water affairs

Department:
Water Affairs
REPUBLIC OF SOUTH AFRICA

DWA REPORT NO: P WMA 12/T60/00/4311

Feasibility Study for Augmentation of the Lusikisiki Regional Water Supply Scheme (WP 10317)

WATER DISTRIBUTION INFRASTRUCTURE

FEBRUARY 2014

W18_2014_J01407

Project name:	***Feasibility Study for Augmentation of the Lusikisiki Regional Water Supply Scheme***
Report Title:	***Water Distribution Infrastructure***
Author:	***Johann Enslin***
PSP project reference no.:	***J01407***
DWA Report no.:	***P WMA 12/T60/00/4311***
Status of report:	***Final***
First issue:	***January 2014***
Final issue:	***February 2014***

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LIST OF STUDY REPORTS

This report forms part of the series of reports, prepared for the Feasibility Study for Augmentation of the Lusikisiki Regional Water Supply Scheme. All reports for the Study are listed below.

Report Name	**DWA Report Number**
Water Resources Assessment	P WMA 12/T60/00/3711
Assessment of Augmentation from Groundwater	P WMA 12/T60/00/3811
Intermediate Reserve Determination	P WMA 12/T60/00/3911
Legal, Institutional and Financial Arrangements	P WMA 12/T60/00/4011
Domestic Water Requirements	P WMA 12/T60/00/4111
Irrigation Potential Assessment	P WMA 12/T60/00/4211
Water Distribution Infrastructure	***P WMA 12/T60/00/4311***
Materials and Geotechnical Investigations	P WMA 12/T60/00/4411
Zalu Dam Feasibility Design	P WMA 12/T60/00/4511
Regional Economics	P WMA 12/T60/00/4611
Environmental Screening	P WMA 12/T60/00/4711
Record of Implementation Decisions	P WMA 12/T60/00/4811
Main Study Report	P WMA 12/T60/00/4911

This report is to be referred to in bibliographies as:

Department of Water Affairs, 2014. FEASIBILITY STUDY FOR AUGMENTATION OF THE LUSIKISKI REGIONAL WATER SUPPLY SCHEME: Water Distribution Infrastructure, P WMA 12/T60/00/4311

Prepared by:

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Executive Summary

The Lusikisiki Regional Water Supply Scheme (LRWSS) supplies water to the town of Lusikisiki and surrounding villages. In 2010 the Department of Water Affairs undertook a feasibility study to investigate the proposed LRWSS, including the possible Zalu Dam in the Xura River, and to define the most attractive composition and size of the water supply components, taking augmentation from groundwater resources into account. This report investigates the bulk water distribution components, including a water treatment plant (WTP), pump stations, bulk pipelines and reservoirs for raw and potable water.

The yield from the proposed Zalu Dam will be able to provide for the LRWSS area's most probable domestic demand of 5.4 million m^3/a up to 2040, and a further 1.45 million m^3/a (excluding losses of 10%) for irrigation purposes. The additional yield from the 17 potential production boreholes can also augment the system.

If the potential irrigation is not developed then the proposed Zalu Dam will be able to provide for the most probable domestic demand for the LRWSS area until about 2060. Due to these uncertainties in the allocation of the water from the propose Zalu Dam, the assessment of the recommended bulk supply options was performed for two scenarios:

- ***Scenario 1** for an annual supply of 5.4 million m^3/a from the proposed Zalu Dam and 0.95 million m^3/a from groundwater sources, solely for domestic use.*
- ***Scenario 2** for an annual supply of 7.2 million m^3/a from the proposed Zalu Dam and 0.95 million m^3/a from groundwater sources for domestic use, should irrigation not be implemented.*

RAW WATER INFRASTRUCTURE

Raw water is abstracted at the gauging weir T6H004 on the Xura River and gravity fed to the raw water pump station, from where it is pumped to the Lusikisiki WTP.

To accommodate the future water releases from Zalu Dam, the raw pumping station will have to be upgraded. The required pump station capacity is 171 (228)[1] ℓ/s. The suction pipe required is

[1] *Scenario 2 figures are shown in brackets in the executive summary.*

450 (550) mm diameter. Due to the absence of as-built drawings, it is recommended that the sump depth should be revisited during the upgrade.

LUSIKISIKI WATER TREATMENT PLANT

Although the capacity of the existing Lusikisiki WTP is 2.8 Mℓ/day, the current demand is already far beyond 2.8 Mℓ/day. The WTP consists of a combination of flocculation, sedimentation and filtration processes.

The Lusikisiki WTP was visited twice, once in 2011 and again in 2013, for an on-site assessment of the WTP, treatment processes and the treated water distribution into the existing bulk supply system. At the time of the site visits the WTP was generally in a well-maintained condition, but a number of aspects that require attention were, however, identified. The lack of as-built information seriously impairs the understanding of the existing WTP.

It was established that the existing WTP can, due to the modular units, be modified and extended for future requirements of the upgraded scheme. However, future extensions to the plant are subjected to land availability, future domestic water demands and hydraulic requirements.

The expansion and upgrade of the existing WTP was investigated in relation to a complete new plant. The refurbishment of the existing 2.8 Mℓ/day WTP at Xura, and the construction of a new 12 Mℓ/day WTP at Xura is the most favourable WTP Option, although the difference in terms of the URV's is only marginal.

Raw water from the Xura River is currently treated adequately except for colour, turbidity and alkalinity. The impoundment of water in the proposed Zalu Dam will have an impact on the quality of the water that will need to be treated. A multi-level outlet structure (off-take) will however allow for the selection of the best quality water in the dam to be released in order to meet both the level of water in the dam and the treatment objectives. The proposed treatment options in this report address the water quality problems associated with the levels in the dam from where water is released into the Xura River.

