CONTRACT No. NKT 176/2018

FOR

WATER SERVICES INFRASTRUCTURE GRANT
ARLINGTON BULK WATER SUPPLY

TECHNICAL REPORT (TR) FINAL

REPORT No 176/2018/TR01
June 2019

THIS DOCUMENT IS COMPILED BY:

RTT CONSULTING (PTY) LTD,
51 Parfitt Avenue, Park West, Bloemfontein 9301
Tel: 051 444 0701
Fax: 051 444 0701
rttrading@webmail.co.za

UNDER THE DIRECTION OF:

NKETOANA LOCAL MUNICIPALITY
PO Box 26, Reitz 9810
Tel: +27 (0) 58 863 2811
Fax: +27 (0) 58 863 1567
mmanzi@nketoanafs.co.za

DOCUMENT CONTROL

DOCUMENT INFORMATION

	Information
Contract Number	NKT 176/2018
Project Name	Construction of 19.4Km mPVC pipeline from Lindley to Arlington
Issue Date	May 2019
Last Saved Date	June 2019
File Name	Detail Design Stage

DOCUMENT HISTORY

Version	**Issue Date**	**Changes**
1.0	22/05/2019	Version No.1
2.0	09/06/2019	Version No.2

DOCUMENT APPROVALS

Role	**Name©**	**Signature**	**Date**
Pr. Tech. Eng. (Hydraulic/Civil)	H Montano Gonzalez		
Director RTT Consulting PTY (LTD)	TM Mokhothu		

