CITY OF TSHWANE METROPOLITAN MUNICIPALITY

CONTRACT NUMBER: RTD 04-2014/15/RATSHW12

For

Design of water reticulation for metered yard connections and /or waterborne sanitation and toilet top structures including all the bulk services if necessary in Hammanskraal West Extension 10

Detail Design Report
Water and Sewer Bulk Services

Report no.: 18616_R08_R00_Ext 10 Bulk Detail Design Report

29 September 2017

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DETAIL DESIGN REPORT APPROVAL

CONTRACT NAME	:	**Design of water reticulation for metered yard connections and /or waterborne sanitation and toilet top structures including all the bulk services if necessary in Hammanskraal West Extension 10**
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CONSULTANT	:	**Nyeleti Consulting (Pty) Ltd**

Franz de Lange		29/09/2017
Name (Print)	**Signature**	**Date**

For Consultant

Nyeleti Consulting (Pty) Ltd

Name (Print)	**Signature**	**Date**

For City of Tshwane

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1 INTRODUCTION

Nyeleti Consulting was appointed for Contract Number RTD04-2014/15/RATSHW12 for Consulting Engineering Services for the Design of water reticulation for metered yard connections and /or waterborne sanitation and toilet top structures including all the bulk services if necessary in Hammanskraal Extension 2 and 10.

The Scope of the appointment was defined as follow:

a.) The design of a new reticulation system for metered yard connections and waterborne sanitation including toilet top structures.
b.) The reticulation must meet the City of Tshwane standards for water and waterborne sanitation.
c.) The bulk water services must meet the City of Tshwane standards.

Upon investigation, the need for upgrading of bulk services to the area became apparent and the scope of work was expanded to include the following:

- a.) The bulk water supply pipeline from the Hammanskraal West Reservoir.
- b.) The outfall sewer from Hammanskraal Ext 10 to the existing ND1 200 main sewer next to the Apies River.

This report only deals with the water and sewer bulk services, required to service the water and sewer reticulation in Hammanskraal West Extension 10, but it will also service other extensions of Hammanskraal West.

The scope of services of the appointment includes:

a.) Inception
b.) Concept and Viability
c.) Design Development
d.) Documentation and Procurement
e.) Contract Administration and Inspection
f.) Close Out
g.) Additional services: OHS & Environmental Control

2 PROJECT DEFINITION

2.1 Background

Hammanskraal West Extension 10 is situated in Region 2. The City has relocated community members to the area which will be divided into 2767 stands. The area is currently not serviced with water and sanitation. As the scope of works stated the inclusion of bulk services, if necessary, the adequacy of the existing bulk services to accommodate the development of Hammanskraal West Extension 10 as well as the surrounding areas which are currently under development was investigated.

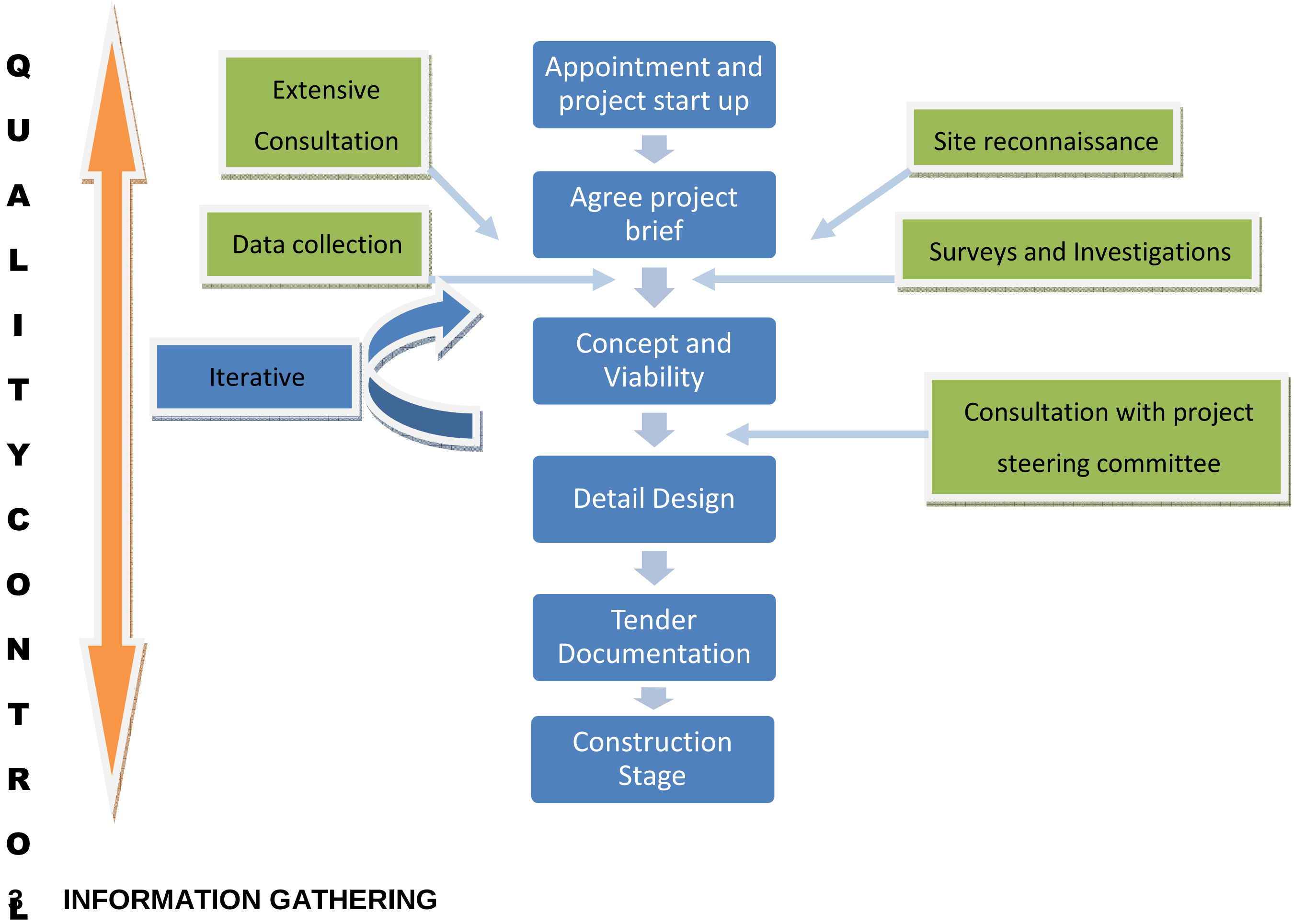
The investigation indicated that existing bulk water and bulk sewer were both insufficient to service Hammanskraal West Extension 10. This report only deals with the upgrade of bulk water and sewer in Hammanskraal West. The Detail design of water and sewer reticulation for Hammanskraal West Extension 10 is covered in a separate report (Report no: 18616_R07_R00_Ext 10 Reticulation Detail Design Report)

2.2 Study Area

The project area is located North of Pretoria, off the N1 in Hammanskraal. The primary and affected wards is ward 49. A locality plan is attached in **Annexure A**.

2.3 Brief Outline of Methodology

The following flowchart describes the project design cycle and the relevant principles applied at the various stages. The flow chart will assist in programming, identifying milestone and possible risks. It is specifically noted that a full EIA is not required as the land is already occupied, however notification is still necessary to comply with Gauteng Province requirements.



3 INFORMATION GATHERING

3.1 Previous Reports

The following reports and information was obtained and consulted:

- Master Plan Water System – Temba: Retic – Hammanskraal West Reservoir, compiled by GLS Consulting, dated April 2016
- Master Plan Water System – Temba: Bulk -Temba compiled by GLS Consulting, dated December 2016
- Master Plan Sewerage System – Temba_Babelegi: Temba and Babelegi drainage area, compiled by GLS Consulting, dated April 2016
- Additional Land use, densities and area data were provided by GLS Consulting

3.2 Site visit

On 8 November 2016 the consultant visited the site for the first time and assessed the following:

a. Ground conditions in the area
b. Topographical layouts
c. Geological outcrops and other restrictions
d. Water courses and affected environmental constraints like wetlands etc.

Various follow up visits were made to the site to verify possible routes for Bulk Water and Sewer services. Both Hammanskraal and Hammanskraal West Reservoir were visited to assess the existing infrastructure.

3.3 As-built Drawings

As-built drawings of the following existing services were obtained from CoT or the consultants which designed the services:

- Th existing dual purpose pumping and gravity main, which is fed from the Temba Treatment Plant pump station and connects the Hammanskraal and Hammanskraal West reservoirs.
- The Hammanskraal West Reservoir
- The bulk sewer line servicing Hammanskraal West Extension 2, which was completed in 2015.
- The bulk Sewer lines running alongside the Apies river to the Temba Waste Water Treatment Works

4 BULK WATER PIPELINE DESIGN

4.1 Overview of Hammanskraal Bulk Water Supply

Hammanskraal forms part of the Temba Bulk Supply System, which lies partly in Gauteng and partly in North West Province. The system is served by two water treatment plants, namely:

- Klipdrift WTP, which is owned and operated by Magalies Water, with a capacity of 18 000kl/day.
- Temba WTP, which is owned and operated by Tshwane, with a capacity of 60 000kl/day.

There are also two reservoirs in the Hammanskraal area, namely:

- Hammanskraal Reservoir
- Hammanskraal West Reservoir.

There is a ND500 pumping main from the Temba reservoirs, which are situated at the Temba WTP, which Tees off into a ND600 line to Hammanskraal West reservoir and a ND600/ND500/ND450 to Hammanskraal reservoir. The reticulation networks for areas that have been developed are linked directly to the pumping mains via Pressure Reducing Valves (PRV’s).

City of Tshwane’s philosophy is to separate bulk and reticulation systems, which led to the need for a new large diameter gravity main from Hammanskraal West reservoir back to the Hammanskraal West reticulation networks, which will allow the existing PRV connections to be closed and by-passed and new connections will not require the PRVs. The new gravity main will have to be linked to the eastern branch which supplies Hammanskraal West Proper / X01 / X02 as well as Hammanskraal South. (Master Plan Water System – Temba: Retic – Hammanskraal West Reservoir, compiled by GLS Consulting)

Construction of a pump station at Babalegi reservoir is currently underway and is estimated to be completed by mid-2018. Once the pump station is complete the Hammanskraal reservoir will be fed via the Babalegi pump station.

The Hammanskraal System as described is shown in Figure 1.