BULK WATER DISTRIBUTION INFRASTRUCTURE

The available data in terms of the existing water supply infrastructure is very limited, and no as-built drawings, or information, could be sourced. A map of the existing infrastructure was *however obtained from UWP Consulting Engineers. The data on the UWP Map, together with the information that is reported in the 2009 SRK Report, and site visits to some of the existing reservoirs was the best information that could be sourced in terms of the existing infrastructure.*

BULK PIPELINES

The existing Bulk Supply System already exceeds 50% of its life expectancy, and this system's capacity is far below the future water requirements in 2040. Also, most of the pipelines are Asbestos Cement (AC) pipes which are regarded as a health risk. Furthermore, since the standard pipeline diameters for a complete new scheme equal the standard pipeline diameters for an extension of the existing scheme it is recommended that the existing scheme be replaced.

The proposed bulk supply pipeline routes were drawn on the 1:50 000 topographical maps, modelled with the WADISO Model to determine the pipeline diameters and pumping requirements. The total length of uPVC (sizes range from 63 mm to 315 mm) and steel pipelines (sizes range from 400 to 450 mm) are 178 (174) km and 4 (7.5) km, respectively.

BULK AND VILLAGE RESERVOIRS

*The total estimated storage volume of the existing bulk and village reservoirs is 5 335 m^3. The village reservoirs, and their appurtenant works, are generally in a poor condition and are also in a general state of disrepair. A report of the assessment is included in **Appendix D.***

The required storage volumes were taken as two times the water requirements. The total required storage volume is 78 521 (106 575) m^3. Although the option to retain, and refurbish, the existing storage reservoirs was investigated, to replace all with new reservoirs will cost a mere R 5.5 million (excluding P&Gs and VAT). It is recommended to perform a structural integrity assessment on the existing reservoirs to confirm the most feasible option.

COST ESTIMATE

***Table i** summarises the capital cost of expansion, upgrades and new infrastructure required.*

Table i: Estimated capital costs for the preferred bulk distribution option

Bulk Supply Infrastructure Component	Estimated Capital Costs	
	Scenario 1	Scenario 2
Bulk Supply Pipelines	R 160 556 187	R 167 055 697
Bulk Supply and Village Reservoirs	R 162 930 455	R 221 143 737
Pumping Stations	R 25 326 259	R 33 071 590

Bulk Supply Infrastructure Component	***Estimated Capital Costs***	
	Scenario 1	***Scenario 2***
Borehole Development	*R 9 147 600*	*R 9 147 600*
Water Treatment Plant - Option A	*R 55 249 200*	*R 75 602 000*
Sub Total	***R 413 209 700***	***R 511 706 223***
Preliminary and General (20% of Sub Total)	*R 82 641 940*	*R 102 341 245*
Total (Excl. VAT)	***R 495 851 641***	***R 614 047 468***
VAT (14% of Total)	*R 69 419 230*	*R 85 966 646*
Total (Incl. VAT)	***R 565 270 870***	***R 692 236 213***

The annual Operation and Maintenance Cost was assumed to be 2.5% of the capital cost for the construction of a totally new scheme, as per the VAPS Guidelines. The following was assumed in terms of refurbishment costs:

- *The WTP will have to be refurbished every 15 years at a cost of 50% of the construction cost of a new WTP.*
- *Each borehole will have to be refurbished every 10 years at a cost of 50% of the borehole development cost.*
- *Each pumping station will have to be refurbished every 10 years at a cost of 50% of the construction cost of a new pumping station.*

The average weighted energy cost, at 2012/13 Eskom Ruraflex Tariffs, was estimated to be R 0.64 per kWh, and the URV calculations were based upon this tariff.

Table of Contents

Page

List of Figures

Page

List of Tables

Page

Appendices

List of abbreviations

AC	Asbestos Cement
CCPP	Calcium Carbonate Precipitation Potential
CCT	Chlorine Contact Tank
D:NWRP	Directorate: National Water Resource Planning
DOC	Dissolved Organic Carbon
DWA	Department of Water Affairs
EPBS	Eastern Pondoland Basin Study
EWR	Ecological Water Requirements (Reserve)
FSL	Full Supply Level
LRWSS	Lusikisiki Regional Water Supply Scheme
ND	Nominal Diameter
MAR	Mean Annual Runoff
OD	Outside Diameter
O&M	Operation and Maintenance
PAC	Powdered Activated Carbon
RGSF	Rapid Gravity Sand Filter
RSA	Republic of South Africa
SABS	South African Bureau of Standards
SANAS	South African National Accreditation System
VAPS	Vaal Augmentation Planning Study
URV	Unit Reference Value

List of abbreviations

WQ	Water Quality
WRC	Water Research Commission
WTP	Water Treatment Plant
BWDI	Bulk Water Distribution Infrastructure

List of units

a	annum
ha	hectare
hrs	hours
km	kilometre
km^2	square kilometre
kV	kilo Volt
kW	kilo Watt
kWh	kilo Watt hour
kWh/day	kilo Watt hour per day
ℓ	litre
ℓ/cap/day	litre per capita per day
ℓ/s	litre per second
m	metre
m/s	metre per second
m^3	cubic metre
m^3/s	cubic metre per second
m^3/a	cubic metre per year
masl	metres above sea level
mg	milligram
mg/ℓ	milligram per litre
mg/ℓ as $CaCO_3$	milligram per litre per Calcium Carbonate (Hardness)
mg/ℓ Pt	milligram per litre per measured against a Platinum Cobalt Reference Solution (Colour)

List of units

million m^3	million cubic metres
million m^3/a	million cubic metres per annum
Mℓ	megalitre
Mℓ/day	megalitre per day
mm	millimetre
mS/m	milli Siemens per metre
MW	megawatt
NTU	Nephelometric Turbidity Units
pH	pH units (acidity)
µg/ℓ	microgram per litre
Ø	diameter in mm
s	second
V	Volt
°C	degrees Celsius (temperature)

1 INTRODUCTION

The Department of Water Affairs (DWA) appointed **BKS (Pty) Ltd** in association with four sub-consultants (**Africa Geo-Environmental Services, KARIWA Project Engineers & Associates, Scherman Colloty & Associates and Urban-Econ**) with effect from 1 September 2010 to undertake the **Feasibility Study for Augmentation of the Lusikisiki Regional Water Supply Scheme**.