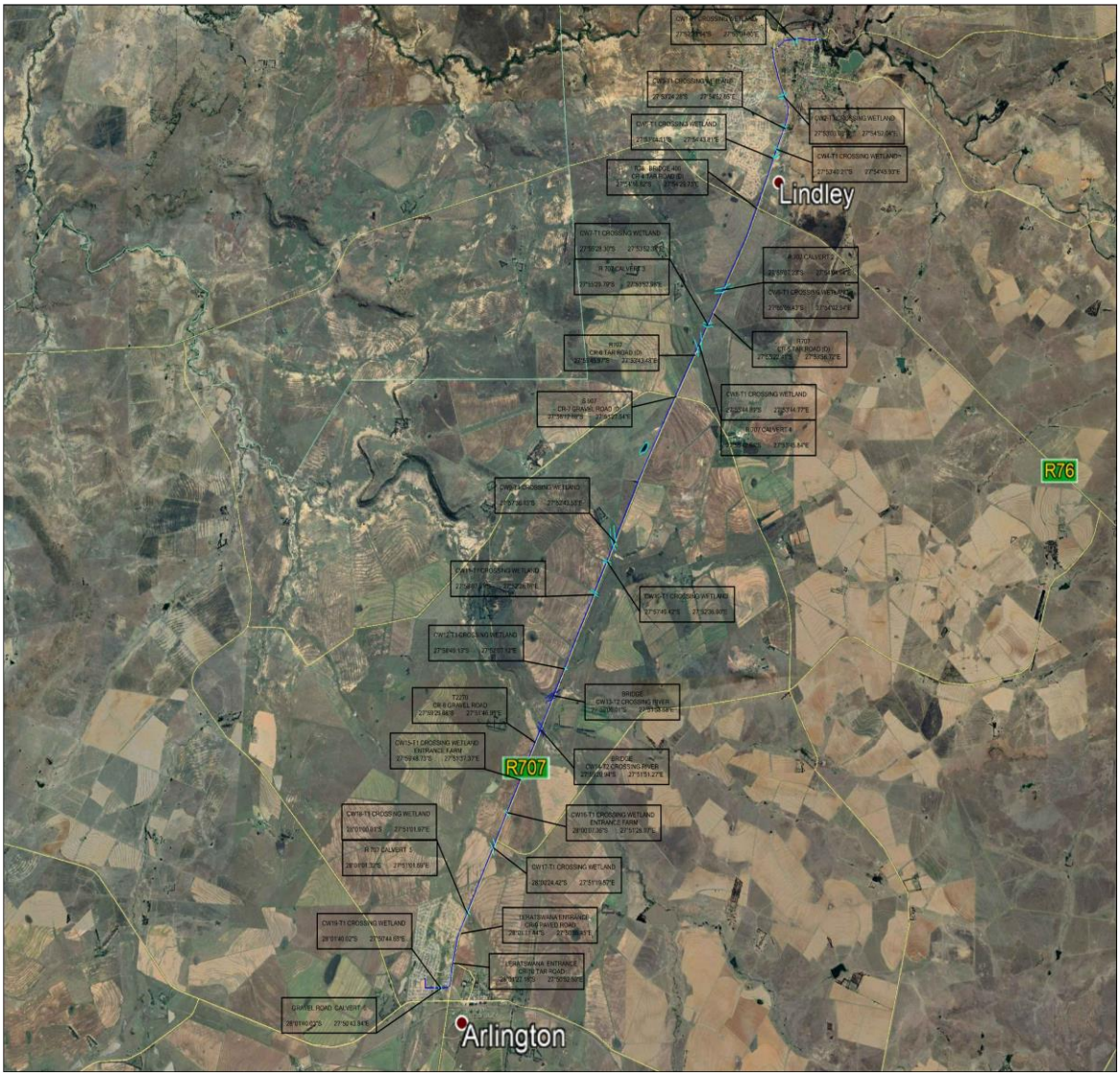
TABLE OF CONTENTS

1. INTRODUCTION

1.1 Background

RTT Consulting PTY (LTD) has been appointed by Nketoana Local Municipality (NLM) to provide professional services for the plan, design and implementation of the proposed: Construction of 19,4km mPVC pipeline from Lindley to Arlington. The main outcome will be after the project is completed have a Bulk Water Supply from existing Water Treatment Work at Lindley to discharge in Leratswana's existing Reservoir.

The main purpose of this report is to outline the scope as per instruction of works and stablish the methodologies to be applied for execution of the project.



2. SITE INVESTIGATIONS

2.1 Geotechnical Investigation Results

It is important to note that the recommendations are based primarily on the profiling of test pits and the interpolation of information between test pits. It is therefore possible that variations from the expected conditions can occur.

Several refusals shallower than 800mm indicate that excavations may be a constraint on site.

Excavations are to be adequately drained should rainwater fill trenches during construction or if the water tables rise.

The clayey materials encountered on site should be cut to spoil insofar economically feasible while materials with a plasticity index below 10 being considered suitable for backfilling of the pipe line. The bedding and blanket materials should comply with SABS 1200LB.

2.1 Environmental Investigations Results

Most of the Specialist Studies are concluded as part of the initial scope of the project which include the following:

- There are 18 watercourse crossings (2 river crossings and the rest are drainage lines) alongside the route R707.
- It was identified few rocky outcrops close to Lindley Town and river crossings.

Those are the highlighted results found after specialist investigations; therefore, Water Use License Application have to be in place with the crossing methodology that applies to this specific project.

All wayleave and permits for each farm and roads crossings have to be in place before construction start.

3. DESIGN ASPECTS

The design for water bulk pump lines and storage reservoirs is based on the Guidelines for design of municipal services (Red Book).

Friction losses has been calculated, verified and checked. The friction loss formulae used is the Darcy-Weisbach formulae and results are provided in the following tables.

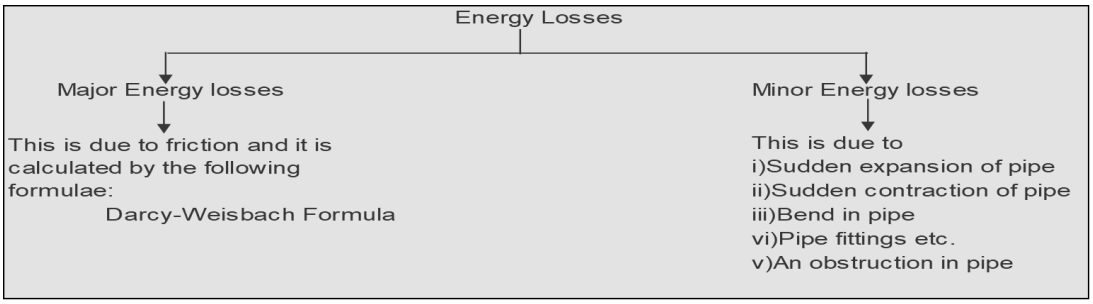
The λ - factor is obtained from Moody-Diagram, and is a function of the Hydraulic diameter of the pipeline, ε -Stiffness of the pipe, Reynolds number (Calculated) for turbulent flow.