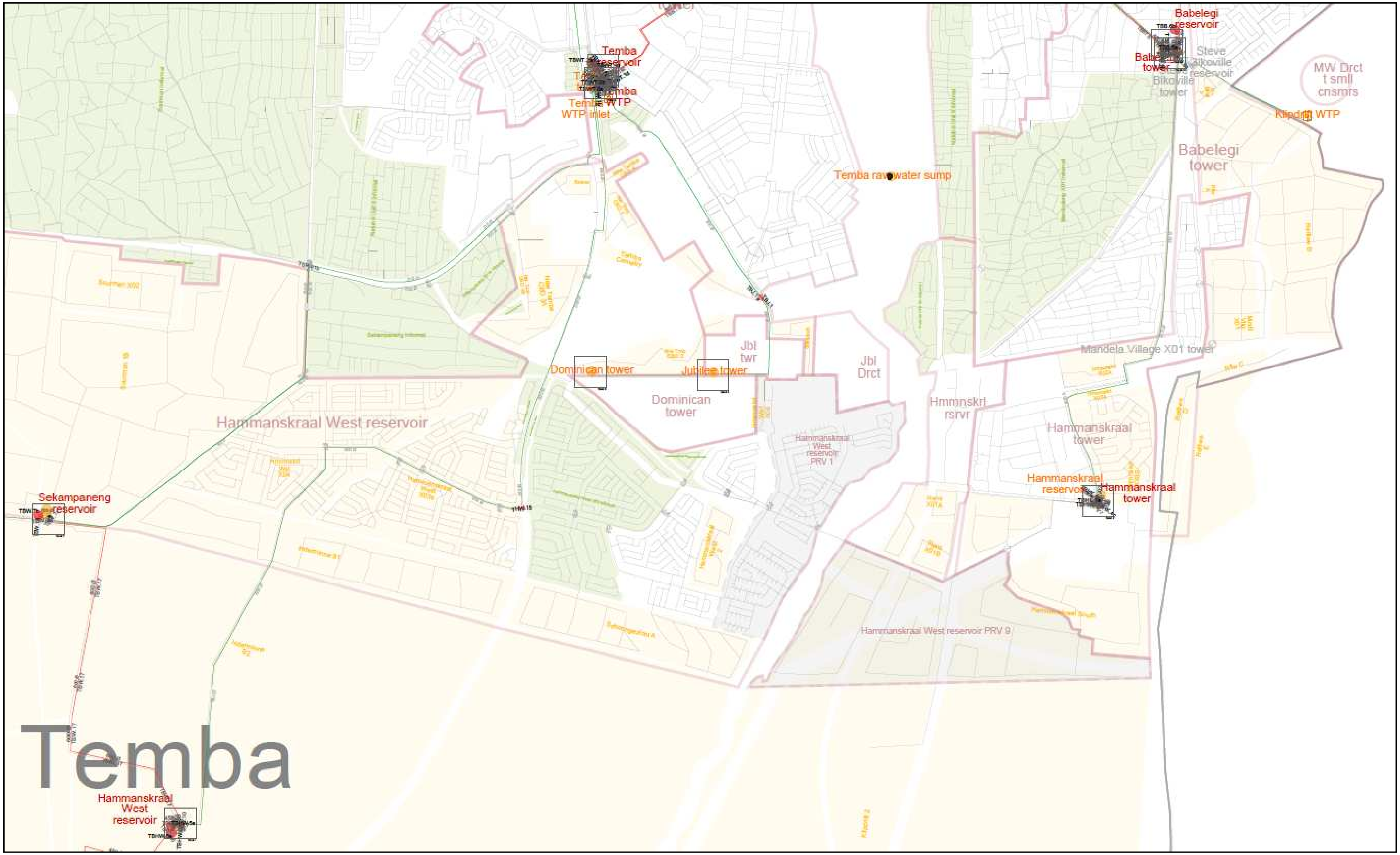


Figure 1: Hammanskraal Bulk Water Supply System (GLS Consulting, 2016)

The future gravity main will comprise of three sections, which will be referred to by the following names throughout the rest of the report:

Western Leg – The pipe section between the Hammanskraal west reservoir and the Tee to the Temba WTP. This section forms the scope of works of the project discussed in this report. Areas supplied by this section are Inderminne B1, Hammanskraal West Ext4 and Hammanskraal West Ext10.

Northern Leg – A proposed gravity main section that will run north from the Tee towards the Temba WTP, parallel to the existing pump line to supply areas toward the North. Areas that will be supplied by this pipeline are Rentview, New Temba View, New Temba View X01 and, New Temba CBD 1/2/3A/3B/4.

Eastern Leg – The existing dual-purpose pumping and gravity main between the Tee and the Hammanskraal reservoir. Construction of this line was completed in 2004. Areas supplied by this pipeline are Hammanskraal West Proper / X01 / X02 as well as Hammanskraal South.

4.2 Bulk Water Pipeline Scope

This report addresses the design of the proposed new large diameter gravity delivery pipe from Hammanskraal West reservoir back to the Hammanskraal West reticulation networks (Western Leg). Only the section of pipe between the Hammanskraal West reservoir and the tee-off to/from the Temba WTP will be constructed under this project. The scope includes the connection to existing pipework at the Hammanskraal reservoir and connection to the Northern and Eastern Legs. All the water demand values on the proposed pipeline as well as demands on the Eastern and Northern Legs are considered part of the design of the pipeline.

A ND900 reducing to a ND800 pipe was suggested in the *Master Plan Water System – Temba: Retic – Hammanskraal West Reservoir, by GLS Consulting*.

The scope of works as discussed is indicated in yellow on Figure 2 below.

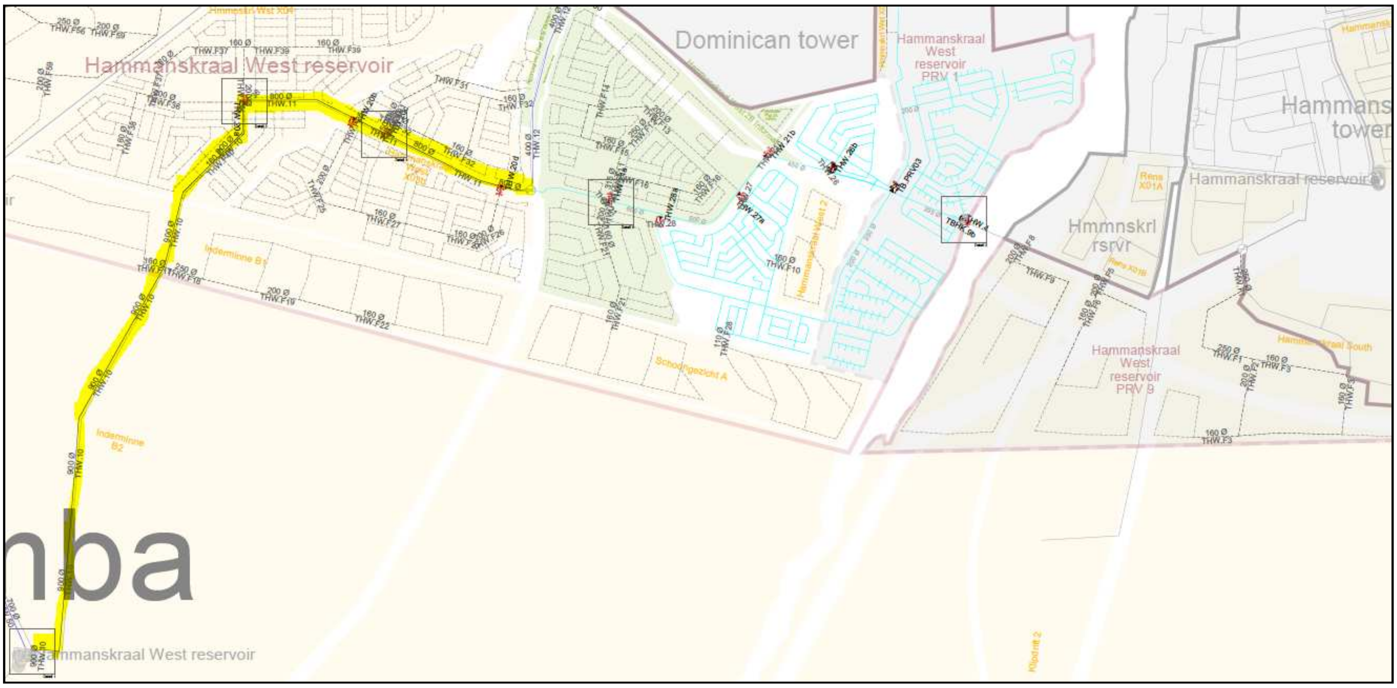


Figure 2: Bulk Water Pipeline Scope (Image from GLS Masterplan Report)

4.3 Proposed Route

The route indicated by the Masterplan was investigated and found to be feasible. The pipeline will follow the same route as the as the existing DN600 pumping main, but will as far as possible be constructed on the opposite side of the road. The pipeline will be constructed:

- Along the Northern side of the reservoir access road
- Along the western side of the road on the North-running section
- Along the southern side of the road on the East-running section

As there is no other logical alternative route and the route was proposed in the GLS Masterplan, no alternative routes were investigated.

The layout drawing of the bulk water pipeline (18616-D-WAT-L13) is included as **Annexure B**.

4.4 Water Demand

The *Master Plan Water System – Temba: Retic – Hammanskraal West Reservoir, by GLS Consulting* gives several Draw-off points on each leg. Water demand values for each of these points were supplied by CoT. The information is presented in Table 1 below.

Table 1: Draw-off points and Water Demand Values (CoT)

Section	Connection as per GLS Masterplan	Supply Area	Demand (ℓ/s)	Total Demand (ℓ/s)
Western Leg (Scope)	THW.F17	Inderminne B1	17.8	**196.80**
	THW.F18	Inderminne B1	41.5	
	THW.20a	X4	73.2	
	THW.20b	X10	22.6	
	THW.20c	X10	26.1	
	THW.20d	X10	15.6	
Northern Leg (Future)	THW.12	Various	95.7	**95.70**
Eastern Leg (Existing)	THW.21a	Various	99.2	**318.60**
	THW.28a		24.2	
	THW.27a		41.8	
	THW.21b		1.2	
	THW.26b		12.5	
	PRV1		76.2	
	PRV9		63.5	

For the Supply Areas on the Western and Northern Leg, Area, Landuse and Density data was previously supplied by GLS Consulting. This data was used to verify the Demand values as presented in Table 1. Furthermore, as Nyeleti Consulting is also responsible for the design of water and sewer reticulation in Hammanskraal West Ext10, accurate demand values were available for the Draw-off points to Hammanskraal West Ext10 (Calculations for the demand of Hammanskraal West Ext10 are included in **Annexure C**).

