STELLENBOSCH MUNICIPALITY

SEWER MASTER PLAN
(Final Draft)

June 2019

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LIST OF ABBREVIATIONS & ACRONYMS

AADD	-	Annual average daily demand
d	-	Day
DWA	-	Department of Water Affairs
ECE	-	Element Consulting Engineers
FDA	-	Future Development Area
GIS	-	Geographic Information System
GLS	-	GLS Consulting Engineers (Pty) Ltd
h	-	Hour
ha	-	Hectare
IMQS	-	Infrastructure Management Query Station (software)
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
ℓ	-	Litre
ℓ/day/UE	-	Litre/day/unit erf
ℓ/min	-	Litre/minute
ℓ/min/m pipe/m Ø diameter	-	Litre/minute/meter per pipe length/meter pipe
ℓ/min/UE	-	Litre/minute/unit erf
ℓ/s	-	Litre/second
m	-	Metre
m a.s.l.	-	Metres above mean sea level
m/s	-	Metres per second
Mℓ	-	Megalitre
mm	-	Millimetre
P&G	-	Preliminary and general
PDDWF	-	Peak daily dry weather flow

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
uPVC	-	Unplasticised polyvinylchloride
UH	-	Unit Hydrographs
UWD	-	Unit Water Demand (e.g. ℓ/stand/d, or kℓ/ha/d)
VAT	-	Value Added Tax
WWTP	-	Wastewater Treatment Plant

1. INTRODUCTION

1.1 BRIEF

GLS consulting engineers (GLS) were appointed to update the master plan of the sewer distribution system for Stellenbosch Municipality (SM).

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 distribution systems of the towns within the Stellenbosch Municipality.

1.2 STUDY AREA

The location of Stellenbosch within the Western Cape is shown on Figure SS1.1. The urban areas within the boundary of the Stellenbosch Municipality are:

- Stellenbosch (including Jamestown and De Zalze)
- Dwars River (Pniel, Kylemore, Johannesdal and Lanquedoc)
- Greater Franschhoek (Franschhoek, La Motte and Wemmershoek)
- Klapmuts
- Raithby

The rural areas within the boundary of the Stellenbosch Municipality are:

- Faure system
- Polkadraai system
- Koelenhof system
- Muldersvlei system
- Meerlust
- Helderberg and Croydon

Figures SS1.2 show 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.

It should be noted that there is no existing sewer systems in the Faure, Muldersvlei, Meerlust, Helderbg and Croydon areas and these areas make use of septic tanks as these areas are mostly agricultural setups.

Polkadraai and Koelenhof form part of the Stellenbosch town drainage area as they both gravitate to the Stellenbosch WWTP.

1.3 PREVIOUS MASTER PLANNING

GLS conducted a sewer master plan for Stellenbosch Municipality for the town of Stellenbosch in June 1993. In 1999 GLS updated the master plan for various density scenarios.

In 2008 Element Consulting Engineers (ECE) in association with GLS conducted sewer master planning for the sewer systems of Stellenbosch town, the Dwars River area, the Greater Franschhoek area, Klapmuts and Raithby.

In December 2011 these sewer master plans where updated again for Stellenbosch Municipality by GLS.

These previous master plans have been updated 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 Stellenbosch Municipal area. This study is confined to the sewerage networks and therefore the process and sufficiency of the 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 Stellenbosch Municipality 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 Stellenbosch Municipality only.

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2. EXISTING SYSTEM

2.1 SYSTEM LAYOUT AND OPERATION

The layouts of the Stellenbosch sewer systems are shown on Figures SS2.1 with a separate Figure for each area as follows:

- a - Stellenbosch town
- b - Dwars River and Meerlust
- c - Greater Franschhoek area
- d - Klapmuts
- e - Raithby, Faure, Helderberg & Croydon
- f - Polkadraai
- g - Koelenhof & Muldersvlei

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 Wastewater Treatment Plant (WWTP), which in turn could be sub-divided into several sub-drainage areas each as shown on Figure SS2.2.

Polkadraai and Koelenhof form part of the Stellenbosch WWTP drainage area as both these areas are connected to the Stellenbosch town sewer system and are treated at the Stellenbosch WWTP.

The other rural areas, Meerlust, Faure, Helderberg, Croydon and Muldersvlei make use of septic tanks as these areas are mostly agricultural setups so there is no formal existing sewer system.