3.1 Water Supply Demand.

Demand Calculations		
Actual Population	=	No. Of Total Stands x No. of people per house hold
	=	5195
Population Growth Rate ***	=	Actual Population + Population Growth ***
	=	7277
AADD	=	Population x Water demand per person
	=	1819250.00 l/d
AADD (Average Annual Daily Demand)	=	AADD X 1.5 (Supply line x 1.5)
	=	2728875.00 l/d
Q (Flow)pump	=	AADD (Supply line x 1.5) x 24 / Pumping hours(16 hours)
	=	4093312.5 l/d
	=	47.38 l/s
	=	0.047 m^3/s
Final Results for Pipeline Class, Velocity and Diameter Calculation		
mPVC Class 16		
Velocity	=	1.10 m/s
Inside Diameter	=	233.8 mm
Outside Diameter	=	250 mm

*** Population Growth Rate were calculated by assuming a level of service to be at a minimum Residential (Low Income) by 2015, with a 5% growth in Residential (Medium Income) by 2015 and a further 15% growth in Residential (Medium Income) by 2030 and further 2043 (total growth in Residential (Medium Income) of 20%), as stipulated in the All town study report done by DWA for Arlington (Ref no.: WP9713), dated October 2014.

3.2 Head Losses Diagram



Head Loss Calculation			
Static Head Part 1	=	Elevation2 -	Elevation1
	=	1554.26	1481.38
	=	72.88 m	
Reynolds number			
Re	=	25800.42	flow is turbulent
Friction Factor			
ʎ	=	0.024	

Major Losses **Darcy- Weisbach**		
Pipe Length L=	20129,00	m
Pipe Diameter D1=	0,2338	m
Flow Q=	0,047	m^3/s
Velocity V1=	1,104	m/s
Reynolds number Re=	25800,42	≥4000 Turbulent flow
Friction factor ʎ =	0,02	
Acceleration Gravity=	9,81	m/s^2
Total Friction loss in pipe Hf =	**129,25**	**m**

Minor Losses

Head losses due to pipe fittings

Fitting type	**Quantity**	**K factor**	**Head Losses**	
11.25º Elbow	50,00	0,35	1,09	m
22.5º Elbow	40,00	0,35	0,87	m
45° bend	120,00	0,35	2,61	m
90° bend	23,00	0,75	1,07	m
Gate Valve	19,00	0,17	0,20	m
Air Valve	24,00	0,20	0,30	m
Scour Valve	15,00	0,20	0,19	m
Total head losses valves and fittings HL =			**6,32**	**m**

Local Losses					
Type of losses	Quantity	K factor	Kc	Head Losses	
Entrance (Head losses)	1	0,50		0,03	m
Exit (Head losses)	1	1,00		0,06	m
Sudden Enlargement	0			0,00	m
Sudden Reduction	0		0,45	0,00	m
Total local losses HL =				**0,093**	**m**

Total Head Losses

$H_{Total} = H_{static} + H_f + H_L + H_L$

$= \mathbf{208.54m}$

3.3 Hydraulic Design

A hydraulic profile from existing Water Treatment Plant (WTP) in Lindley to Leratswana's Reservoir is giving an idea on which will be the situation of the hydraulic gradient and pressures for the whole pipeline.

There are 3 physical obstacles between the two towns, Lindley and Arlington, on an average elevation of 1580m AMSL. The 3 hillsides are at chainage 1900 m - 2300 m; 3600 m - 3950 m and 7350 m - 9300 m from WTP in Lindley.

The gradient was considered to start at Lindley WTP with an approximate ground level of 1481.38m that increases in the route to Arlington before to the highest point of 1597.9m at 8.9km, and gradually decreases and increase arriving to Leratswana's Reservoir with 1554.23m.

Hence to be functional; the entire system will require a new pump station to be consider as a booster pump at 8.9km approximately from Lindley WTP, to supply water with enough pressure to the reservoir in Leratswana's reservoir.

The pump station and booster pump designs will be discussed in a separate report.

3.4 Air Valve Design.

The Air valves serve to prevent the accumulation of air at high points along the pipeline; this is achieved by exhausting large quantities of air while the system is filled and also by releasing pockets of air as they accumulate while the system is in operation and under pressure.