Table 2: Calculated Water Demand Values

Area	Landuse	Demand Calculation						
		Area (ha)	**Density (Stands /ha)**	**No of Erfs**	**Kℓ/erf /day**	**Flow (ℓ/s)**	**Peak Factor**	**Peak Hourly Demand (ℓ/s)**
Inderminne B1	Low cost housing	131.42	20	2628	0.7	21.3	3.4	72.40
Hammanskraal West X4	Low cost housing	164.59	20	3292	0.7	26.7	3.4	90.68
Hammanskraal West X10 – Point 1	Low cost housing	From Hammanskraal West X10 Water Reticulation Design						47.30
Hammanskraal West X10 – Point 2		From Hammanskraal West X10 Water Reticulation Design						53.90
Rentview	Mixed	6.26	27.3	171	0.7	1.39	3.4	4.71
Temba View	Business /Commercial	19.19	40	768	0.7	6.22	3.4	21.15
Temba View X01A	Low cost housing	2.88	24.35	70	0.7	0.57	3.4	1.93
New Temba CBD 3A	Mixed	42.15	40	1686	0.7	13.66	3.4	46.44
New Temba CBD 3B	Low cost housing	7.12	20	142	0.7	1.15	3.4	3.93
New Temba CBD 2	Mixed	38.16	40	1526	0.7	12.37	3.4	42.04
New Temba CBD 1	Mixed	7.75	40	310	0.7	2.51	3.4	8.53
New Temba CBD 4	Mixed	4.77	40	191	0.7	1.54	3.4	5.25

Table 3 provides a comparison between the values provided by CoT (from Table 1) and the values calculated in Table 2 for each connection. The calculated values are all between 22% and 57% higher than the values provided by CoT.

Table 3: Comparison of Values provided by CoT versus Calculated Values

<table>
<tr><th></th><th>Peak Hourly Demand (ℓ/s)</th><th>Draw-off Point</th><th>Calculated Value (ℓ/s)</th><th>Value Provided by CoT</th><th>Section</th></tr>
<tr><td>Inderminne B1</td><td>72.40</td><td>THW.F17</td><td>21.73</td><td>17.80</td><td rowspan="5">Western Leg</td></tr>
<tr><td></td><td></td><td>THW.F18</td><td>50.67</td><td>41.50</td></tr>
<tr><td>Hammanskraal West X4</td><td>90.68</td><td>THW.20a</td><td>90.68</td><td>73.20</td></tr>
<tr><td>Hammanskraal West X10</td><td>47.30</td><td>THW.20b</td><td rowspan="2">101.20</td><td rowspan="2">64.30</td></tr>
<tr><td></td><td>53.90</td><td>THW.20d</td></tr>
<tr><td>Rentview</td><td>4.71</td><td rowspan="8">THW.12</td><td rowspan="8">133.98</td><td rowspan="8">95.70</td><td rowspan="8">Northern Leg</td></tr>
<tr><td>Temba View</td><td>21.15</td></tr>
<tr><td>Temba View X01A</td><td>1.93</td></tr>
<tr><td>New Temba CBD 3A</td><td>46.44</td></tr>
<tr><td>New Temba CBD 3B</td><td>3.93</td></tr>
<tr><td>New Temba CBD 2</td><td>42.04</td></tr>
<tr><td>New Temba CBD 1</td><td>8.53</td></tr>
<tr><td>New Temba CBD 4</td><td>5.25</td></tr>
</table>

The calculated water demand values for the Western and Northern legs will be used to design the new section of the pipeline. The sum of the water demands for the Eastern leg will be multiplied with a factor of 1.31 to obtain a value that is more conservative and in line with the Western and Northern legs.

An additional 50 ℓ/s (which is the worst-case scenario as only Temba view is zoned for Business) was included for fireflow, which can increase the demand at any of the draw-off points at any time. Figure 3 illustrates the peak hourly demands at each Draw-off Point and the proposed size for the Tee-piece Branch that were used to conduct the design. Tee-pieces were sized so that the velocity does not exceed 1.8m/s during normal flow conditions or 2.2m/s with fireflow added. Calculations for sizing of Tee-pieces are given in **Annexure C**.

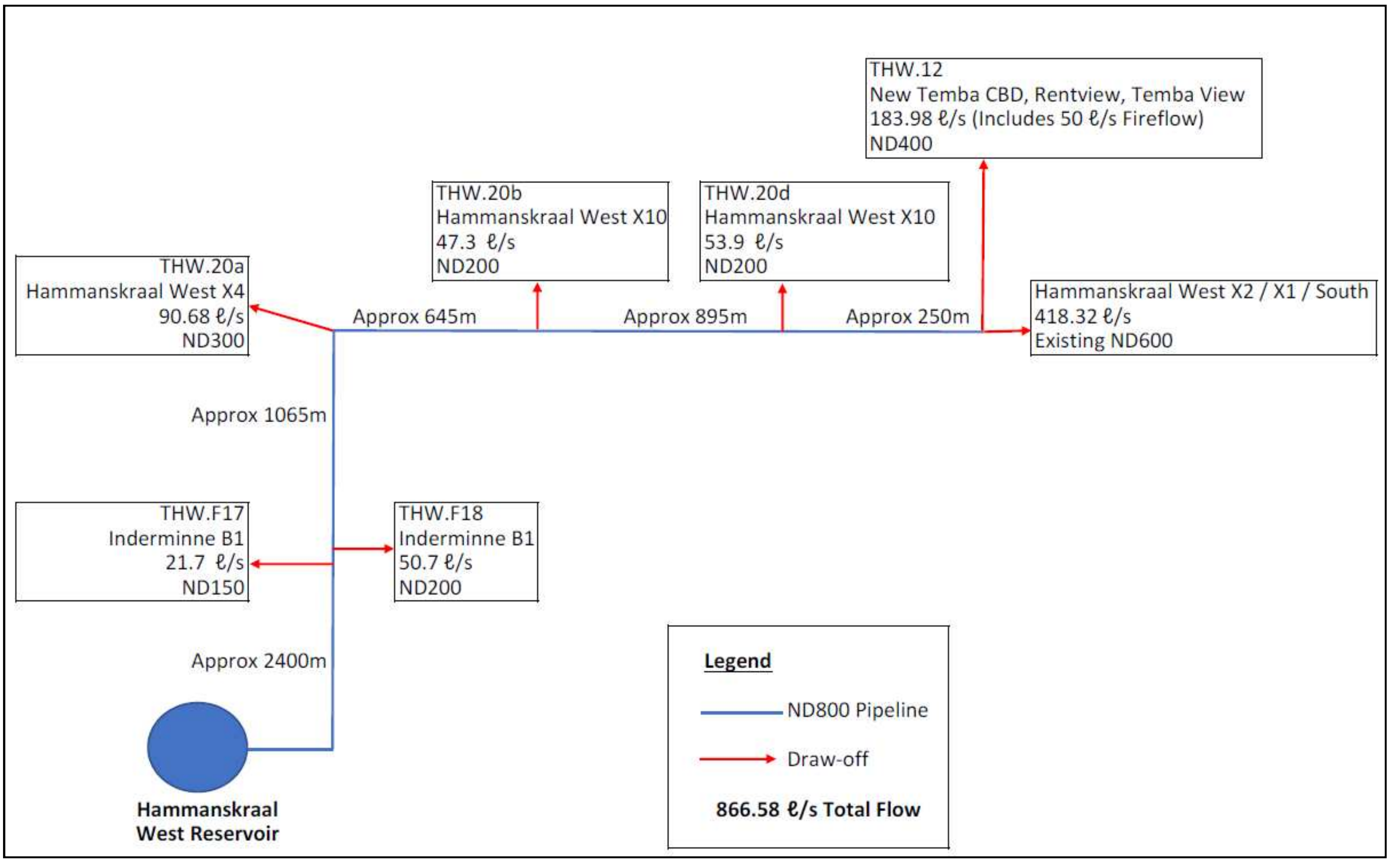


Figure 3: Schematic Layout of Draw-off Points, Sizes and Peak Hourly Demands

4.5 Selection of Pipe Size and Material

As indicated by Figure 3 the maximum flow in the pipeline is 866.56 ℓ/s. The City of Tshwane Guidelines for the Design and Construction of Water and Sanitation Systems states that the maximum velocity in any pipe = 1.8m/s. The smallest inner pipe diameter that can satisfy the above criteria is 783mm.

City of Tshwane allows both steel and PVC-O (Molecularly Orientated Polyvinylchloride) pipes for large diameter Pipelines. PVC-O is only available up to size ND800. An initial comparison was done between the flow capacities of ND800 PVC-O and steel pipes.

Table 4: Comparison of Flow Capacities of Pipe Materials

Maximum Flow in Pipe		**866.56 ℓ/s**
Pipe Material	**Inner Diameter**	**Velocity**
DN800 Steel (8mm Wall Thickness)	797mm	1.74m/s
DN800 PVC-O (Class 16)	757.8mm	1.92m/s

The DN800 PVC-O pipe cannot satisfy this requirement. Furthermore, as PVC-O is fairly new in South Africa and has no proven track record it is considered a high-risk choice. The other pipes forming the Hammanskraal West bulk water system to which the proposed new pipe will be connected are steel pipes, therefore installing a steel pipe will allow for a uniform system and connections.

The entire 5.2km section of pipe that form the Western leg as described in Section 4.1 will be a ND800 steel pipeline. This deviates from the ND900 pipe diameter proposed for the first 3.4km in the *Master Plan Water System – Temba: Retic – Hammanskraal West Reservoir, by GLS Consulting*, but based on the demand values and design criteria provided by CoT and GLS there is no clear reason to install a ND900 pipeline (which will dramatically increase the project cost) over this section.

4.6 Hydraulic Design of Pipeline

4.6.1 Static Pressure

The top water level of the Hammanskraal West Reservoir is 1179.3m. The lowest point on the bulk pipeline is approximately 1118.5m. The resulting maximum static pressure is approximately 60.8m.

4.6.2 Dynamic Pressure

The long sections for the pipeline (Drawings no. 18616-D-WAT-LS01 to 18616-D-WAT-LS06) indicate the proposed pipeline and the corresponding static and dynamic hydraulic gradelines. The pipeline was analysed for two scenarios:

- New pipe
- Aged pipe, where the pipe roughness would have increased.