On 1 November 2012, BKS (Pty) Ltd was acquired by **AECOM Technology Corporation**. The new entity is a fully-fledged going concern with the same company registration number as that for BKS. As a result of the change in name and ownership of the company during the study period, all the final study reports will be published under the AECOM name.

1.1 BACKGROUND TO THE PROJECT

In the 1970s Consultants O'Connell Manthé and Partners and Hill Kaplan Scott recommended that a regional water supply scheme based on a dam on the Xura River and a main bulk supply reservoir close to Lusikisiki (located within the then defined "administration area" of Zalu Dam) would provide potable water supply for the entire region between Lusikisiki and the coast, extending from the Mzimvubu River in the south west to the Msikaba River in the north east. Some areas up to 15 km inland of Lusikisiki would also be supplied. A **White Paper** describing the scheme was tabled by the Transkei Government in 1979. It was envisaged that the scheme would be constructed in phases. Details of the proposed phasing of the scheme are provided in *Hill Kaplan Scott* (1986).

After the reincorporation of the Transkei Homeland into the Republic of South Africa (RSA) in 1994, the DWA took over responsibility for further development of the scheme. The Directorate: Water Resources Planning commissioned the *Eastern Pondoland Basin Study* (EPBS) in 1999 to further investigate the water supply situation in the area, with a specific focus on further development in the area originally earmarked for the Lusikisiki Regional Water Supply Scheme (LRWSS). This detailed investigation was undertaken for surface and groundwater sources, which reaffirmed that the Zalu Dam was the preferred source of surface water and recommended further investigation of groundwater sources to augment water supply to the entire area or to sub-areas.

In 2007, SRK Consulting undertook the *Lusikisiki Groundwater Feasibility Study* to investigate groundwater potential and compare the new data with data produced by earlier studies. This study reported that there is a relatively strong possibility of finding high yielding boreholes, and that a combination of surface water (Zalu Dam) and groundwater would be the most feasible solution for the LRWSS.

1.2 STUDY AREA

The study area comprises the entire region between Lusikisiki (up to about 15 km inland) and the coast, extending from the Mzimvubu River in the south-west to the Msikaba River in the north-east. This area includes the Zalu Dam site in the Xura River and the selected conveyance routes between the dam and the extended supply area (refer to **Figure 1.1**). It also includes the boreholes to be developed for augmentation and the routes of the pipelines to augment the water supply to the users.

In the south-western part of the study area the main focus will be on water supply from groundwater, due to the distance from the surface water source (Zalu Dam) as well as due to difficult topography.