The design was considered using the guidelines and standards for the positioning and sizing of air valves. The rules of thumb for air valve sizing according to the pipeline of 250mm diameter and flow velocity under 2m/s for air valve types double action or double orifice and air valve anti shock, the Air valve diameter is acceptable 50mm.

This project was designed assuming the worst-case scenario, so the scour valve diameter is 0.75 of Pipe diameter (or nearest next size of valve), ΔH will be taken as maximum value.

4. BULK WATER PIPELINE IMPLEMENTATION

4.1 Water Pipeline mPVC 250mm DIA

The pressurized water pipeline will be accommodated alongside of the road R707 except Lindley and Arlington towns with recommended route avoiding disturbance between erf boundaries.

The pipe was selected and specified in accordance with SABS 791-1977, DWS specifications DWS 1130 (design, manufacture and supply of steel pipes and DWS1131 (Lining and coating of steel pipes and specials). The mPVC 250mm DIA pipeline will be conventionally laid in a trench and backfilled to natural ground level. The Trenches average for the weigh will be 900mm and the depth of 1500mm, there will be cases where depth vary depending on type of soil and the area of the excavation. Excavation in hard rock material may require the use of pneumatic breakers or blasting.

The joints will be all adaptors and fittings flanges will be specified in accordance with Table D, BS4504 and must be anchored with concrete blocks at all changes of directions and at all valves. Where anchor blocks are in direct contact with the pipe (at all bends), the bend shall be protected by means of a layer of plastic sheeting. It is important that all anchor blocks shall be extended onto the socket area of the fitting that is being anchored, and shall be keyed into the sides and bottom of the trench.

The pipeline counts with air valves on all picks points and when decrease up or down the slope, the system will have every 5000m isolate valves for maintenance purpose and scour valve for the drainage of the system. The pipeline and associated fittings are designed to be capable of withstanding the test pressure of at least 1.25 times maximum operating pressure.

This project also will be facing two (2) river crossings and few wetland areas and the methodology will be in accordance with the "Specification DWS 1110, Construction of pipelines" CROSSING OF ROADS, RAILWAYS AND STREAMS.

4.2 Access to the Pipeline

The design will take full account of the pipeline route and layout to ensure that adequate access is available to all parts of the pipeline for future inspection and or maintenance work.

4.3 Protection of Air Valves

All air valves must be installed on hydrant tee, Steel pipe – Copo treated, isolated by Ball valve, with all necessary reducers to fit air valve according to specifications. The complete installation inside the valve chamber will be steel pipes.

All valves will be installed and protected in valve chambers with concrete floor, walls in 230 mm Brickwork, precast Cover with handles and vent pipes.

Indicating name boards need to identify the type of installation by means of the following denotation - "AV" - at all installations, on white name board with lettering in red.

4.4 Bedding and Backfilling

All bedding material shall conform to SABS 1200 Section LB and shall be carefully and thoroughly compacted to produce a level uniform bed onto which the pipe is directly laid according Engineer Specifications.

The Engineer must approve the material used for backfilling. The backfill material must comply with Clause 3.16 of Specification DWS 1110: Construction of pipelines.

According Geotechnical and Heritage reports there are few rocky outcrops identified and for the bedding in those cases are recommended after finalize with the blasting; removed all the rocky material from site and placed 50mm blinding mass concrete 15Mpa with concrete mixer on site. Then bedding and blanket with selected granular material will follow according bedding details design.

Where requires the material will be supplied from a borrow pit or Commercial area close to the construction pipeline.

4.5 Wetland Crossings

The pipe will be buried in a 1.5 m deep trench after damming the stream and allowing it to flow downstream. A backup pump with capacity greater than the diversion design flow rate of the river should be on site and in good working order at all times.

- Damming of the Stream Procedure:
  1- Lay temporary a number of Ø110 PVC pipes on clean stones along the crossing point following the stream water debit, then throw in rock across the stream, 100 to 300 mm rock.
  2- Throw up stream of rock, clean stone 10 TO 19 mm.
  3- Then throw up stream a layer of minimum 300 mm of clay to seal it off.

Following the pipe would be laid in a trench dug through the stream basin. The trench would be relatively shallow and would have anchor concrete blocks of 25Mpa and the distance between each thrust block will be depending the total wet area in order to protect and to secure the pipe against flotation when empty.