The following parameters were used in determining the dynamic hydraulic gradeline:

- Software: TechnoCAD Watermate 2016
- Method for calculating head loss: Darcy-Weisbach
- Roughness coefficient – new pipe: k=0.06mm
- Roughness coefficient – aged pipe: k=0.6mm
- Maximum Velocity allowed (without fireflow): v = 1.8m/s
- Maximum Velocity allowed (with fireflow): v = 2.2m/s
- Design Flow: Maximum demand over each section (with 50 ℓ/s fireflow)

The maximum dynamic pressure was calculated as 49.7m.

The Watermate Analysis Output Files are included in **Annexure D**.
Table 5 gives a summary of the demands and pressures at each of the draw-off points during peak hours.

Table 5: Summary of Peak Demand and Pressure at Draw-off Points

Area	Draw-off Point	Peak Hourly Demand (ℓ/s)	Tee-piece Branch Size	Pressure under Peak Flow (New Pipe)	Pressure under Peak Flow (Old Pipe)
Inderminne B1 – Point 1	THW.F17	21.73	ND150	31.1	28.4
Inderminne B1 – Point 2	THW.F18	50.67	ND200	31.1	28.4
Hammanskraal West X4	THW.20a	90.68	ND300	44.0	40.3
Hammanskraal West X10 – Point 1	THW.20b	47.3	ND200	49.7	45.6
Hammanskraal West X10 – Point 2	THW.20d	53.9	ND200	38.0	33.3
Northern Leg	THW.12	133.98	ND400	36.5	28.4
Western Leg		418.32	Existing ND600	36.5	28.4
Fireflow		50			
Total		**866.58**			

4.6.3 Surge Pressure

A conservative but realistic calculation of the maximum possible surge was done as a preliminary check. The Maximum Surge Pressure during instantaneous valve closure was calculated as 183.1m. This value will however only be achieved if the valve is closed in a duration shorter than the pipeline period, which was not deemed possible for the large valves used on this pipeline.

The fastest time in which the valve could be closed was taken as 15 seconds (it is still unlikely that the valve can be closed this fast). The maximum pressure in the pipeline will then be 135.4m.

Calculations are attached in **Annexure C**.

4.6.4 Design Pressure

Various operating conditions result in different internal pressures in the pipe system. Three basic conditions are designed for as follows:

- **PFA (Allowable operating pressure)**: The pressure, exclusive of surge, that a component can safely withstand in permanent service.
- **PMA (Allowable maximum operating pressure)**: The maximum internal pressure, including surge, that a component can safely withstand in service.
- **PEA (Allowable test pressure)**: The maximum hydrostatic pressure that a newly installed component can withstand for a relatively short duration. For steel pipes the allowable test pressure is taken a that pressure resulting in a material stress equal to 85% of the guaranteed minimum yield stress of the particular type of steel. Plastic pipes cannot be tested at pressures much higher than the allowable operating pressures without plastic deformation taking place.
- The pressures calculated are summarised in Table 6.

Table 6: Summary of Design Pressure

Pressure (m)				
Maximum Dynamic Pressure	Surge pressure	Maximum Static Pressure	PFA	PMA
49.7	135.4	60.8	60.8	135.4

Based on **Table 6** flanges, valves and other components will be designed as PN16.

4.7 Pipe Structural Design and Specifications

4.7.1 Internal Forces

Material specifications and minimum pipe wall thickness was chosen to satisfy **City of Tshwane's Particular Specifications – Steel Pipes**.

The following grade steel material is allowable:

- 300WA (Yield Stress = 300MPa)
- X52 (Yield Stress = 358MPa)
- X56 (Yield Stress = 386MPa)

Based on the yield stress of each steel grade the required wall thickness to withstand the PFA and PMA were determined as shown in Table 7.

Table 7: Required Wal Thickness for Steel Grades

Type of Steel	Yield stress (MPa)	Required Wall thickness (mm)	
		PFA	PMA
300WA	300.00	1.6	2.4
X52	358.00	1.4	2.0
X56	386.00	1.3	1.9

CoT specifies a maximum D/t ratio of 120 when calculating Pipe Wall Thickness. This means that an ND800 pipe should have a wall thickness of more than 6.67mm.

Consequently, an 8mm wall thickness was selected.

4.7.2 External Loads

The buckling resistance of the pipe was checked for what was deemed the worst-case scenario, namely laid with 3.5m cover and a high water table (0.5m below the surface). The 8mm wall thickness was found to be sufficient. Calculations are shown in **Annexure C**.

4.7.3 Other Pipe Specifications

Due the pipe size it is recommended that the pipe be manufactured as a spiral welded pipe (submerged arc-welding process(SAW)). Pipes must be manufactured with beveled ends be joined by butt welds.

4.8 Corrosion Protection

4.8.1 Internal Lining

The two lining systems generally available and used for water pipelines in South Africa and covered in **City of Tshwane's Particular Specifications – Steel Pipes** are Cement Mortar (CML) and epoxy. Factory applied CML is advantageous for smaller diameter pipes as it permits internal make-good of field joints without the requirement for man access.

However, for a DN800 pipe an **epoxy lining with minimum dry film thickness shall be 600µm**. Epoxy linings are factory applied using solvent free materials applied by hot plural component airless spray. Field make-good of these coatings requires blast cleaning of the exposed steel inside the pipe. This may be carried out with portable suction guns and fine grit. The performance of the epoxy lining field joints is critically dependant on application, but the diameter of this pipeline makes proper application possible.

4.8.2 External Coating

The two coating materials/systems preferred by City of Tshwane and comprehensively covered in the **Particular Specifications – Steel Pipes:**

- Fusion Bonded Polyethylene (FBPE)
- Three Layer Polyethylene (3LPE)

Fusion Bonded Polyethylene (FBPE)
The fusion bonded polyethylene systems sometimes suffer from relatively poor adhesion to substrate and cathodic disbondment resistance. In the event of coating damage, there is no secondary defence against corrosion as the polyethylene shields the underlying substrate from cathodic protection.

Three Layer Polyethylene (3LPE)
3LPE is only available locally on pipelines up to 800mm in diameter.
Mechanised application of FBE field joint coatings for 3LPE provides a joint primer coating of equivalent standard to the pipe. When used with 3LPE, the epoxy needs to be shielded with either cold or hot applied tape to provide electrical and mechanical protection to the joint. Generally, this repair procedure is not practical on small projects.

Repair of Field Joints and Damage to Pipe
Field joints for both these materials full circumferential wrapping. Ad hoc repairs of 3LPE require full circumferential wrapping other than melt stick.

It is essential that the joint make good material matches the factory coated pipe in terms of electrical and mechanical characteristics, i.e. the dielectric strength and resistance to permeability by water vapour should be the same or better. The thickness of the mastic is between 750 – 1000 µm and the tape would be applied as a double wrap. The rolls used would only be a maximum of 150mm wide, as wider rolls are difficult to handle in the field and it is essential to ensure that the tape is not over-tensioned during application. Manual or mechanised tape application machines are recommended to ensure that tape tension and helix angle are correctly maintained.

Both coating materials offer decent protection against mechanical damage. FBPE offers several alternative field joint coating systems and generally lead times are shorter than for 3LPE. Fusion Bonded Polyethylene is recommended for this project, but if availability is an issue 3LPE would also be suitable.

4.8.3 Cathodic Protection

The pipe will be connected to the other steel pipes in the Hammanskraal System and there are major powerlines in the vicinity of all of these pipes. Therefore, Cathodic Protection will be critical for the longevity of the pipeline.

For purposes of the detail design of the cathodic protection system the following surveys and tests will be specified in the contract:

- Soil resistivity survey
- Soil analysis
- Anode groundbed survey
- Stray current survey
- Foreign service interference
- Current drainage tests

The above surveys and tests will be performed during the investigation phase of the contract followed by a detail design and call for quotations from specialists in the field of installation of cathodic protection systems.

The design of the cathodic protection system should be done by a specialist subconsultant and the construction thereof by a nominated subcontractor.

4.9 Valves, Fittings and Specials

The positions of isolating valves, air valves and scour valves are indicated on the long sections. Valves will all comply with **City of Tshwane's Particular Specifications – Steel Pipes**, which will form part of the tender specifications.

It is recommended that the isolating valves are butterfly valves due the size of this pipeline and the relatively low pressure.

4.10 Connections to Existing Bulk Water Infrastructure

4.10.1 Connection at Hammanskraal West Reservoir

When the Hammanskraal West Reservoir was constructed, pipework was designed for the reservoir to be fed and to supply via the existing DN600 dual rising and gravity main. However, provision was made for the connection of a future gravity pipeline from the reservoir. The future connection point is indicated on Figure 4. According the drawing the connection is for a DN800 pipe, which should allow for a relatively uncomplicated connection.

When a contractor is appointed for construction of the pipeline, one of his first tasks will be to expose the connection to confirm the size and depth of the connection point, as well as any other service crossings.