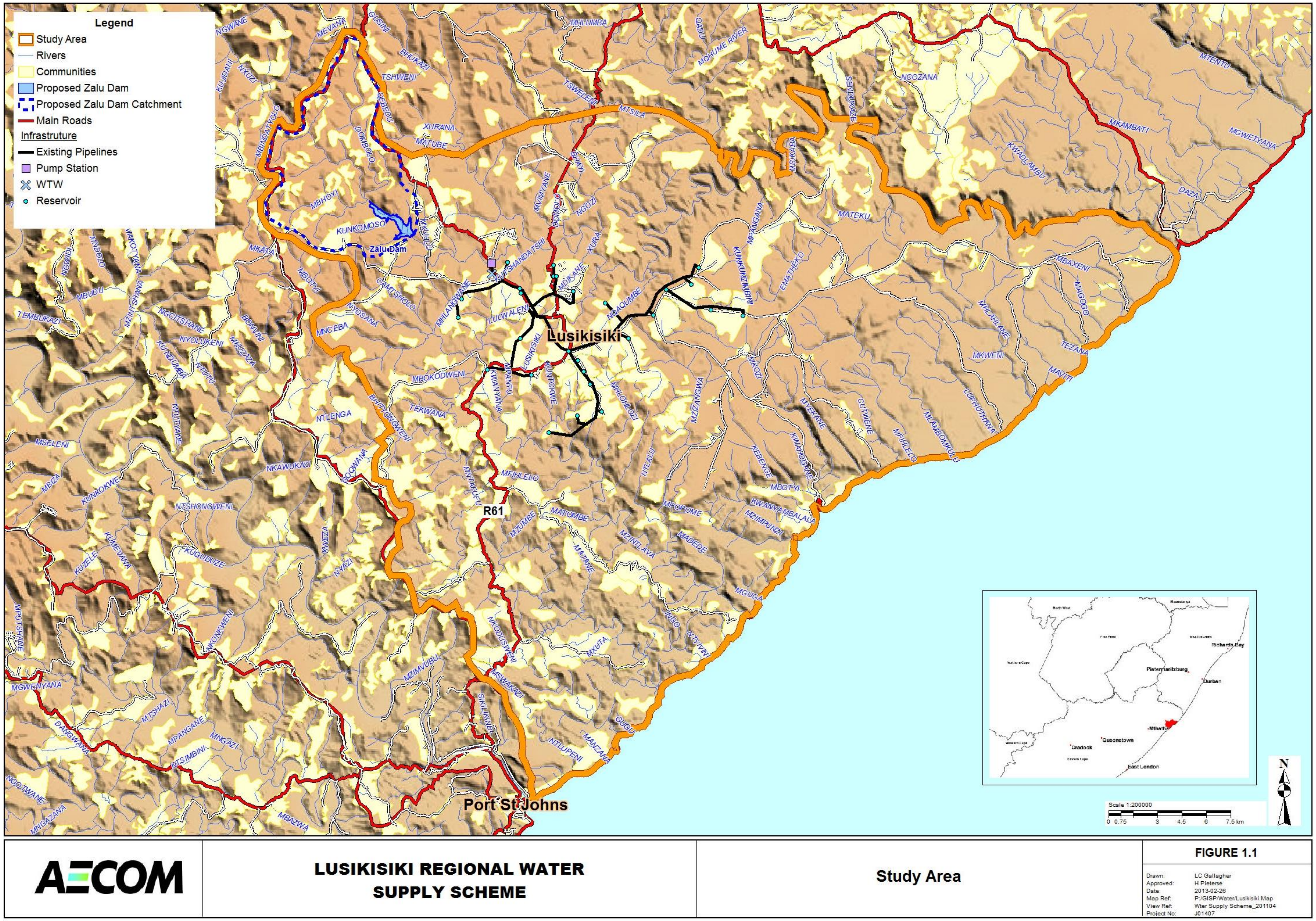

Figure 1.1: Study area

1.3 Objective, Scope and Organisation of the Study

The objective of this study was to complete a comprehensive engineering investigation at feasibility level for the proposed LRWSS, including the possible Zalu Dam in the Xura River, and to define the most attractive composition and size of the water supply components, taking augmentation from groundwater resources into account.

This feasibility study provided for the assessment of all aspects that impact on the viability of utilising a combination of surface water (via the Zalu Dam on the Xura River) and groundwater (via boreholes) for the expansion of the existing water supply scheme to provide all water users in the study area with an appropriate level of water supply. The study was therefore required to:

- Identify all of the technical issues likely to affect implementation, and to define and evaluate all of the actions required to address these issues;
- Provide an estimate of cost with sufficient accuracy and reliability to ensure that management decisions can be made with confidence;
- Assess irrigation potential; and
- Provide sufficient information to enable design and implementation to proceed without further investigation.

The required activities for this project have been grouped into 14 modules, as shown below:

1. **PROJECT MANAGEMENT**
   - 1.1 Study initiation and inception
   - 1.2 Project management and administration
2. **WATER RESOURCES**
   - 2.1 Hydrology
   - 2.2 Yield analysis
   - 2.3 Reservoir sedimentation
3. **GROUNDWATER AUGMENTATION**
4. **RESERVE - ECOLOGICAL WATER REQUIREMENTS**
5. **WATER REQUIREMENTS**
   - 5.1 Domestic water requirements
   - 5.2 Agriculture / Irrigation potential
6. **WATER SERVICE INFRASTRUCTURE**
   - 6.1 Distribution infrastructure
   - 6.2 Water quality

1.4 Scope of this Report

The activities specific to the **Water Distribution Infrastructure** module include the following:

- Assessment of the areas that can be supplied with the available water from the proposed Zalu Dam and identified potential boreholes until 2040;
- Assessment of the raw water infrastructure;
- Water Treatment Plant (WTP) assessment and recommended treatment process options;
- Determination of the required bulk (potable) water supply infrastructure based upon the available water and the most probable water demand scenario until 2040;
- Water quality testing and assessing;
- Feasibility level design and costing of the most feasible infrastructure options;
- Economic assessment of the most feasible bulk supply infrastructure options; and
- Recommendations for preliminary and detailed design of the infrastructure options.

This **Water Distribution Infrastructure Report** is the deliverable for **Module 6** of the *Feasibility Study for Augmentation of the Lusikisiki Regional Water Supply Scheme*.

2 WATER REQUIREMENTS AND RESOURCES

The purpose of distribution infrastructure is to adequately and efficiently meet the water needs of the region it supplies. The existing infrastructure is already under strain at present; the possibility of it being able to satisfy the ever increasing water needs of the surrounding region in its current condition is highly unlikely.

New bulk distribution alternatives as well as further water resources are required to address these factors.

2.1 WATER REQUIREMENTS

A population and water requirement forecast was conducted to determine what the LRWSS would need to cater for. These projections are described in detail in the *Domestic Water Requirements* report of this study, and a summary of the findings are displayed in **Table 2.1** below.

Table 2.1: Most probable annual domestic water requirements scenario

Area	Most Probable Domestic Water Requirements (million m^3/a)			
	2010	2020	2030	2040
LRWSS area	3.26	3.80	4.50	5.40
Study area	6.80	7.60	8.70	9.90

****LRWSS area:*** *the area that will be directly influenced by the proposed Zalu Dam*

****Study area:*** *the entire region that is being investigated in this study, defined in* ***Section 1.2****, includes the area that will be serviced by groundwater*

In addition to the projected domestic requirements, if irrigation should be developed in the area it would add another 1.45 million m^3/a to the water requirements. However, the irrigation requirements will be supplied directly from the proposed Zalu Dam and <u>no provision was made for irrigation infrastructure in this study</u>.

Figure 2.1 delineates the possible extent of the supply (LRWSS area) from Zalu dam as well as the potential production boreholes.