There are 13 pumping stations in the Stellenbosch system (including Polkadraai and Koelenhof), 3 in the Dwars River system, one in the Franschhoek system and 3 in Klapmuts as indicated on Figures SS2.1 and SS2.2.

Tables SS2.1a and SS2.1b provide a summary of all the system components.

Table SS2.2 lists the actual and potential fully occupied present Peak Daily Dry Weather Flows (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 SS2.3 shows the integrity of the pipes in two categories:

- Pipes for which slopes (or invert levels of manholes) were available from the as-built drawings.
- Pipes for which invert levels were calculated based on minimum slopes.

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 in an attempt to continuously improve the data integrity.

2.3 DRAINAGE AREA, WATER DEMAND AND SEWER FLOWS

The total drainage area for each sewer system is shown on Figures SS2.2.

2.3.1 Stellenbosch town

The present Annual Average Daily Demand (AADD), for the existing Stellenbosch system that contributes to the domestic sewer flow is ± 25 417 kℓ/d, which includes unaccounted-for-water (UAW).

The PDDWF for the Stellenbosch system is estimated at ± 22 571 kℓ/d, or roughly 88% of the AADD. Approximately 87% of this is a direct contribution from connections to the sewerage system, and the other 13% is contributed by groundwater infiltration.

2.3.2 Dwars River

The present AADD, for the existing Dwars River system that contributes to the domestic sewer flow is ± 1 839 kℓ/d, which includes UAW.

The PDDWF for the Dwars River system is estimated at ± 1 466 kℓ/d, or roughly 79% of the AADD. Approximately 80% of this is a direct contribution from connections to the sewerage system, and the other 20% is contributed by groundwater infiltration.

2.3.3 Franschhoek

The present AADD, for the existing Franschhoek system (including La Motte and Wemmershoek) that contributes to the domestic sewer flow is ± 4 007 kℓ/d, which includes UAW.

The PDDWF for the Franschhoek system is estimated at ± 3 356 kℓ/d, or roughly 83% of the AADD. Approximately 76% of this is a direct contribution from connections to the sewerage system, and the other 24% is contributed by groundwater infiltration.

2.3.4 Klapmuts

The present AADD, for the existing Klapmuts system that contributes to the domestic sewer flow is ± 1 602 kℓ/d, which includes UAW.

The PDDWF for the Klapmuts system is estimated at ± 1 227 kℓ/d, or roughly 76% of the AADD. Approximately 82% of this is a direct contribution from connections to the sewerage system, and the other 18% is contributed by groundwater infiltration.

2.3.5 Raithby

The present AADD, for the existing Raithby system that contributes to the domestic sewer flow is ± 105 kℓ/d, which includes UAW.

The PDDWF for the Raithby system is estimated at ± 88 kℓ/d, or roughly 83% of the AADD. Approximately 76% of this is a direct contribution from connections to the sewerage system, and the other 24% is contributed by groundwater infiltration.

2.3.6 Faure system

No existing sewer network

2.3.7 Polkadraai system

The present AADD, for the existing Polkadraai system that contributes to the domestic sewer flow is ± 153 kℓ/d, which includes UAW.

The PDDWF for the Polkadraai system is estimated at ± 126 kℓ/d, or roughly 82% of the AADD. Approximately 74% of this is a direct contribution from connections to the sewerage system, and the other 26% is contributed by groundwater infiltration.

2.3.8 Koelenhof system

The present AADD, for the existing Koelenhof system that contributes to the domestic sewer flow is ± 233 kℓ/d, which includes UAW.

The PDDWF for the Koelenhof system is estimated at ± 200 kℓ/d, or roughly 85% of the AADD. Approximately 78% of this is a direct contribution from connections to the sewerage system, and the other 22% is contributed by groundwater infiltration.

2.3.9 Muldersvlei system

No existing sewer network

2.3.10 Meerlust

No existing sewer network

2.3.11 Helderberg & Croydon

No existing sewer network

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

Sewer flow patterns with a relatively high confidence level were obtained from sewer flow measurements, which were used to calibrate the Stellenbosch sewer system analysis program (SEWSAN) model for previous studies done by GLS.

In March 2017 flow meter readings were taken at various locations in Stellenbosch town. These measurements together with daily flow readings measured at the Stellenbosch, Dwars River, Franschhoek, Wemmershoek and Klapmuts WWTP's were used to calibrate the SEWSAN models for Stellenbosch Municipality for this study. From these flow measurements useful information was derived to establish parameters such as stormwater ingress, typical unit hydrographs and leakage/infiltration.