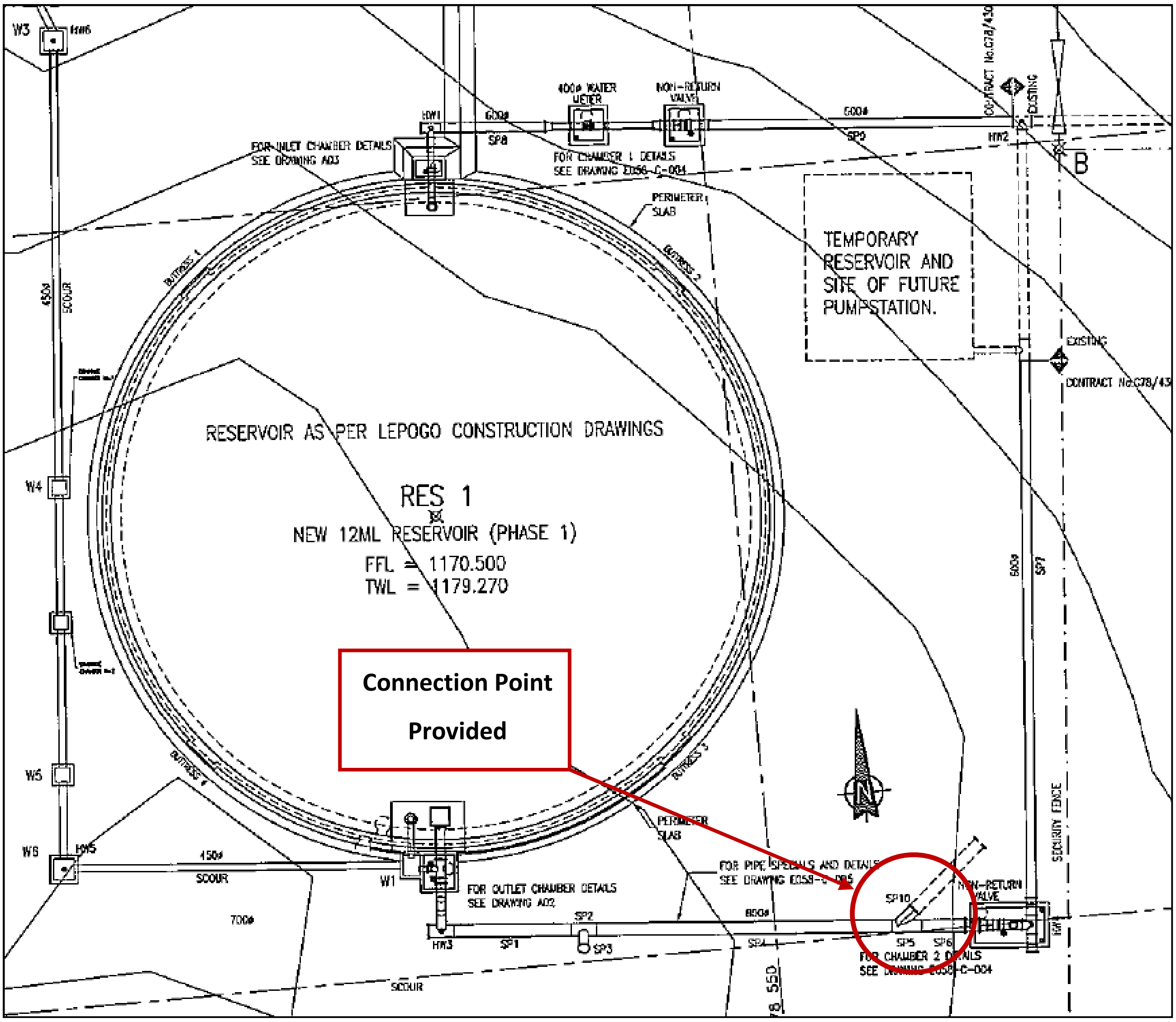


Figure 4: As-built Drawing of Hammanskraal West Reservoir

4.10.2 Connection to the Eastern and Northern Legs

Where the current ND450 pumping main from the Temba Reservoirs tees into the ND600 pumping main serving Hammanskraal West there is an existing valve chamber. The new ND800 will connect to the existing system next to the existing valve chamber. The proposed configuration of the two valve chambers is shown on Figure 5.

During normal operating conditions, all valves will be open except valve V3. The Eastern leg will then be fed from the Hammanskraal West Reservoir via the New ND800 gravity line. CoT will have the option to feed the Eastern Leg and Future Northern Leg from the Temba Reservoirs pumping main by opening valve V3 and closing Valve V4.

A draw-off point for the future Northern Leg will also be provided as well as an isolating valve which will in future allow CoT to close-off the Eastern leg while the Northern leg remains operational.

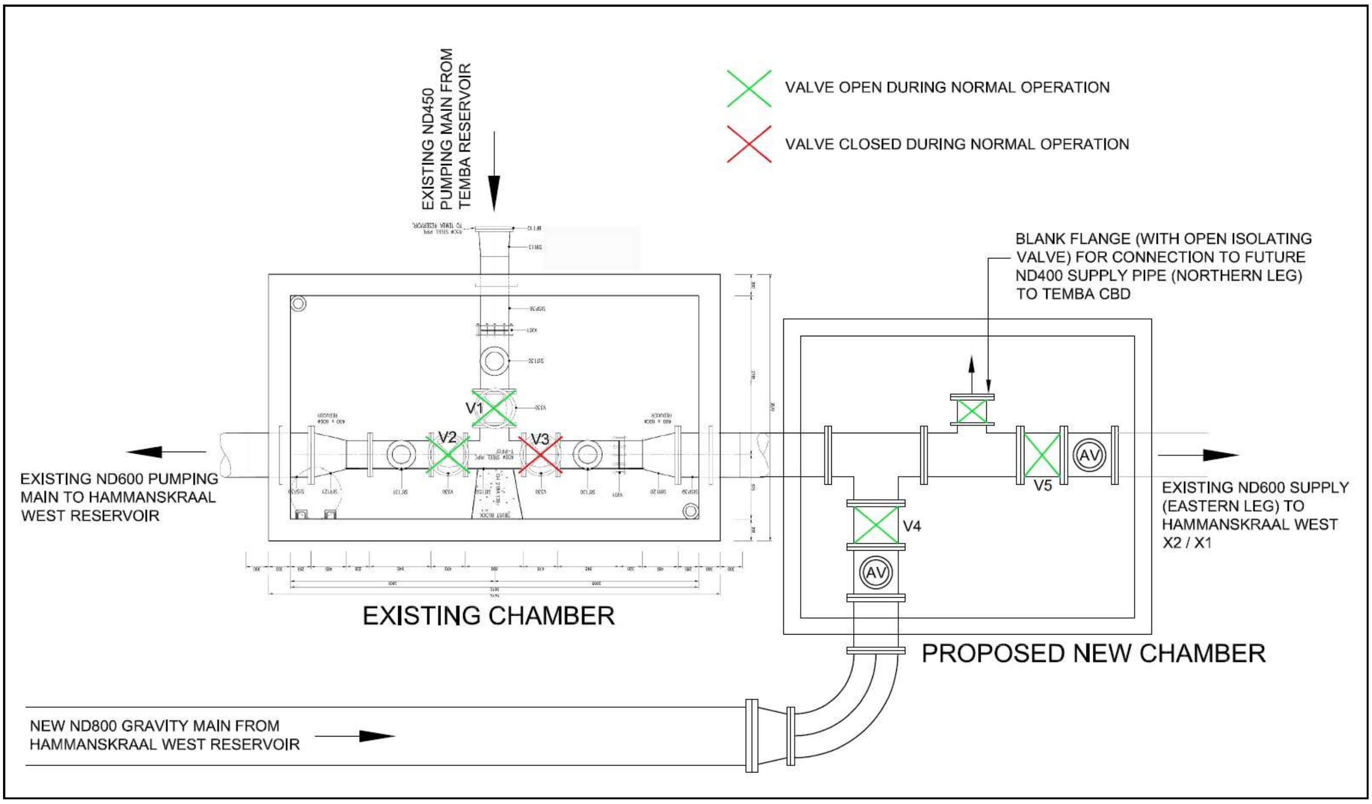


Figure 5: Proposed Connection to Eastern Leg

4.11 Construction Considerations

4.11.1 Road Crossing

The pipe does not cross any major roads. Currently all roads in the vicinity of the pipeline are gravel roads.

4.11.2 Stream Crossing

The pipe crosses the stream that separates Hammanskraal West Extension 10 from Extension 4. Although it is defined as a stream, no clear stream could be distinguished on site. Figure 6 indicates the location of the stream crossing. It is not expected to pose major construction difficulties, but is an environmental consideration (this is discussed in further detail under Section 0).

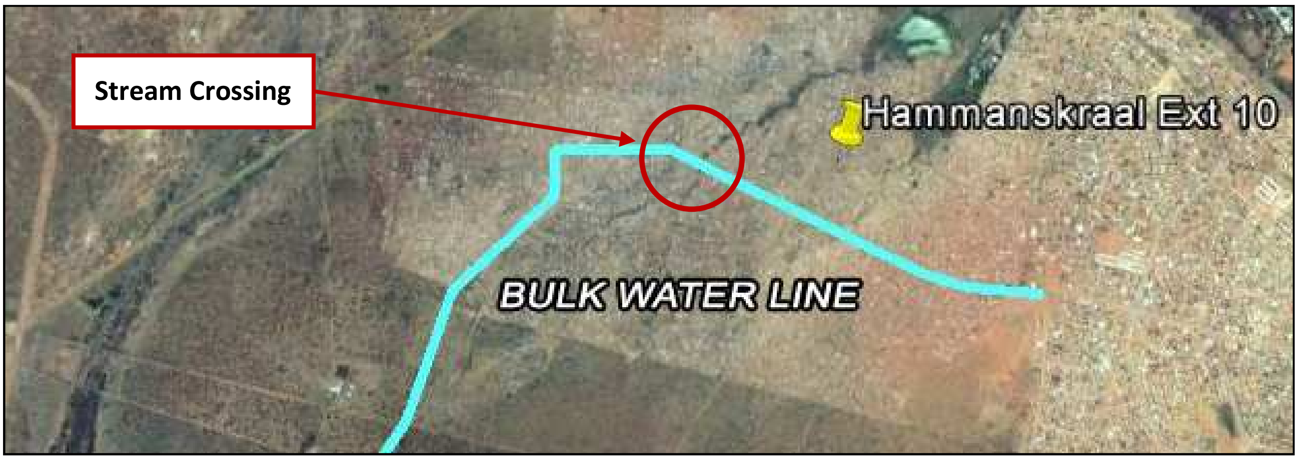


Figure 6: Stream Crossing

4.11.3 Trench Widths

The **City of Tshwane Standard Specifications for Municipal Civil Engineering Works** gives the Trench Widths for waterpipes larger than 620mm as W = 2B + S, where:

B = 800mm for this project

S = 250mm

Hand held rammers used for compaction of bedding, have base plates with approximate dimensions of 300mm x 300mm. Allowing for working space of 400mm on the side of the pipe will ensure that the required compaction densities can be achieved for pipe bedding material with significantly reduced risk of damage to the pipe.

Specified trench width for the bulk water pipeline will then be 1.6m (comprised of 2x400mm + 800mm).

4.11.4 Quality Control

Quality control plays a major role in the longevity of a welded steel pipeline. Items covered in **City of Tshwane's Particular Specifications – Steel Pipes** that will be specifically monitored and addressed during the construction stage are**:**

- Transportation, handling and storage of pipes
- Approved welding procedure and qualified welders
- Protection of coating and lining during welding
- Field joint repairs of coating and lining

The following tests will be performed:

- Hydrostatic test on every pipe to a minimum of 90% of nominal yield strength.
- Radiographic, Ultrasonic and dye penetration tests on all welding.
- Check all pipes for dimensional compliance with relation to diameter.
- Tests to measure thickness of coating and lining.
- Spark test to check the uniformity and compliance of the lining and coating to ensure electrical isolation of steel material. Holiday Testing as per ASTM G62 requirements for both internal and external coatings. Any repairs to the lining and coating due to either the spark test or the thickness tests will be done in a different colour, or be clearly identified for later reference if any failures are experienced later in the lifespan of the pipeline.
- Data packs with all of the required ISO 10750-1 Certificates of Conformity for the coating materials, as well as the required Quality Control Procedures (QCP) pertaining to the application and testing during production.