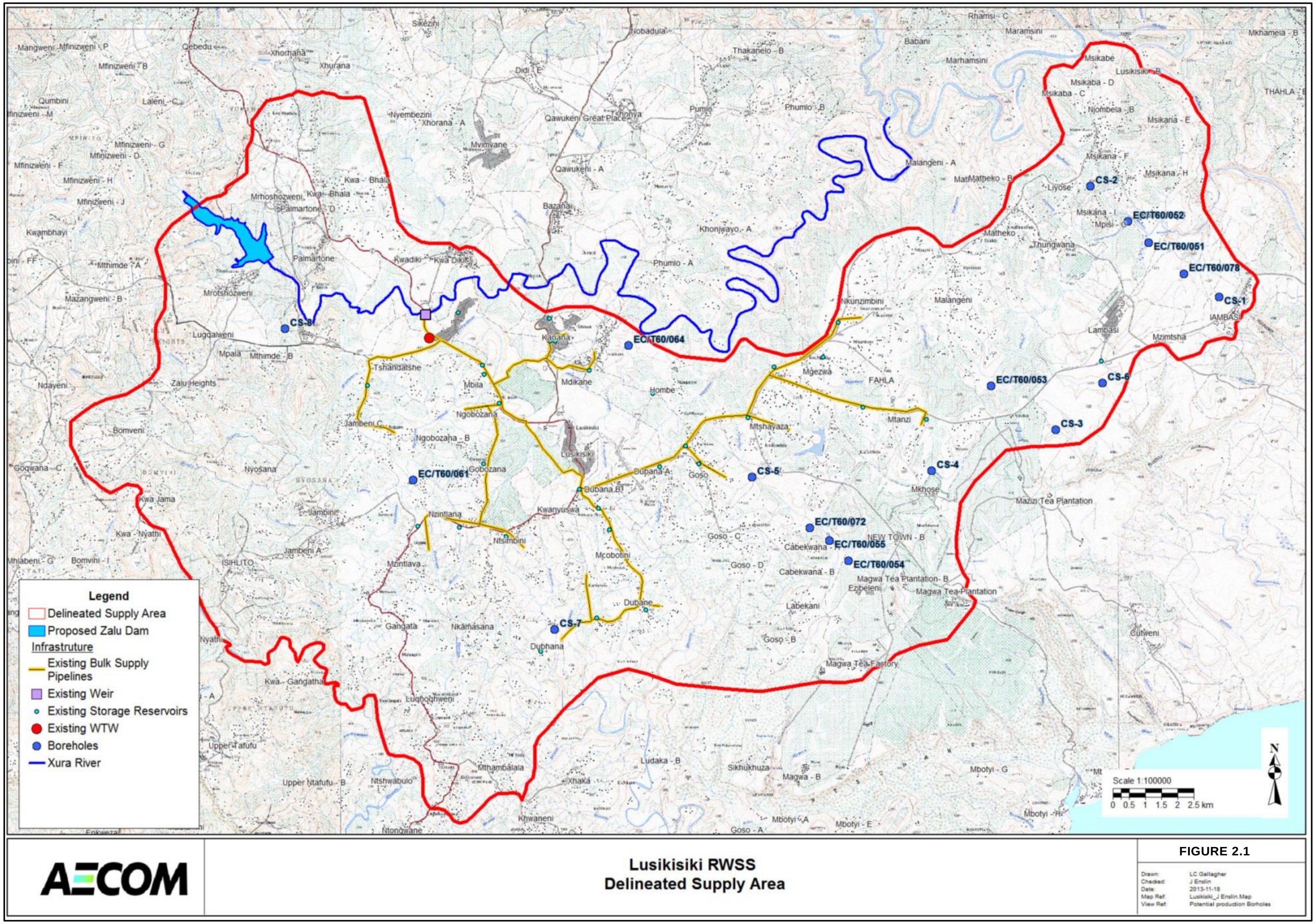

Figure 2.1: Delineated area of supply

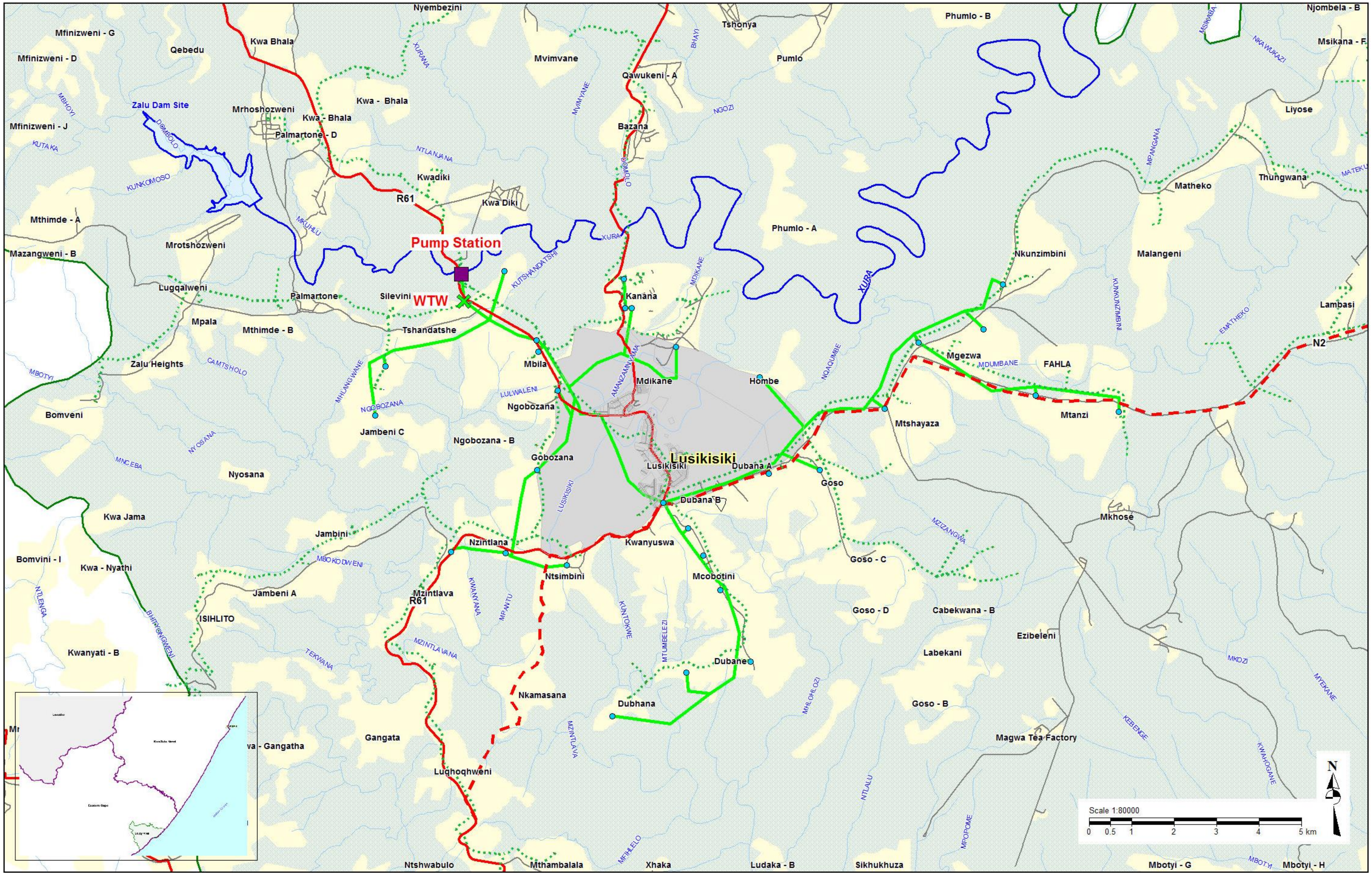

Figure 2.2: Villages to be supplied by the LRWSS

2.2 Areas to be Supplied

The areas to be supplied by the proposed Zalu Dam, and the potential production boreholes, as well as their most probable demands in 2040, are summarised in **Table 2.2** and are shown on a map in **Figure 2.2**.

Table 2.2: Areas to be supplied and the future (2040) estimated water requirements

Area/Village to be Supplied	Projected 2040 Water Demand (million m^3/a)	Area/Village to be Supplied	Projected 2040 Water Demand (million m^3/a)	Area/Village to be Supplied	Projected 2040 Water Demand (million m^3/a)
Bazana	0.050	Cabekwana	0.003	Dubana-A	0.340
Bomveni	0.142	Ganata	0.180	Dubana-B	0.038
Jambeni-C	0.205	Gobozana	0.385	Dubane	0.124
Kanana	0.162	Goso-C	0.049	Dubhana	0.013
Kwa-Bhala	0.213	Goso-D	0.054	Fahla	0.018
Kwadiki	0.030	Ishilito	0.069	Goso	0.272
Kwa Diki	0.045	Jambeni	0.065	Kwanyuswa	0.182
Lugqalweni	0.008	Jambeni-A	0.073	Lambasi	0.079
Mdikane	0.647	Luqhoqhweni	0.112	Malangeni	0.139
Mpala	0.034	Lusisiki	0.184	Matheko	0.088
Mrhoshozveni	0.038	Mbila	0.282	Mcobotini	0.163
Mtimde-B	0.040	Mtambalala	0.057	Mgezwa	0.216
Mvimvane	0.062	Mzintlana	0.123	Msikana-F	0.090
Nyembezini	0.010	Ntongane	0.012	Msikana-H	0.006
Palmerton	0.125	Ntsimbini	0.135	Mtanzini	0.144
Palmerton-D	0.012	Nyathi	0.005	Mtshayaza	0.238
Qawukeni	0.045	Nzintlana	0.081	Mzimtsha	0.034
Tsandatshe	0.089	Upper Ntafufu-A	0.033	Nkunzimbini	0.091
Zalu Heights	0.077	Upper Tafufu-A	0.133	Tungwana	0.007
Total Demand	**6.35**				

2.3 Water Resources

The main potential future surface water resource for the area is the proposed Zalu Dam on the Xura River. Furthermore, this supply can be augmented with groundwater resources from seventeen identified potential production boreholes.