The SEWSAN models were populated with unit hydrographs's (UH's) as described in Figure SS5.1, Chapter 5, which is based on the analysis of many flow recordings done for similar previous studies.

From this data the dry weather flow was predicted and the SEWSAN models adjusted to simulate the PDDWF. The predicted flow volume from the SEWSAN model corresponds well with the actual flow volumes of the entire system measured at the various WWTP's (see Figure SS2.4).

2.6 EXISTING OPERATIONAL PROBLEMS

The following operational problems were indicated by the operational staff:

- Contamination of rivers with raw sewage caused by spilling during power cuts.

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

It is recommended that field tests be carried out to verify pump duty points at all the pumping stations. The unknown pipe diameters and invert levels should also be determined in order to improve the confidence levels of the models.

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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 "***S****ewer* ***W****ater* ***I****nterface* ***F****or* ***T****reasury systems*"). The program was used to analyse the present land use and water demand situation in Stellenbosch, 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 Stellenbosch Municipality has a SAMRAS 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 SAMRAS software suite in future.

The treasury records for the period June 2017 to July 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 Stellenbosch Municipality, 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
- PARKS - Parks
- RES - Residential stands
- UNKNOWN - All stands where the category of the land use code is unclear

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 250 m²
- RES 500 - 250 m² to 500 m²
- RES 1 000 - 500 m² to 1 000 m²
- RES 1 500 - 1 000 m² to 1 500 m²
- RES 2 000 - 1 500 m² to 2 000 m²
- RES > 2 000 - larger than 2 000 m²

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's (UWD's) that might not be applicable to them. The large water users are discussed later in this Chapter.

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 Stellenbosch Municipality 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 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 SS3.1.

Figure SS3.1 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 30% for Stellenbosch town, 50% for the Dwars River area, 32% for the Greater Franschhoek area, 20% for Klapmuts, 32% for Faure, 28% for Polkadraai, 28% for Muldersvlei, 26% for Meerlust and 21% for Helderg and Croydon. The results are summarised in Table SW3.3.

The global UAW of 24 % should be able to be reduced by implementing a Water Demand Management Programme.

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 SS3.1.

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 informal areas in the area, an UAW figure of 34% for Stellenbosch town, 33% for the Dwars River area, 37% for the greater Franschhoek area, 27% Klapmuts, 20% for Raithby, 20% for Faure, 20% for Polkadraai, 20% for Koelenhof, 20% for Muldersvlei, 37% for Meerlust and 20% for Helderg and Croydon were applied for modelling purposes of the existing system.

For modelling purposes of the future system, an UAW figure of 30% for Stellenbosch town, 30% for the Dwars River area, 30% for the greater Franschhoek area, 20% Klapmuts, 20% for Raithby 20% for Faure, 20% for Polkadraai, 20% for Koelenhof, 20% for Muldersvlei, 30% for Meerlust and 20% for Helderg and Croydon were 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 Stellenbosch was determined. The results are summarised per suburb in Table SS3.1.

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 SS3.2 is a list of all the stands defined as large users in SWIFT for Stellenbosch Municipality. The table shows the 50 largest users 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 sewer system model. The 50 largest users in the Stellenbosch Municipality have a total AADD of 6 902 kℓ/d (excluding UAW), representing ± 25% of all water sold in the Stellenbosch Municipality.

3.4.7 Informal settlements

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

The following informal settlements were reported to be present in the 2011/12 Water Services Development Plan (performed by WorleyParsons for the Stellenbosch Municipality) dated June 2011:

- 8 235 households in Stellenbosch (Kayamandi)
- 226 households in Jamestown
- 1 635 households in Franschhoek (Langrug and Mooiwater area)
- 30 households in Dwars River (Kylemore and rural area)
- 256 households in Klapmuts

These settlements receive water from a number of unmetered stand pipes and therefore contribute to the UAW figure.

3.4.8 Present water demand summary

Table SS3.4 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 UH for modelling the sewer flow contributions of typical erven. The 14 UH's are described in Figure SS5.1, Chapter 5, and are based on the analysis of many flow recordings done for previous studies. Table SS3.5 is a summary of how the various land uses in Stellenbosch were mapped to these UH's. Figure SS3.1 shows the stands coloured in accordance with their land use 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 65%) 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 65% and 80% 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 Stellenbosch are summarised in Table SS2.2. 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 from 69% to 90% of the actual present AADD for the towns in the Municipal area.