A specialist Independent Third Party Inspector shall be appointed for acceptance control testing of pipework, coating and linings. The Inspector will fullfill most of the duties above and also be responsible for acceptance control of valves and fittings.

Before handing over the pipeline to CoT, the entire pipe will be hydraulically field-tested and disinfected as described in the **City of Tshwane Standard Specifications for Municipal Civil Engineering Works**.

5 BULK SEWER DESIGN

5.1 Overview of Bulk Sewer System around Hammanskraal

There are many (mainly low-cost housing) developments and upgrading of informal settlements currently underway in the Hammanskraal, which has increased the need for bulk sewer service upgrades in Hammanskraal. Hammanskraal West Extension 10 and the surrounding townships on which this report is based, drains towards the Temba Waste Water Treatment Works on the banks of the Apies River. The system is shown in Figure 7 below.

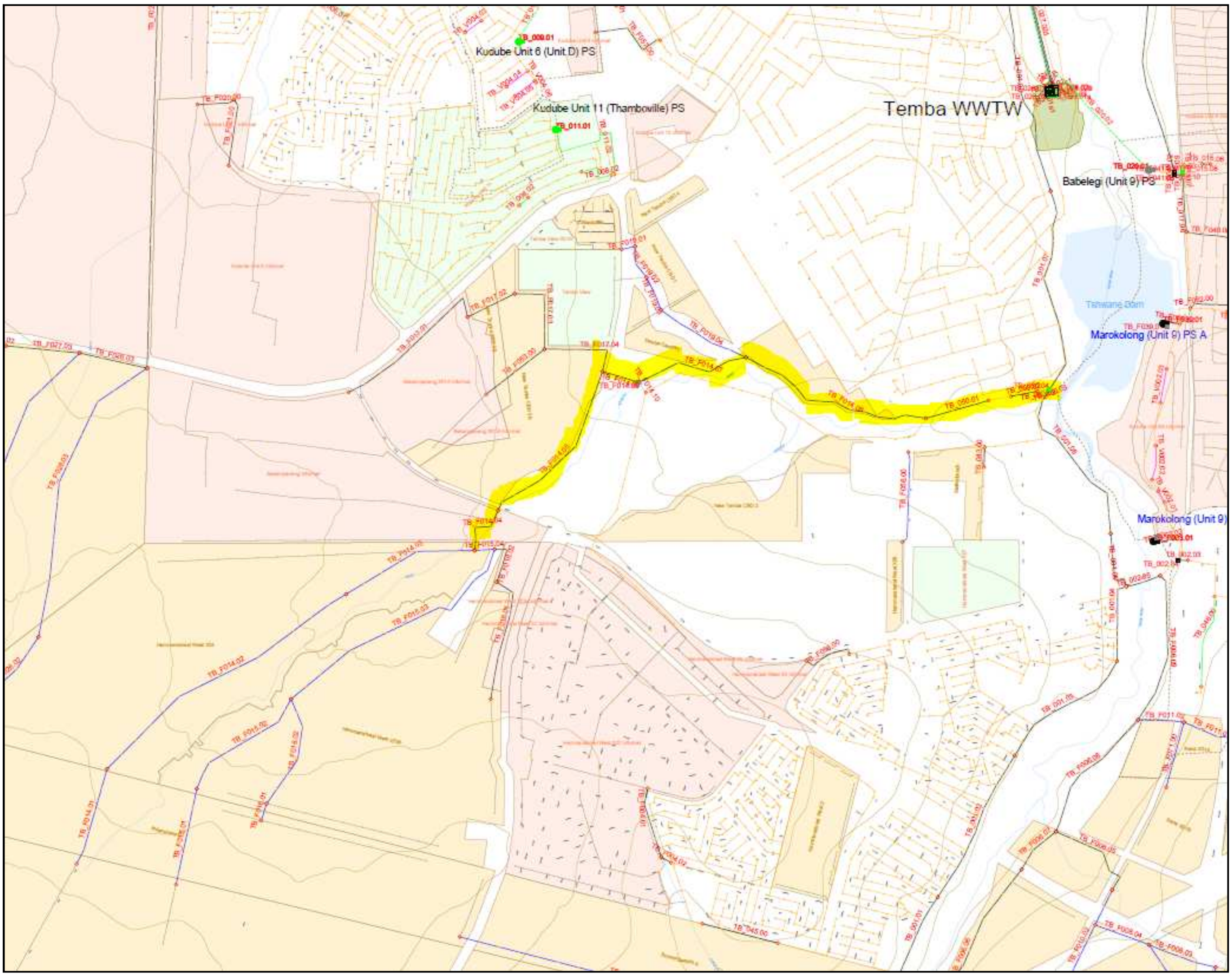


Figure 7: Hammanskraal Bulk Sewer System (GLS Consulting, 2016)

The line required to drain Hammanskraal West Ext10 and surrounds is indicated on the drawing as TBF014.04-TBF014.05-TBF014.06-TBF014.07-TBF014.08 (highlighted in yellow) and the diameter proposed by the GLS Masterplan as a 355mm / 400mm line which then joins an existing 400mm (with the intention that the existing line either needs to be upgraded to 525mm or a parallel pipe installed).

This was discussed with CoT an GLS during a meeting. The outcome of the meeting was that Nyeleti Consulting will design an entirely new line from Extension 10 to the connection point on the bank of the Apies River. GLS provided area sizes, landuses and densities for Nyeleti Consulting to calculate the outflow values from all contributing suburbs.

5.2 Sewer Outflow

The City of Tshwane Guidelines for the Design and Construction of Water and Sanitation Systems was used to determine the sewer outflows for the outfall sewer. Because Nyeleti Consulting is also responsible for the reticulation design of Hammanskraal West Ext 10, detailed accurate outflow values were available for Hammanskraal West Ext 10. The calculations are given in **Annexure E**.

Table 8: Sewer Outflow Contributing to Outfall Sewer Flow

	Area (ha)	**Density (Stands/ ha)**	**No of Erfs**	**Kℓ/erf/ day**	**Flow (ℓ/s)**	**Peak Factor**	**Infil-tration Factor**	**Peak Flow (ℓ/s)**	**Total Flow (ℓ/s)**	**Enters line at Manhole**
Hammanskraal West X10	Value obtained from Hammanskraal West X10 Sewer Reticulation Design							59.32	182.05	MH427
Inderminne	Value obtained from Hammanskraal West X10 Sewer Reticulation Design (Accommodated in X10 network)							57.00		
Hammanskraal West X4	164.59	20	3292	0.6	22.9	2.5	1.15	65.73		
Sekampaneng 1	61.20	7.47	457	0.6	3.17	2.5	1.15	9.12	9.12	MH601
Sekampaneng 2	45.40	7.47	339	0.6	2.36	2.5	1.15	6.77	70.12	MH616 or MH617
Rentview	6.26	27.3	171	0.6	1.19	2.5	1.15	3.41		
Temba View	19.19	40	768	0.6	5.33	2.5	1.15	15.32		
Temba View X01A	2.88	24.35	70	0.6	0.49	2.5	1.15	1.40		
New Temba CBD 3A	42.15	40	1686	0.6	11.71	2.5	1.15	33.65		
New Temba CBD 3B	7.12	20	142	0.6	0.99	2.5	1.15	2.84		
Sekampaneng X01A Informal	32.29	10.44	337	0.6	2.34	2.5	1.15	6.73		
Total Flow									**261.29**	

5.3 Proposed Route

For the most part, the proposed new outfall sewer will follow the approximately the same route as the existing DN315 / DN400 outfall sewer that serves Hammanskraal Ext. 2, but will be constructed on the opposite side of the stream in the middle section. The outfall sewer will be constructed:

- From a point on the northern side of Hammanskraal Ext. 10 where it will collect flow from Ext. 4
- It will cross the K224 Provincial road (Harry Gwala Avenue) by means of pipe jacking
- Run along the northern side of the K224 road in an easterly direction and cross the stream
- Run along the western side of the Unnamed Road towards Temba in a northerly direction
- It will cross the unnamed road towards Temba by means of pipe jacking.
- It will cross the group of electricity servitudes
- Run in a northerly direction parallel to the existing outfall sewer serving Ext. 2 on its western side
- Cross two streams and an electrical servitude in a north-easterly direction
- Run along the northern side of the stream in an easterly direction
- Cross Temba Road (classified by CoT as U4(a) Collector) road in an easterly direction by means of pipe jacking
- Run along the northern side of the stream in a north-easterly direction

- Cross over an existing 600mm dia. outfall sewer and connects to the 1 200mm dia. outfall sewer that is running on the western side along the Apies River to the Temba Wastewater Treatment Works.

➢ This section of the route indicated by the bracket above, differs from the route proposed in the masterplan which runs in a northerly direction on the western side of the floodline along the stream. The flood area is very wide because of the restriction caused by the culvert under the K224 (Harry Gwala Avenue). Because this area is earmarked for development of a CBD, the flood area may in future be reduced by increasing the capacity of the culvert and/or channeling the stream. For this reason, the proposed route of the outfall sewer has been moved to the eastern side of the Unnamed Road towards Temba as described above. As there is no other logical alternative route.

The City of Tshwane owns the land over which the outfall sewer runs.

5.4 Connection to Existing Bulk Line

This outfall sewer will cross over an existing 600mm dia. outfall sewer and connects at an existing manhole to the 1200mm dia. outfall sewer that is running on the western side along the Apies River to the Temba Wastewater Treatment Plant.

5.5 Pipe and manhole specifications

The minimum sewer invert depth is 1,2m (as per CoT Guidelines for the Design and Construction of Water and Sanitation Systems) and the maximum depth is 2,5m except where it connects to the main sewer at the end where the depth is 3,1m.

Manholes have been placed no more than 110m apart resulting in a total of 44 manholes. Fall through manholes is at least 80mm in all manholes. Manholes will have concrete covers. At stream-crossings the manholes have been placed outside the area demarcated by the floodlines.

The outfall sewer has been designed to flow no more than 70% of full flow capacity as per the Tshwane Design Guidelines. The minimum slope on any section of the sewer is 0,44% (1 in 225) with a flow velocity of 1,6 m/s. The maximum flow velocity over the last section of the sewer where it connects to the main sewer, is 2,7 m/s.