The historic and 1:50 year yield of the proposed Zalu Dam, with a full supply level of 612 masl, is 6 and 7.2 million m^3/a, respectively (for more detail see *Water Resources* report). The estimated total yield from the seventeen identified potential production boreholes is 0.95 million m^3/a (for more detail see *Assessment of Augmentation from*

Groundwater report). The localities of Zalu Dam and the potential production boreholes are shown in **Figure 2.1**.

A larger Zalu Dam, 1.5 MAR at full supply level of 622.6 masl, has a historic and 1:50 year yield of 9.8 and 10.9 million m^3/a, respectively. The larger 1.5 MAR Zalu Dam has a bigger yield that could supply a wider area if the decision is made to implement this size of dam.

The **development of new irrigation schemes** in economically deprived rural areas is viewed as a **key strategic objective by the National Government** in order to stimulate socio-economic development, and as such the development of irrigated agriculture as a new economic activity along the Xura River was considered in this Study.

However, during planning there are many uncertainties regarding the implementation of the irrigation development and associated activities. The main uncertainty relates to the timing of new irrigation development and to the actual quantity of water that will be used beneficially for this purpose. If, in the worst case, none or only a portion of the water intended for irrigation is taken up for that purpose, increasing amounts can be reallocated for domestic use and for possible other economic activities, such as industrial development, which are not yet envisaged.

Due to these uncertainties, the assessment of the recommended bulk supply options was performed for two scenarios:

- **Scenario 1** for an annual supply of 5.4 million m^3/a from the proposed Zalu Dam and 0.95 million m^3/a from groundwater sources, solely for domestic use.
- **Scenario 2** for an annual supply of 7.2 million m^3/a from the proposed Zalu Dam and 0.95 million m^3/a from groundwater sources for domestic use, should irrigation not be implemented.