3.5.4 Informal settlements

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

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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 SS2.2.

4.2 POTENTIAL FUTURE LAND DEVELOPMENTS

The potential areas for future developments were identified in consultation with the Planning Directorate of Stellenbosch Municipality. 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 are shown on Figure SS4.1, 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 (FDA), based on the statistics obtained from the analysis of the present water demands and in consultation with water services of Stellenbosch, to determine their potential water demand. The results are listed in Table SS4.1.

4.4 SEWER FLOWS OF FUTURE LAND DEVELOPMENTS

Tables SS4.1 and SS6.3 also shows the UH allocations to the future land developments, as well as estimates for their infiltration flows and PDDWF.

4.5 FUTURE WATER DEMAND

The future AADD (that contributes to the sewer flow) of the Stellenbosch Municipality system studied for this report is ± 75 173 kℓ/d. The future AADD represents an increase of ± 90 % over the present fully occupied AADD that contributes to the sewer flow. The potential future developments account for ± 78 % of the future AADD.

4.6 FUTURE SEWER FLOW

The future PDDWF's of the drainage areas in Stellenbosch are summarised in Table SS4.2. The future PDDWF of ± 60 572 kℓ/d is ± 80 % of the future AADD for the entire Stellenbosch Municipality.

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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 Stellenbosch 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 2038 (i.e. 20 years) as the horizon for planning purposes. The total PDDWF for the Stellenbosch system can then potentially be ± 57 385 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 rights. For planning of future systems, PDDWF's of all potential future developments were added.

5.1.3 Unit sewer flows

The SEWSAN program uses a unit hydrograph 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 SS5.1. These are based on the analysis of many flow recordings, as performed for previous studies. In the analysis and planning of the system, the unit hydrograph ordinates are adjusted to reflect the actual percentages of the AADD.

5.1.4 Total base flow (Infiltration and Leakage)

As part of the unit hydrographs, 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 ± 84% of the total base flow in the system. The base flow rates for each UH type is listed in Figure SS5.1. The other ± 16% 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 SS5.3). The total base flow in the Stellenbosch Municipality systems is typically ± 35% 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 SS5.3.

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 SS5.1 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 SS5.2.

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 2,5 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 SS5.2). 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 pipe sizes. The IPDWF philosophy, as described below, was therefore used.

Pipe sizes in gravity mains should 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.

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 Pump stations

The following criteria apply to the design and evaluation of pumping stations:

- Pump configurations should be such that there is always at least one standby pump available for emergency purposes.
- Pumping station capacity should be such that it equals or exceeds the peak wet weather flow which arrives at the pumping station, or the peak dry weather flow 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 pumping station 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 hours 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 SS5.2.

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 experienced 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.

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6. EVALUATION AND MASTER PLAN

6.1 EXISTING SYSTEM

6.1.1 Replacement value

Table SS6.1 provides an estimate of the replacement value of the existing Stellenbosch Municipality system, based on the cost functions shown on Figure SS5.2. It amounts to a total value of R 853,3 m (incl. VAT) and a PDDWF unit value of ± 29 402 R/kℓ/d.

6.1.2 External contributions to sewer flow

The Digteby area is accommodated by the Stellenbosch WWTP, as well as the existing Koelenhof developments. These areas will be reported on individually in the report however it should be noted that these areas contribute to the total existing sewer flow accommodated at the Stellenbosch WWTP.

6.1.3 Existing drainage areas and sewer flows

Table SS2.2 provides a breakdown of the existing land use in each sub-drainage area, as well as the estimated contribution of each land use type to the total PDDWF for that area.

6.1.4 Spare capacities

Figure SS6.1 shows the relative spare capacities in the existing Stellenbosch Municipality system under IPDWF. The red and light blue lines indicate pipes where capacity problems (< 30% spare) may be experienced.

6.1.5 Flow velocities under peak demand

Figure SS6.2 shows the flow velocities in the existing Stellenbosch Municipality system under full flow conditions. A small number of pipes have velocities less than 0,6 m/s. It can be noted however, that a minimum slope resulting in v = 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 SS2.3.

6.1.6 Flow hydrographs

The present PDDWF hydrographs at each WWTP are shown on Figure SS6.6.

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 SS6.3.

6.2.2 Accommodation of future land developments

The future land developments are accommodated in the extended drainage areas. Table SS6.3 is a summary of the future land development areas linking to the Stellenbosch system, their AADD and PDDWF, UH's, 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 SS6.4.