5.6 Pipe material

For the size of sewer pipes required the only suitable material is concrete.
Concrete sewer pipes with sacrificial layers (15mm) will be specified for the outfall sewer.

Class 75D pipes will be used. The pipes shall be laid on Class B bedding for Rigid Pipes as per the City of Tshwane Standard details.

For the three road crossings that will be constructed by means of pipe jacking, ND900 Class 100D Reinforced Concrete In-the-wall Joint Jacking Pipes will be used. These pipes will also be required to be supplied with a 15mm sacrificial layer. Where two pipes with varying diameters connect manholes will be constructed.

5.7 Bulk Sewer Layout

A Layout Drawing of the outfall sewer (18616-D-SEW-L06) is included in **Annexure F**.

6 ENVIRONMENTAL IMPACT ASSESSMENT PROCESS

Both the bulk water pipeline and the outfall sewer are listed activities in terms of Regulation 982 & 983 published under the National Environmental Management Act (NEMA) (Act No. 107 of 1998). The following listed activities are applicable to the proposed services:

Activity 9:

The development of infrastructure exceeding 1000m in length for the bulk transportation of water or storm water- (i) with an internal diameter of 0.36m or more or, (ii) with a peak throughput of 120 liter per second excluding where such developments will occur in a road reserve or within an urban area.

Activity 10:

The development and related operation of the bulk transportation of sewerage, effluent or process water, waste water (i) with an internal diameter of 0.36m or more or, (ii) with a peak throughput of 120 l per second excluding where such developments will occur in a road reserve or within an urban area.

Consequently, a Basic Assessment Process is required. The Basic Assessment is undertaken in accordance to the requirements of the National Environmental Management Act, 1998 (NEMA), as well as the Regulations in terms of Section 5 of the National Environmental Management Act, 1998.

Basic Assessment Process

Pre-application:

- An application form and declaration of interest by the EAP (Environmental Assessment Practitioner) was submitted informing the Environmental Authority of our intention to proceed with the environmental process.

Public Participation Process, include the following:

- The proposed development has been advertised in a local newspaper and on site as well as in a government gazette;
- The adjacent landowners, tenants and resident's associations was informed directly, in writing, of the application for environmental authorization for the proposed development;
- Interested and affected parties were given a 30 day period within which to lodge any objections;
- After the 30 day period has expired a report is to be written on how any objections and/or comments raised by interested and affected parties together with an indication as to how the objections will be addressed, if at all.

Basic Assessment Report:

- The report provides a description of the activity, description of property and location and a description of environment, legislation, need and desirability, significant impacts and management as well as mitigation.
- A description is given of the public participation process.

Environmental Management Plan:

- Describes the methods and procedures needed for the mitigation and monitoring processes of the environmental impacts identified in the EIA Report.

Both the bulk water pipeline and the outfall sewer crosses a river or encroaches on the floodline at least once. Consequently, a Water Use License Application (WULA) is also required according to Section 21 of the National Water Act which requires any activity occurring within a watercourse, within the 1:100 flood-line of any watercourse and/or within 500m of the boundary of any wetland is required to be registered and licensed.

The Application is dealt with in two phases i.e. Phase 1: Initial reconnaissance and Phase 2: Final document and submission.

Phase 1:

Identify all water use activities requiring Licensing and/or Registration;

Gather all relevant information to support the application, including supporting documentation;

Consult with the Department of Water and Sanitation regarding the intention of the Development and the possible water use activities which will take place at the Development.

Phase 2:

Compile the technical document to support the application;

Complete the required water use license / registration forms for the water use activities taking place;

Submit the water use license applications / registrations together with the technical support document and other supporting documents to the relevant Authority and follow up.

Discussions with the client will be carried out to obtain all relevant information and to ensure all requirements by DWS is adhered to.

The process for the above is underway and a Terrestrial Ecological Habitat Integrity Assessment is being conducted.

7 PROJECT COST ESTIMATE

Based on the conceptual design, a construction cost estimate has been done and is provided below Table 9.

