sewers and verify the duty points of the existing sewer pumping stations.
- Knysna bulk sewer upgrade - Phase 1
- Knysna bulk sewer upgrade - Phase 2
- Sedgefield bulk sewer upgrade - Phase 1
- Implement Future PS K8 drainage area - Phase 1
- Implement Future PS K8 drainage area - Phase 2
- Sedgefield bulk sewer upgrade - Phase 2
- Knysna bulk sewer upgrade - Phase 3
- Knysna bulk sewer upgrade - Phase 4
- Knysna bulk sewer upgrade - Phase 5
- Sewer infrastructure for existing unserviced erven in Sedgefield - Phase 1

7.11.4 Cost estimates and phasing in of works

The total cost (year 2018/19 value) for all the required works is estimated at R 360,11 million (including P&G's, contingencies and fees, excluding VAT). This total can be broken down as follows:

Gravity sewers	:	R	252,9 million
Diversion structures	:	R	0,59 million
Pumping stations	:	R	55.1 million
Rising mains	:	R	48,3 million
WWTP	:	R	1,8 million
Telemetry	:	R	1,3 million
Total		**R**	**360,11 million**

The capital investment of R 360,11 million is required over time to increase the system capacity from the present PDDWF of roughly 9,6 Mℓ/d, to the future horizon of 19,8 Mℓ/d PDDWF.

Tables KMS6.4a &KMS6.4b also gives an indication of when the works are required. The required expenditure should be phased to remain in line with the increase in PDDWF.

The proposed projects with the highest priority in the KM system are included in Table KMS6.4c. The estimated cost of items required in the next 5 years is ± R 93,2 million.

7.12 MASTER PLAN UNIT COST

The required capital expenditure for these priority sewer infrastructure projects is as follows:

- R 26,5 million for the 2018/19 financial year
- R 29,4 million for the 2019/20 financial year
- R 37,3 million for the 2020/21 financial year

Table KMS7.1 is a summary of the total costs associated with the proposed master plan for the sewer system for the next 20 to 25 years, which amounts to R 360,11 million.

The master plan implementation at cost of R 360,11 million will increase the KM system capacity from its present PDDWF of 9 593 kℓ/d to the future PDDWF of 19 843 kℓ/d. This amounts to an implementation unit cost of ± R 35 132 R/kℓ/d.

7.13 UPDATING AND MAINTENANCE OF THE COMPUTER MODEL AND MASTER PLAN

The calibrated computer model of the sewer system is a handy tool for the day to day management of the system and can also be used as a basis for the calculation of services contributions by developers. The utility value of the model will however be lost if it is not properly maintained. The model should therefore be kept up to date with new developments and extensions to the system, and a link to the treasury water sales and land use data.

7.14 MONITORING OF THE SYSTEM

A continuous flow monitoring programme, mainly through an extension of the already established telemetry system, is suggested as it will greatly enhance future calibration and planning studies performed with the model as basis. In addition, its results can be used with a view to identifying those drainage areas where the most stormwater ingress occurs, so that these can be prioritized in terms of the proposed investigation into the causes of the problem.

7.15 STORMWATER INGRESS AND GROUNDWATER INFILTRATION

The impact of stormwater ingress and groundwater infiltration on the operation and performance of a sewer network is in many cases hugely underestimated. A programme whereby sewer flows at strategic points in the network (WWTP's and PS) are monitored, via telemetry, is recommended. Results from these loggings could be used to identify the areas which pose the greatest problems in this regard, after which a strategy to address these problems should be adopted.

7.16 ASSET MANAGEMENT

It is recommended that the current databases as well as hydraulic analyses and master planning results be extended and applied to support the asset register (AR) and asset management plan (AMP).

7.17 PIPE REPLACEMENT PRIORITIZATION

It is recommended that a pipe replacement prioritization analyses is performed for the entire KM sewer network in order to ensure that upgrades and replacements of infrastructure are planned and implemented in an efficient and cost effective manner.

7.18 CONCLUSION

It is recommended that the sewer master plan as described in this report be implemented in order to allow the KM sewer distribution system to keep in step with the anticipated growth and expansion of sewer flow.

Table KMS7.1 Sewer master plan cost summary