6.2.3 External contributors to sewer flow

The future developments of the Vredenheim and Longlands area next to the existing Digteby development will accommodated by the Stellenbosch WWTP, as well as the proposed developments for the Koelenhof area. It should be noted that these areas contribute to the total future sewer flow accommodated at the Stellenbosch WWTP.

6.2.4 Future sewer flow

Table SS4.2 provides a breakdown of the future land use in each sub-drainage area, as well as the estimated contribution of each land use type to the total PDDWF for that area.

6.3 MASTER PLAN

The Master planning for each of the towns in Stellenbosch Municipality 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 SS6.4. Details of the required items, cost estimates and phasing are also indicated in Table SS6.5. Note that the internal network pipes in future developments were treated as schematic and are not included as Master Plan Items. Table SS6.6 shows the required pumping station capacities for the future scenario.

6.3.1 Stellenbosch town

The boundaries of the existing drainage areas in Stellenbosch are increased to accommodate proposed future development areas that fall within these drainage areas.

Due to densification in the Central areas of Stellenbosch in recent years, the collectors sewers in Merriman Street and Dorp Street are currently at capacity and requires upgrading.

It is proposed that the Techno Park and Jamestown pumping stations are abandoned and that the flows from these drainage areas are diverted to the existing De Zalze drainage area. The existing De Zalze 1 & 2 pumping stations should also be abandoned and the sewage from this new drainage area (the Blaauwklippen drainage area) should gravitate along the Blaauwklippen River to the De Zalze 2 pumping station. From here a new pumping station (the proposed Blaauwklippen pumping station) and rising main to the Stellenbosch future pumping station S1 should be constructed (items SSS4.15 & SSS4.16 in Table SS6.5a). It is proposed that sewage is pumped from the proposed Stellenbosch future pump stationing S1 directly to the existing Stellenbosch WWTP through a new rising main (items SSS3.9 & SSS3.10 in Table SS6.5a).

A new Stellenbosch future pumping station 1 drainage area is proposed for future areas S49 - S52, S55, S57 & S58 which gravitates to the proposed Stellenbosch future pumping station S1.

The collector sewer adjacent to the railway-line from Merriman Street to the existing Adam Tas main outfall sewer is currently at capacity and requires upgrading.

Upgrading of the main outfall sewers in Idas Valley with larger sized future sewers is proposed (items SSS1.41 – SSS1.45 in Table SS6.5a)

Upgrading of the main outfall sewer in Cloetesville is proposed when capacity problems occur.

A new future pumping station S3 drainage area is proposed for future development area S80. A new pumping station and rising main (items SSS7.1 & SSS7.2 in Table SS6.5a) should be constructed for this new drainage area that discharges into the existing

Adam Tas drainage area. (A policy regarding the extent of development of area S80 should be adopted as the watershed on the top of the mountain is crossed).

New outfall sewers are proposed to accommodate future development areas in Stellenbosch.

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

6.3.2 Dwars River

The boundaries of the existing drainage areas in the Dwars River WWTP system are increased to accommodate proposed future development areas that fall within these drainage areas.

A number of new outfall sewers are required to collect sewage from the new future development areas in the Dwars River area. The collector sewer between Kylemore and the Dwars River WWTP is at capacity and should be upgraded (items SDS1.1 - SDS1.3 in Table SS6.5a).

A new future pumping station DR1 drainage area is proposed for the future development areas north of the Pniel drainage area. A new pumping station next to the Dwars River with a rising main to the Pniel pumping station should be constructed for this purpose.

A new future pumping station DR2 drainage area is proposed for future development areas DR27 - DR29 north of the proposed future pumping station DR1 drainage area. A new pumping station and rising main (items DRS5.4 & DRS5.5 in Table SS6.5a) should be constructed for this new drainage area that discharges into the proposed future pumping station DR1.

When the proposed future pumping station DR1 and rising main is constructed, the existing Pniel pumping station and rising main should be upgraded according to the master plan.

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

6.3.3 Franschhoek

The boundaries of the existing drainage areas in Franschhoek, Wemmershoek and La Motte are increased to accommodate proposed future development areas and existing unserviced erven that fall within these drainage areas.

A new future pumping station L1 drainage area is proposed for future development area LM1 in La Motte that cannot gravitate to the existing infrastructure. A new pumping station and rising main should be constructed for this new drainage area that discharges into the existing La Motte drainage area.