4.6 River Crossings

Each river crossing for maintenance purpose will have on each side a scour valve and gate valve; then the pipeline of 250mm DIA mPVC continues buried in a deeper trench from 1500mm down to 1800mm, further on a special coupling flange adaptor 250DN suitable for PVC to steel pipe might be added; the steel pipe will installed and encased in reinforced concrete 25Mpa running on level 1800mm. Another special coupling flange adaptor 250DN suitable for steel to PVC pipe is added and a portion of PVC pipe continues up to reach the 1500mm level before a gate valve is included.

- Damming of the River Procedure:
  1- Lay temporary a number of Ø200 PVC pipes on clean stones along the crossing point following the stream water debit, then throw in rock across the stream, 100 to 300 mm rock.
  2- Throw up stream of rock, clean stone 10 TO 19 mm.
  3- Then throw up stream a layer of minimum 300 mm of clay to seal it off.

It is recommended to conduct crossing during winter (Dry Season) to avoid congested waterbodies.

4.7 Road Crossings

The proposed construction works will impact on the following roads R76, R707, S907 and T2270. Any activities taking place within 12m on either side of the road centerline are subject to an approved wayleave from Provincial Road and Transport and Municipal approval.

In addition to the above, both ESKOM and TELKOM will need to be approached for wayleaves as the pipe route crosses their services occasionally.

The provincial road crossing methodology will be trenchless the horizontal drilling. Secondary and tertiary road will be crossed as per instruction of the Engineer. The entrance of each farm will be given access from other side until pipe is laid, backfilled and compacted on the main entrance.

All wayleave and permits have to be in place before any construction commence.

4.8 Surge Control

In the event of an Uncontrolled Situation occurring during power outage from the grid, the pump station become very vulnerable against fluid mechanics phenomenon like water hammer and surge via positive and negative surge waves that will run up and down the length of the pump line.

The protection against these destructive occurrences must be as follows:

- Customized Spring-loaded disk Non-return valve, installed on the pump line at the 90° Junction on the pump line, to be able to force the valve closed against positive reducing flow velocities, when V = 0 m/sec the valve must be fully closed;
- Surge valve - Closed during operational status (De-energise to open), installed on the pump line after the 90° junction, between junction and surge tank - must be incorporated in the PLC and MCC;
- Surge tank, to facilitate and dissipate any surge waves (positive and Negative);
- The measures above will isolate and protect the pump station from probable damages.

4.8 Material and Equipment.

All the pipes and fittings will be storage and protected from any damage and inspection will have to be conducted during transport and installation on site to avoid leakages during pressure test.

All material from the site excavations the Engineer will approve if can be use for backfilling, in the case of bedding and blanket will be provided from commercial quarry.

The source of water to be used during construction and for the pressure test period will be watercarts hire from contractor.

The concrete of 25Mpa for the crossings will be provided from commercial concrete mixer due to the volume of concrete. The rest of concrete used for thrust blocks and base of valve chambers will be mixer on site.

After water pressure test and backfilling is finalized remaining material will have to be remove from site and dispose to a designated area, or a licensed waste disposal facility, if it cannot be re-used.

The contractor should provide a plant during construction with at least the following equipment's: Excavators (20 to 30 ton), Rollers suitable for the compaction of trenches, Graders, TLB's and Tipper trucks (10 m3) or equivalent ADT's Watercarts.

5. OPERATION AND MAINTENANCE

At the moment, the actual and potential levels of institutional capacity and support for operation and maintenance are a municipality's weakness; and due to the lack of operation & maintenance plans and an inadequate budgetary allocation to keep the infrastructure in good state of repair.

The following table shows the Totals for Operational and Maintenance costs as per submitted Business Plan to the Department of Water and Sanitation:

Year	Operational Cost	Maintenance Cost	Total Yearly O&M Cost
Year 1	R50 000.00	R100 000.00	R150 000 00
Year 2	R100 000.00	R150 000.00	R250 000.00
Year 3	R150 000.00	R200 000.00	R350 000.00
Year 4	R200 000.00	R250 000.00	R450 000.00
Year 5	R250 000.00	R300 000.00	R550 000.00

6. SOCIO-ECONOMIC CONSIDERATIONS

With the implementation of this project approximately 20 new jobs will be created during construction of the pipeline for Lindley and Arlington towns respectively. The targeted employment portion will 55% Males, 40% Females and 5% Handicapped. Ward committees will be consulted for the final proportions to be adopted.