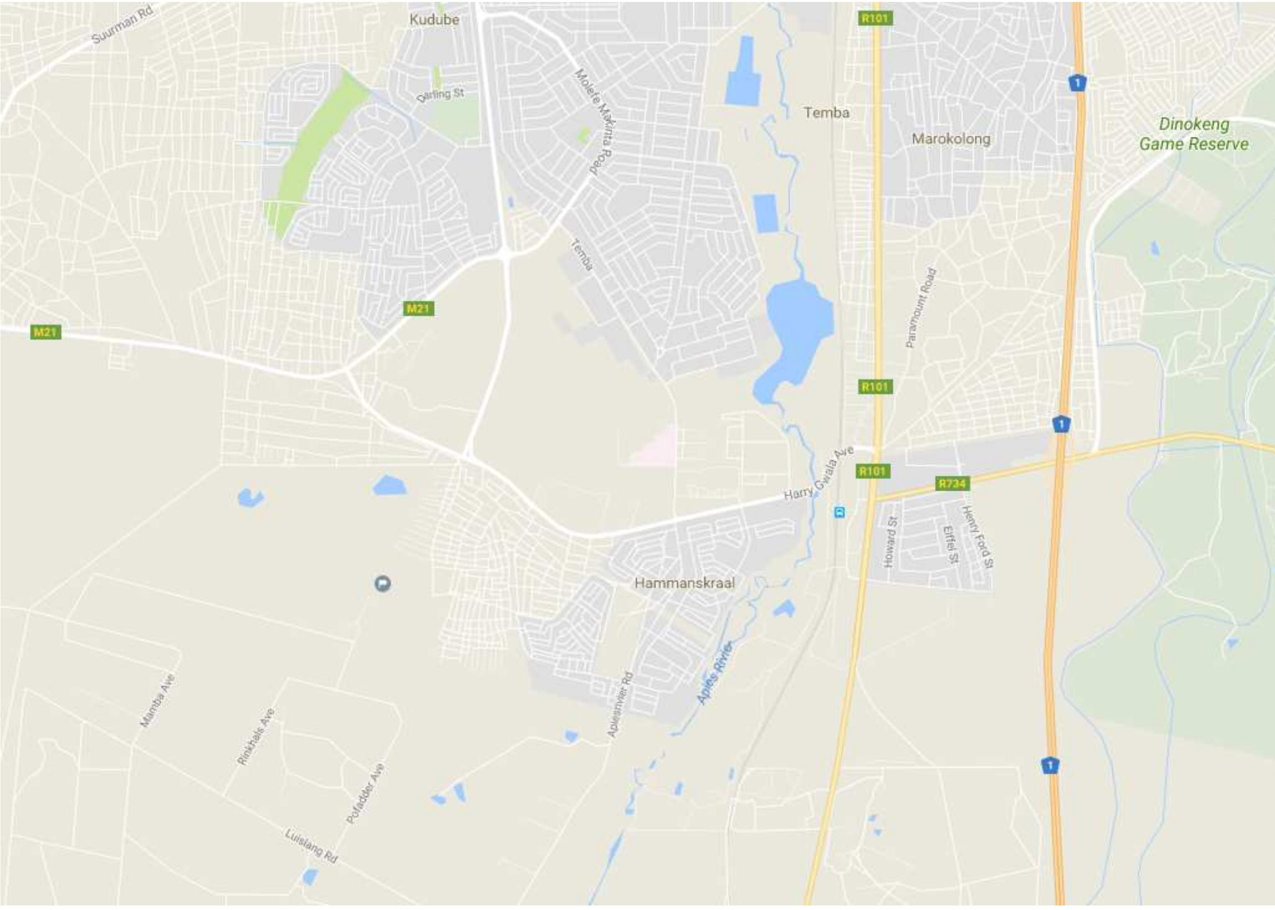
Table 9: Construction Cost Estimate

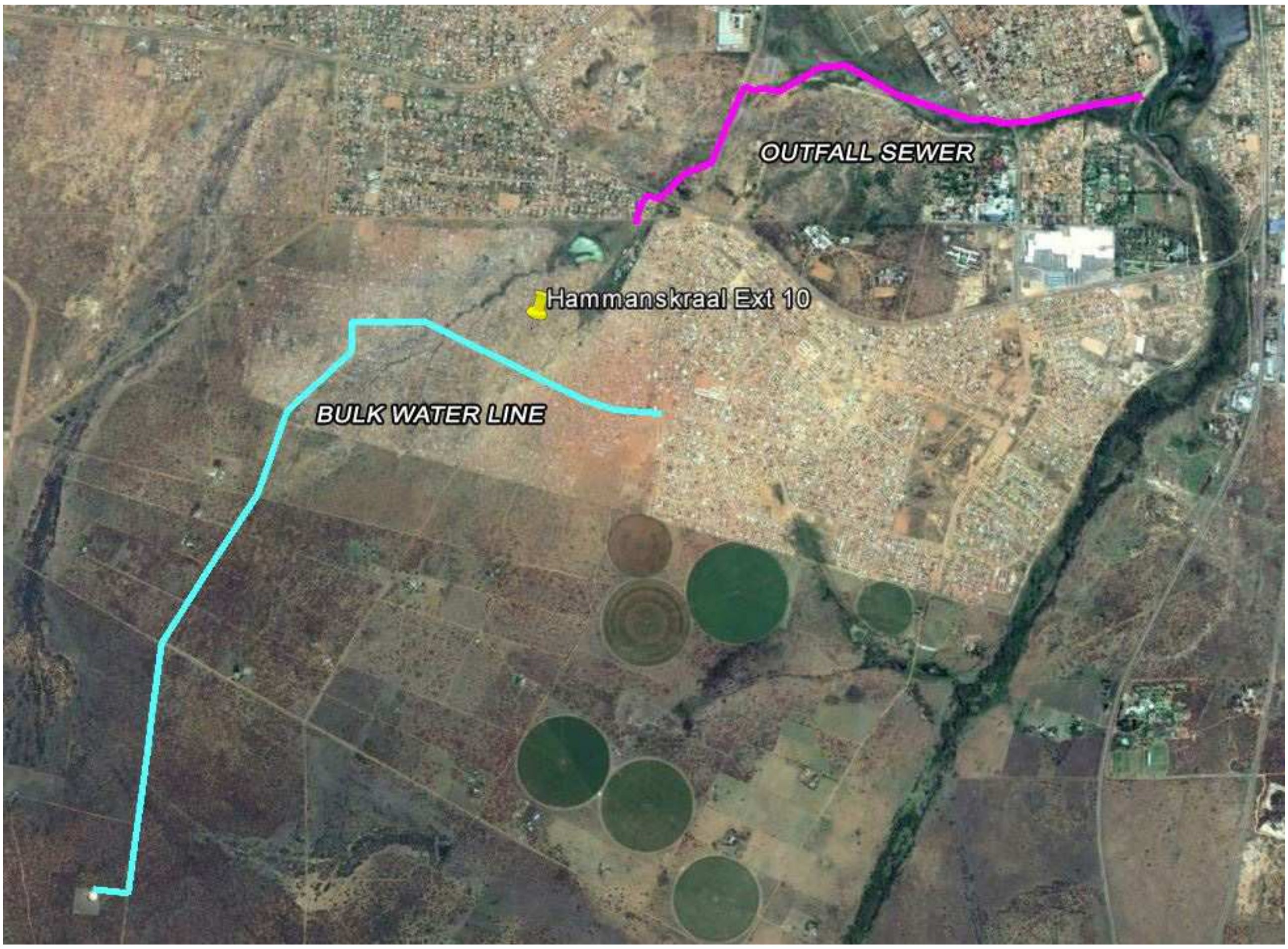
SERIES 0 : GENERAL	**R**	**13 831 000.00**
SECTION 001 : GENERAL REQUIREMENTS AND CHARGES	R	13 596 000.00
SECTION 002 : ENGINEERS'S ACCOMMODATION	R	235 000.00
SERIES 1 : ANCILLARY WORK	**R**	**441 925.00**
SECTION 101: SITE CLEARING AND GRUBBING	R	118 000.00
SECTION 102: ACCOMMODATION OF TRAFFIC	R	123 600.00
SECTION 104 : LANDSCAPING AND GRASSING	R	190 325.00
SECTION 105 : FENCING	R	10 000.00
SERIES 2 : EARTHWORKS	**R**	**8 742 275.00**
SECTION 202A : EARTHWORKS FOR OUTFALL SEWER		
SECTION 201A: GENERAL	R	80 000.00
SECTION 202A: TRENCHING	R	3 193 800.00
SERIES 2B: EARTHWORKS FOR WATER MAIN		
SECTION 201B: GENERAL	R	80 000.00
SECTION 202B: TRENCHING	R	5 388 475.00
SERIES 3 : SEWERS	**R**	**5 314 445.00**
SECTION 302: CONSTRUCTION	R	5 026 270.00
SECTION 302: TESTING	R	288 175.00
SERIES 4: WATER RETICULATION AND WATER MAINS	**R**	**41 909 040.00**
SECTION 4.2 : CONSTRUCTION	R	41 779 040.00
SECTION 4.3 : TESTING	R	130 000.00
SERIES 8 : SPECIFIC WORKS	**R**	**2 136 000.00**
SECTION 804: PIPE JACKING AND BORING	R	2 136 000.00
SUB TOTAL A	**R**	**72 374 685.00**
10% Contingencies	**R**	**7 237 468.50**
SUB TOTAL B	**R**	**79 612 153.50**
14% VAT	**R**	**11 145 701.49**
GRAND TOTAL	**R**	**90 757 854.99**

8 PROJECT PROGRAMME

The proposed project programme is attached as **Annexure G**.

Annexure A: Locality Plans





Annexure B: Bulk Water Pipeline Layout Plan

Annexure C: Bulk Water Pipeline Calculations

C1: Hammanskraal West Extension 10 Water Demand Calculations

Table 10: Water Demand Calculation for Erven

	No of Erfs	Kℓ/erf/day	Flow (ℓ/s)	Total Flow (ℓ/s)	Peak Factor	Peak Hourly Demand (ℓ/s)
Low Cost Housing	2739	0.7	0.0081	22.191	3.4	75.45

Table 11: Water Demand Calculation for Non-residential Stands

Land Use	Erf Area (ha)	Assumed Building Area (m^2)	Erf Kℓ/ha/day	Buildings Kℓ/100m^2/day	Flow (ℓ/s)	Peak Factor	Peak Hourly Demand (ℓ/s)
Public Open Space 1	2.562		15		0.445	3.3	1.47
Public Open Space 2	3.422		15		0.594	3.3	1.96
Public Open Space 3	0.382		15		0.066	3.3	0.22
Public Open Space 4	0.636		15		0.110	3.3	0.36
Cemetery	4.506		15		0.782	3.3	2.58
Soccer Field	0.946		15		0.164	3.3	0.54
Primary South School	2.930	2500	15	0.9	0.769	3.3	2.54
Primary North School	3.078	2500	15	0.9	0.795	3.3	2.62
Secondary School	4.803	3000	15	0.9	1.146	3.3	3.78
Community 1	0.517	300	15	0.3	0.100	3.3	0.33
Community 2	0.517	300	15	0.3	0.100	3.3	0.33
Community 3	0.189	300	15	0.3	0.043	3.3	0.14
Church 1	0.155	300	15	0.3	0.037	3.3	0.12
Church 2	0.283	300	15	0.3	0.059	3.3	0.20
Church 3	0.159	300	15	0.3	0.038	3.3	0.13
Business 1	0.002	1755		0.8	0.163	3.3	0.15
Business 2	0.003	2810		0.8	0.260	3.3	0.15
Business 3	0.003	2855		0.8	0.264	3.3	0.15
Business 4	0.002	1790		0.8	0.166	3.3	0.15
Business 5	0.003	2820		0.8	0.261	3.3	0.15
Business 6	0.002	1615		0.8	0.150	3.3	0.15
Business 7	0.006	6000		0.8	0.556	3.3	0.15
Garage	0.003	2820		0.8	0.261	3.3	0.86
Clinic	0.159	300	15	1.2	0.069	3.3	0.23
Creche 1	0.159	300	15	0.9	0.059	3.3	0.19
Creche 2	0.286	300	15	0.9	0.081	3.3	0.27
Creche 3	0.130	300	15	0.9	0.054	3.3	0.18

Total Peak Hourly Water Demand for Hammanskraal West Ext 10 = 100.51ℓ/s.

C2: Sizing of Draw-off Tee-pieces

HEADLOSS IN PIPE SYSTEMS

Project — **Draw-off Points** — 06/09/2017

Friction Losses	THW.F17	THW.F18	THW.20a	THW.20b	THW.20d	THW.12
Flow (ℓ/s)	21.7	50.7	90.7	47.3	53.9	134.0
Fireflow (ℓ/s)	15.0	15.0	15.0	15.0	15.0	50.0
Length (m)	0.2	0.2	0.2	0.2	0.2	0.2
Internal Diameter (mm)	**150**	**210**	**300**	**200**	**200**	**400**
Pipe Material	Steel	Steel	Steel	Steel	Steel	Steel
Manning	0.02	0.02	0.02	0.02	0.02	0.02
Effective Roughness k (m)	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
Kin. Viscosity	1.14	1.14	1.14	1.14	1.14	1.14
v-1 (m/s) Normal	1.23	1.46	1.28	1.51	1.72	1.07
v-1 (m/s) Fire	2.08	1.90	1.50	1.98	2.19	1.46

Annexure D: Bulk Water Pipeline Analysis

Annexure E: Outfall Sewer Calculations

Table 12: Sewer Outflow Calculation for Erven

	No of Erfs	Kℓ/erf/day	Flow (ℓ/s)	Peak Factor	Infiltration Factor	Peak Hourly Flow (ℓ/s)
Low Cost Housing	2739	0.6	19.021	2.5	1.15	54.69

Table 13: Sewer Outflow Calculation for Non-residential Stands

	Assumed Building Area (m^2)	Buildings Kℓ/100m^2/day	Flow (ℓ/s)	Peak Factor	Infiltration Factor	Peak Hourly Flow (ℓ/s)
Soccer Field	500	2.4	0.139	2.5	1.15	0.399
Primary South School	2500	0.9	0.260	2.5	1.15	0.749
Primary North School	2500	0.9	0.260	2.5	1.15	0.749
Secondary School	3000	0.9	0.313	2.5	1.15	0.898
Community 1	300	0.8	0.028	2.5	1.15	0.080
Community 2	300	0.8	0.028	2.5	1.15	0.080
Community 3	300	0.8	0.028	2.5	1.15	0.080
Church 1	300	0.3	0.010	2.5	1.15	0.030
Church 2	300	0.3	0.010	2.5	1.15	0.030
Church 3	300	0.3	0.010	2.5	1.15	0.030
Business 1	500	0.8	0.046	2.5	1.15	0.133
Business 2	500	0.8	0.046	2.5	1.15	0.133
Business 3	500	0.8	0.046	2.5	1.15	0.133
Business 4	500	0.8	0.046	2.5	1.15	0.133
Business 5	500	0.8	0.046	2.5	1.15	0.133
Business 6	500	0.8	0.046	2.5	1.15	0.133
Business 7	500	0.8	0.046	2.5	1.15	0.133
Garage	300	0.8	0.028	2.5	1.15	0.080
Clinic	500	1.2	0.069	2.5	1.15	0.200
Creche 1	300	0.9	0.031	2.5	1.15	0.090
Creche 2	300	0.9	0.031	2.5	1.15	0.090
Creche 3	300	0.9	0.031	2.5	1.15	0.090
Taxi Rank	300	0.3	0.010	2.5	1.15	0.030

Apart from the sewer outflow generated by Hammanskraal West Extension 10, there are adjoining areas which contribute additional flow to sewer reticulation network. Flows contributed by these areas are given in **Table 14**.

Table 14: Summary of Sewer Inflow per Area

	Area (ha)	**Assumed No of Erfs**	**Kℓ/erf/day**	**Flow (ℓ/s)**	**Peak Factor**	**Infiltration Factor**	**Peak Hourly Demand (ℓ/s)**
Hammanskraal West Ext 4	164.6	3292	0.6	22.861	2.5	1.15	65.73
Inderminne	134	2840	0.6	19.722	2.5	1.15	56.70
Hammanskraal West X10	See **Table 12** and **Table 13**						59.32

The area of Inderminne is located to the South of Hammanskraal West Extension 10 and flow from this area will run Northwards through the entire Hammanskraal West Extension 10 before reaching the outfall sewer currently being designed. Some of the main South-North running sewer pipes have been increased in size to accommodate the additional flow which will be generated when the area of Inderminne is developed.

Hammanskraal West Extension 4 lies to the west of Hammanskraal West Extension 10. A small section of sewer pipe along the Northern border of Hammanskraal West Extension 10 was increased in size to accommodate the flow from Hammanskraal West Extension 4 up to the proposed new outfall sewer.

Annexure F: Outfall Sewer Layout Plan

Annexure G: Project Programme