A few existing outfall sewers require upgrading by replacement with larger sized future sewers.

New outfall sewers are proposed to accommodate future development areas and to service the existing unserviced erven in Franschhoek, Wemmershoek and La Motte.

6.3.4 Klapmuts

The boundaries of the existing Klapmuts Gravity drainage area and the proposed future pumping station K1 drainage area are increased to accommodate future development areas that fall within these drainage areas.

It is proposed that the existing pumping stations in Klapmuts are abandoned and that flow from their drainage areas is diverted to a new Klapmuts future pumping station K1 south of the N1 National Road, next to the R44 Main Road. It is proposed that this pumping station discharges directly into the existing Klapmuts WWTP via a new rising main.

As a result of other specialist studies, it has been proposed that the existing Klapmuts WWTP is increased to a future capacity of 2 Mℓ/day and that a new Klapmuts WWTP is constructed downstream of the existing site in the future when the existing treatment plant reaches its upgraded capacity. A study to determine the preferred site for the new treatment plant should be performed.

Sewage flow from future pumping station K1 should be diverted in the future to the new Klapmuts WWTP through a new bulk outfall sewer (items SKS1.20 & SKS4.1 - SKS4.5 in Table SS6.5a).

Items SKS2.5, SKS2.6 & SKS4.6 - SKS4.8 are proposed to divert flow from the existing Klapmuts WWTP to the future Klapmuts WWTP.

A new future pumping station K2 drainage area is proposed for future development areas K9 & K12 that cannot gravitate to the existing Klapmuts WWTP. A new pumping station and rising main should be constructed for this new drainage area that discharges into the existing Klapmuts WWTP. When the new Klapmuts WWTP is commissioned in future, flow from this pumping station can be diverted to the new Klapmuts WWTP drainage area.

A few existing outfall sewers require upgrading by replacement with larger sized future sewers and new outfall sewers are proposed to accommodate future development areas in Klapmuts.

6.3.5 Raithby

The existing drainage area is increased to accommodate proposed future development areas.

No upgrading of any of the components of the existing sewer drainage system is required.

6.3.6 Faure system

Faure consist mostly of agricultural setups and these areas make use of septic tanks.

6.3.7 Polkadraai system

Polkadraai consist mostly of agricultural setups and these areas make use of septic tanks. However there is an urban development area within the Polkadraai scheme. Digteby is currently serviced with a pump station that pumps the developments sewage to the Stellenbosch WWTP. The existing Longlands development currently makes use of conservancy tanks.

It is proposed in the master plan that the Longlands area along with any other future developments in the area gravitate to the proposed Blaauwklippen PS. The existing Digteby PS will also be decommissioned and will gravitate to the new proposed PS.

Master plan items SSS4.17, SSS4.18 and SSS4.20 will be required to connect the existing developments along with future developments to the proposed PS (SSS4.15). Item SSS4.30 is required to decommission the existing Digteby PS.

6.3.8 Koelenhof system

Koelenhof consist mostly of agricultural setups and these areas make use of septic tanks. However there is an urban development area within the Koelenhof scheme. The Koelenhof urban development area currently gravitates to the Stellenbosch WWTP.

Master plan items SSS8.1 - SSS8.7 will be required to connect the future developments proposed for the Koelenhof area to the existing sewer network that gravitates to Stellenbosch.

6.3.9 Muldersvlei system

Muldersvlei consist mostly of agricultural setups and these areas make use of septic tanks.

6.3.10 Meerlust

Meerlust consist mostly of agricultural setups and these areas make use of septic tanks.

6.3.11 Helderberg & Croydon

Helderberg & Croydon consist mostly of agricultural setups and these areas make use of septic tanks.

6.4 FUTURE SYSTEM

6.4.1 Spare capacities

Figure SS6.5 shows the relative spare capacities in the future Stellenbosch Municipality system 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 v > 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 SS6.2.

6.4.3 Flow hydrographs

The future PDDWF hydrographs are shown on Figure SS6.6, for each WWTP.

6.4.4 Pumping stations and rising mains

Table SS6.6 shows a summary of all the pumping stations in the future system. The table shows which existing pumping stations have sufficient capacity, which pumping stations requires upgrading, which require downsizing, which should be decommissioned in the future and what new pumping stations are required in future.

In the town of Stellenbosch the existing pumping stations and their rising mains for which information was made available, all have sufficient capacity for the future sewer flows. In Dwars River the Pniel pumping station and rising mains should be upgraded in the future when capacity problems occur.