7. FINAL PROJECT COST REVIEW

7.1 Construction Cost Breakdown and Professional Fees

After geotechnical investigation report was needed it a review on the items for excavation and the type of material for bedding to be used on rocky outcrops according SANS and DWS specifications. The value of those items considerable change due to excessive rock that will have to be remove from site using blasting system.

Another item that also is affected is the quantity of concrete used for the two (2) river crossings considering 1 in 100 Flood events and the quantity of steel pipe according DWS regulation for river crossings. Some extra concrete will also be used for the wetlands areas to avoid flotation when pipe is empty.

Horizontal Directional Drill (HDD) is the most common type of trenchless for road crossing and will also have sleeve HDPE pipe of 300mm as part of protection on that portion.

It was requested from the municipality the incorporation of Professional Service Provider for the Occupational Health and Safety Act from Inception until close out stage and this value was not part of initial Professional Fees Estimate.

Also have to be added 2 students during construction period for training on the P&Gs section with an allowance of R5 500.00 per student.

The above comments summarize an explanation for the difference between initial project cost estimated and the final project cost. For the proper and correct implementation of project will be necessary the review for the final cost.

The following table summarize the schedule of quantities including the revised professional fees and disbursements with the inclusion of the fees for Pr. H&S.

Will be provided the breakdown of payments during construction stage with the professional fees as well.

NKETOANA LOCAL MUNICIPALITY

LINDLEY AND ARLINGTON: CONSTRUCTION OF 19.4KM MPVC PIPELINE.

CONTRACT NO: NKT 176/2018

SUMMARY

ITEM	PAYMENT	DESCRIPTION	Tender Amount	
1		PRELIMINARY AND GENERAL	R	3 089 100,00
2		SITE CLEARANCE	R	704 250,00
3		PIPE TRENCHES	R	17 356 267,77
4		CONCRETE STRUCTURES	R	2 895 066,00
5		WATER MAINS	R	16 475 452,25
6		BEDDING	R	8 875 453,94
		Sub Total 1	**R**	**49 395 589,96**
		CONTINGENCIES (10%)	R	4 939 559,00
		Sub Total 2	**R**	**54 335 148,96**
		Professional Fees	R	6 472 026,52
		Professional Construction H&S Agent	R	1 313 859,88
		Disbursements	R	937 311,97
		Sub Total 3	**R**	**63 058 347,33**
		VAT (15%)	R	9 458 752,10
		GRAND - TOTAL	**R**	**72 517 099,43**

The following table shows the revised Professional Fees and Disbursements with VAT excluded

Professional Fees & Disb. VAT Excl	**R 7 409 338,49**
Inception	R 370 466,92
Concept & Viability (Preliminary Design)	R 1 111 400,77
Design Development	R 1 852 334,62
Documentation and Procurement (Final Design)	R 1 111 400,77
Contract Administration and Inspection	R 2 593 268,47
Close up	R 370 466,92

The following table shows the new professionals Fees for the Pr.H&S

Total Fees Pr.H&S VAT Excl	R 1 194 418,07
Inception	R 59 720,90
Concept & Viability (Preliminary Design)	R 238 883,61
Design Development	R 238 883,61
Documentation and Procurement (Final Design)	R 119 441,81
Contract Administration and Inspection	R 477 767,23
Close up	R 59 720,90

8. CONCLUSION

This Technical Report serves to request the revision of the project value for the implementation of the construction of 19,4km mPVC 250mm DIA pipeline from Lindley to Arlington for the total amount of **R 72 517 099.43 VAT Inclusive** after all site investigations are finalized.

It also highlighted in the report the number of rocky outcrops and the different type of crossings that the project will be facing. A total of 18 watercourse crossings, 7 road crossings (provincial) and other 4 road crossings (secondary) and 9 Farm Entrance crossings.

This project is vital for the life and economic development for this town and is crucial the implementation of the bulk water supply from Lindley Water Treatment Works.

9. RECOMMENDATION

- In order to overcome the energy requirement of this system, it is recommended a booster Pump to be installed at 8.9km from Lindley WTP**.**
- Augment storage capacity in Leratswana area to cover further population increases.
- Assess the entire water reticulation network of Arlington and Leratswana in order to reduce the leakages on old Asbestos and uPVC pipes (Water Conservation / Water Demand Management).