2.4 Water Quality Assessment

2.4.1 Review of the Xura River water quality

The following available surface water quality data was reviewed:

- Surface water quality tests as part of the 2009 study by SRK (*SRK, 2009*) were performed on six grab samples that were taken from the Xura River upstream of the proposed Zalu Dam site. The aforementioned samples were taken on one particular day (13 October 2006) during a period when significant rainfall occurred in the river's catchment, and therefore these test results may not be representative of the long-term water quality situation.

The results from these tests however indicated that the quality of water that will flow into the proposed Zalu Dam from its catchment is generally good, with the exception of Total Iron and Total Coliform.

- The DWA also takes surface water samples at Gauging Weir T6H004, on the Xura River, for testing. This weir is located downstream of the proposed Zalu Dam, and raw water is abstracted at this weir for the existing Lusikisiki WTP. DWA took the first samples for testing during August 1995, and the most recent samples for testing, at the time when this report was compiled, were taken during February 2010. **Table 2.3** below indicates the minimum and maximum values for this period.

Table 2.3: DWA Quality data at weir T6H004 on the Xura River

Determinant	Units	Standard Limits*	Minimum	Average	Maximum
Physical and aesthetic determinants					
Conductivity at 25°C	mS/m	≤ 170	9.4	21.8	34.2
Dissolved solids	mg/ℓ	≤ 1 200	61.3	141.8	222.3
pH value at 25°C	pH units	5.0 – 9.7	6.7	7.6	8.5
Chemical-determinants (Macro)					
Ammonia as N	mg/ℓ	≤ 1.5	0.015	0.2	0.4
Calcium as Ca	mg/ℓ	< 150	2.8	14.8	26.7
Chloride as Cl	mg/ℓ	≤ 300	5.2	20.9	36.6
Fluoride as F	mg/ℓ	≤ 1.5	0.050	0.1	0.2
Magnesium as Mg	mg/ℓ	< 70	2.7	10.2	17.6
Nitrate/Nitrite as N	mg/ℓ	≤ 11/0.9	0.020	1.1	2.2
Orthophosphate as P	mg/ℓ	-	0.006	0.4	0.8
Potassium as K	mg/ℓ	< 50	0.2	1.4	2.6
Sodium as Na	mg/ℓ	≤ 200	5.1	15.3	25.5
Sulphate as SO_4^{2-} (Acute health-1)	mg/ℓ	≤ 500	1.9	13.5	25.1
Sulphate as SO_4^{2-} (Aesthetic)	mg/ℓ	≤ 250	1.9	13.5	25.1

**SANS 241-1:2011*

From the data in **Table 2.3** it is deduced that the quality of intake water from the Xura River weir is generally of a good quality. However, parameters such as Total Iron and Total Coliform, which were high during the SRK study, were not analysed.

2.4.2 Groundwater quality

The following available groundwater quality data was reviewed:

- Twelve boreholes, to be used as production boreholes, were previously recommended for conjunctive use with surface water. The water in two of these boreholes has unacceptably high Iron concentrations, and the water in four of these boreholes was found to have marginal Iron concentrations. Both the surface water, upstream of the proposed Zalu dam, and water in three of the recommended production boreholes have unacceptably high bacterial content.
- The *Groundwater Augmentation Report* for this study, which was prepared by **AGES**, identified seventeen boreholes (nine Feasibility Study boreholes as well as eight conceptual, or proposed, boreholes) in total to be used as production boreholes.

The *Groundwater Augmentation Report* states that Bacteria (Faecal Coliforms), Iron and Chloride are the key concerns in terms of the groundwater resources. For each one of the 17 identified potential production boreholes the afore-mentioned key concerns are reported in terms of the DWA Groundwater Classes, which are defined in Volume 1 of WRC Report Number TT 101/98, Quality of Domestic Water Supplies. A summary of the suitable identified production boreholes, and their respective DWA Groundwater Classes, is given in **Table 2.4**.

Table 2.4: Groundwater quality of the envisaged production boreholes

Borehole Number	DWA Groundwater Class	Anticipated Concentrations	Desired Concentrations
EC/T60/051	Class 2: Iron	Iron: 0.2 - 2 mg/ℓ	< 0.1 mg/ℓ
EC/T60/052	Class 2: Bacteria	Bacteria: 1 - 10 counts per 100 mℓ	< 1 count per 100 mℓ
EC/T60/053	Class 2: Bacteria	Bacteria: 1 - 10 counts per 100 mℓ	< 1 count per 100 mℓ
EC/T60/054	Class 1	-	
EC/T60/055	Class 1	-	
EC/T60/061	Class 2: Chloride, Bacteria and Iron	Iron: 0.2 to 2 mg/ℓ	< 0.1 mg/ℓ
		Bacteria: 1 - 10 counts per 100 mℓ	< 1 count per 100 mℓ
		Chloride: 100 - 200 mg/ℓ	< 100 mg/ℓ
EC/T60/064	Class 4: Iron and Bacteria	Iron: > 10 mg/ℓ	< 0.1 mg/ℓ
		Bacteria: > 100 counts per 100 mℓ	< 1 count per 100 mℓ
EC/T60/072	Class 4: Coliforms	Coliforms: > 1000 counts per 100 mℓ	< 10 count per 100 mℓ