The existing pumping stations 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 pumping stations be verified by field pumping tests.

All pumping stations 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) pumping stations.

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

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 Stellenbosch Municipality sewer network in order to ensure that upgrades and replacements of infrastructure are planned and implemented in an efficient and cost effective manner.

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7. Summary

This report describes the study undertaken with respect to the updating of the master plan for the sewer distribution system of the Stellenbosch Municipality (SM). The initial sewer master plan was compiled by GLS consulting engineers (GLS) and documented in a report, dated December 2011.This master plan was subsequently updated by GLS and documented in a report, dated June 2017.

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 SM 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 SM is responsible for the operation and maintenance of the sewer reticulation systems of the towns within the boundary of the OM, which are:

Urban areas
- Stellenbosch
- Dwars River
- Franschhoek
- Klapmuts
- Raithby

Rural areas
- Fuare
- Polkadraai
- Koelenhof
- Muldersvlei
- Meerlust
- Helderberg & Croydon

Figure SS1.2 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 SS2.1 shows the Stellenbosch, Dwars River, Franschhoek, Klapmuts, Raithby, Faure, Polkadraai, Koelenhof, Muldersvlei, Meerlust Helderberg & Croydon systems as operated by the SM.

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 SS2.2.

Most of the rural areas consist mostly of agricultural setups and are serviced by septic tanks.

7.3.1 Pumping station

There are 13 PS's in the Stellenbosch system, 3 in Dwars River, 1 in Franschhoek which has been decommissioned, 3 in Klapmuts, none in the Riathby, 1 in Polkadraai and none in the Koelenhof system as indicated on Figures SS2.1 and SS2.2.

7.3.2 Pipe network

The total SM system consists of ± 432 km of gravity sewers and ± 21 km of rising mains.

7.4 WATER DEMAND AND SEWER FLOWS

Stellenboscch

The present Annual Average Daily Demand (AADD), for the existing Stellenbosch system that contributes to the domestic sewer flow is ± 25 417 kℓ/d, which includes unaccounted-for-water (UAW).

The PDDWF for the Stellenbosch system is estimated at ± 22 571 kℓ/d, or roughly 88% of the AADD.

Dwars River

The present AADD, for the existing Dwars River system that contributes to the domestic sewer flow is ± 1 839 kℓ/d, which includes UAW.

The PDDWF for the Dwars River system is estimated at ± 1 466 kℓ/d, or roughly 79% of the AADD.

Franschhoek

The present AADD, for the existing Franschhoek system (including La Motte and Wemmershoek) that contributes to the domestic sewer flow is ± 4 007 kℓ/d, which includes UAW.

The PDDWF for the Franschhoek system is estimated at ± 3 356 kℓ/d, or roughly 83% of the AADD.

Klapmuts

The present AADD, for the existing Klapmuts system that contributes to the domestic sewer flow is ± 1 602 kℓ/d, which includes UAW.

The PDDWF for the Klapmuts system is estimated at ± 1 227 kℓ/d, or roughly 76% of the AADD.

Raithby

The present AADD, for the existing Raithby system that contributes to the domestic sewer flow is ± 105 kℓ/d, which includes UAW.

The PDDWF for the Raithby system is estimated at ± 88 kℓ/d, or roughly 83% of the AADD.

Faure system

No existing sewer network

Polkadraai system

The present AADD, for the existing Polkadraai system that contributes to the domestic sewer flow is ± 153 kℓ/d, which includes UAW.

The PDDWF for the Polkadraai system is estimated at ± 126 kℓ/d, or roughly 82% of the AADD.

Koelenhof system

The present AADD, for the existing Koelenhof system that contributes to the domestic sewer flow is ± 233 kℓ/d, which includes UAW.

The PDDWF for the Koelenhof system is estimated at ± 200 kℓ/d, or roughly 85% of the AADD.

Muldersvlei system

No existing sewer network

Meerlust

No existing sewer network

Helderberg & Croydon

No existing sewer network

7.5 SEWER FLOW MEASUREMENTS AND CALIBRATION

The Sewer system analysis program (SEWSAN) models were populated with unit hydrographs (UH) as described in Figure SS5.1, Chapter 5, which is based on the analysis of many flow recordings done for previous studies in the Western Cape Province.

Sewer flow patterns with a relatively high confidence level were obtained from sewer flow measurements, which were used to calibrate the Stellenbosch sewer system analysis program (SEWSAN) model for previous studies done by GLS.

From this data the dry weather flow was predicted and the SEWSAN models adjusted to simulate the PDDWF. The predicted flow volume from the SEWSAN model corresponds well with the actual flow volumes of the entire system measured at the various WWTP's (see Figure SS2.4).

7.6 WASTEWATER TREATMENT PLANTS

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

•	Stellenbosch WWTP	- Capacity	35,00 Mℓ/d
•	Pniel WWTP	- Capacity	1,35 Mℓ/d
•	Klapmuts WWTP	- Capacity	2,40 Mℓ/d
•	Wemmershoek WWTP	- Capacity	5,00 Mℓ/d
•	Raithby WWTP	- Capacity	0,15 Mℓ/d
	Total Capacity		**43,90 Mℓ/d**

The total capacity for the existing WWTP's in SM is roughly equal to 1,5 x the present PDDWF of 29,04 Mℓ/d.

The analysis of the capacities of the existing SM 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:

Stellenbosch (Including Polkadraai & Koelenhof)	R	799,43 m
Dwars River	R	83,68 m
Franschhoek	R	191,97 m
Klapmuts	R	58,81 m
Raithby	R	10,55 m
Total	R	1 144,37 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 SM it was assumed that all presently unoccupied erven will become occupied. In addition, certain areas in SM 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 SM are shown on Figure SS4.1, coloured according to the land use.

7.8.2 Future water demand

The future AADD (that contributes to the sewer flow) of the Stellenbosch Municipality system studied for this report is ± 75 173 kℓ/d. The future AADD represents an increase of ± 90 % over the present fully occupied AADD that contributes to the sewer flow. The potential future developments account for ± 78 % of the future AADD.

7.8.3 Future sewer flow

The future PDDWF's of the drainage areas in Stellenbosch are summarised in Table SS4.2. The future PDDWF of ± 60 572 kℓ/d is ± 80 % of the future AADD for the entire Stellenbosch Municipality.

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 IPDWF 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

A few bulk pipelines in SM are currently near or at capacity and requires upgrading.

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 SM was compiled with the use of computer models. The master plan was compiled for a total PDDWF of 60 572 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 SM 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 SM 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 SS6.4 and listed with short descriptions in Table SS6.4a. These proposed master plan items are grouped together in proposed projects which are summarised in Table SS6.4b.

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

- Connect new bulk (Adam Tas) sewer to existing system
- Klapmuts bulk sewer infrastructure - phase 1
- Implement Blaauwklippen drainage area - phase 1
- Upgrade Kylemore main outfall sewer
- Implement Blaauwklippen drainage area - phase 2
- Klapmuts bulk sewer infrastructure - phase 2

- Dorp Street outfall sewer upgrades
- Implement Blaauwklippen drainage area - phase 3
- Adam Tas bulk outfall sewer - phase 2
- Merriman/Banghoek outfall sewer upgrades
- Upgrade existing capacity: Lanquedoc PS drainage area
- Sewer infrastructure for existing unserviced erven: Franschhoek
- Klapmuts bulk sewer infrastructure - phase 3

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 247,338 million (including P&G's, contingencies and fees, excluding VAT). This total can be broken down as follows:

Gravity sewers	:	R	189,84 million
PS's	:	R	20,11 million
Rising mains	:	R	32,92 million
Total		**R**	**242,87 million**

The capital investment of R 242,87 million is required over time to increase the system capacity from the present PDDWF of roughly 29,03 Mℓ/d, to the future horizon of 60,57 Mℓ/d PDDWF.

Tables SS6.4a & SS6.4b 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 SM system are included in Table SS6.4c. The estimated cost of items required in the next 3 to 4 years is ± R 78,664 million.

7.12 MASTER PLAN UNIT COST

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

- R 10,87 million for the 2018/19 financial year
- R 32,55 million for the 2019/20 financial year
- R 26,20 million for the 2020/21 financial year
- R 9,04 million for the 2021/22 financial year

Table SS7.1 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 242,87 million.

The master plan implementation at cost of R 242,87 million will increase the SM system capacity from its present PDDWF of 29 034 kℓ/d to the future PDDWF of 60 572 kℓ/d. This amounts to an implementation unit cost of R 7 700 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 SM 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 SM sewer distribution system to keep in step with the anticipated growth and expansion of sewer flow.

Table SS7.1: Master plan cost summary20