Borehole Number	DWA Groundwater Class	Anticipated Concentrations	Desired Concentrations
EC/T60/078	Class 1	-	
CS-1	Class 1	-	
CS-2	Class 2: Bacteria	Bacteria: 1 - 10 counts per 100 mℓ	< 1 count per 100 mℓ
CS-3	Class 2: Bacteria		
CS-4	Class 2: Bacteria		
CS-5	Class 2: Bacteria		
CS-6	Class 2: Bacteria		
CS-7	Class 2: Chloride, Bacteria and Iron	Iron: 0.2 - 2 mg/ℓ	< 0.1 mg/ℓ
		Bacteria: 1 - 10 counts per 100 mℓ	< 1 count per 100 mℓ
		Chloride: 100 to 200 mg/ℓ	< 100 mg/ℓ
CS-8	Class 2: Iron and Chloride	Iron: 0.2 - 2 mg/ℓ	< 0.1 mg/ℓ
		Chloride: 100 - 200 mg/ℓ	< 100 mg/ℓ

Based on the probable parallel use of both treated surface water and groundwater for the supply area, it is expected that the blending of the treated surface water with groundwater will yield the desirable concentrations of iron and chloride in the blended water. The concentration of iron, chloride and bacteria of the blended water for each borehole was assessed.

2.4.3 Water quality problem areas

Based on the analysis of limit available data, **Table 2.5** identifies the water quality parameters that should be targeted to allow the preliminary and detail design of the future treatment plants to be optimised. The water sampling and analysis protocol should review all the water quality constituents, but focus on those that will impact the treatment process.

Table 2.5: Surface, borehole and WTP water constituents to be analysed

Constituent	Unit	Source		
		Xura River	Boreholes	WTP
Physical and aesthetic determinants				
Colour Unfiltered	mg/ℓ Pt	X		X
Colour Filtered	mg/ℓ Pt	X		X
Conductivity at 25°C	mS/m	X	X	X
pH value at 25°C	pH units	X	X	X
Temperature	°C	X	X	X
Chemical-determinants (Macro)				
Nitrate/Nitrite as N	mg/ℓ		X	
Fluoride	mg/ℓ		X	X
Total Alkalinity	mg/ℓ as $CaCO_3$	X	X	X
Calcium	mg/ℓ	X	X	X
Micro-determinants				
Arsenic as As	µg/ℓ	X	X	X
Iron as Fe	µg/ℓ	X	X	X
Manganese as Mn	µg/ℓ	X	X	X
Chemical-determinants (Organic determinants)				
Dissolved organic carbon as C	mg/ℓ	X		

Further monitoring is required to assess the seasonal variation of the water upstream of the proposed Zalu Dam, for the listed parameters. The seasonal variation and future trends will need to be assessed in terms of their impact on the water treatment process. **Table 2.6** lists the recommended sampling frequency.

Table 2.6: Recommended sampling frequency

Sampling point	No samples per year	Sampling frequency
Xura River	26	2 – weekly
Boreholes	2	6 – monthly
WTP Effluent	26	2 – weekly

2.4.4 Water Quality changes due to the constrution of a dam on the Xura River

For the purposes of this report only conceptual water quality changes in the proposed Zalu Dam are considered. The surface water quality data just downstream of the proposed Zalu Dam (**Table 2.3**) was reviewed, indicating a good quality water of the Xura

River in the vicinity of (and assumed to be the same as the inflow to) the proposed Zalu Dam.

However, water contained in dams has different physical, chemical, and biological properties compared to free-flowing water in a river. Factors of dam morphology are thermal stratification, chemical stratification (dissolved gasses, biogeochemistry and temporal patterns), and the density of the currents. Warming or cooling of the water affects the amount of dissolved oxygen and suspended solids it contains and influences the chemical reactions which take place in it.

Dams also trap most of the nutrients carried by the river. The still standing and nutrient rich water promotes the growth of algae. During warm weather, algae are likely to proliferate near the surface. Through photosynthesis the algae consume the reservoir nutrients and produce large amounts of oxygen. Summer releases from the surface layer of a dam will thus tend to be warm, nutrient-depleted, high in dissolved oxygen, and may contain high concentrations of algae. High levels of algae can give water an unpleasant smell and taste. When algae in a dam die, they sink to its bottom layer, where they decay and in doing so consume the already limited oxygen levels. The acidity of this oxygen-depleted water often dissolves minerals from the dam bed, such as iron and manganese.

Warm weather releases from a dam with low-level outlets will be cold, oxygen-poor, nutrient-rich and acidic, and may contain high mineral concentrations.

During the first few years after a dam is filled the decomposition of submerged vegetation and soils can drastically deplete the level of oxygen in the water and increase the concentrations of organic carbon. Thorough clearing of vegetation in the submergence zone before the dam is filled can reduce this problem. Through the depletion of the decomposing vegetation, dams often 'mature' over time, resulting in an improvement of the quality of water.

Detailed Water Quality Modelling, including further sedimentation analysis, for the proposed Zalu dam should be performed during the design stage. This detailed modelling is however beyond the scope of this study.

A multi-level dam outlet allows the flexibility to select water from various levels depending on the specific requirements. This can be beneficial to both the downstream environment (stable water temperatures and nutrient loads) and to the treatment process (off-take below the algae level, with the best water quality characteristics for lowest cost / highest quality treatment).

2.4.5 Water quality trend analysis

At this stage, no trend analysis was performed to determine the expected surface and groundwater quality at the end of the design horizon. Between 1995 and 2011 (16 years), the water quality in the Xura River did not show noticeable signs of deterioration. However, the quality of surface water in the catchment could deteriorate over time, due to increased population densities and agricultural/industrial growth in the areas close to the Xura River.

Furthermore as discussed in **Section 5.3.4** the water quality is expected to change significantly after the construction of the Zalu Dam.

Due to the position and level of development around the boreholes, the groundwater quality constituents are not expected to deteriorate significantly in the foreseeable future.

3 EXISTING LRWSS INFRASTRUCTURE

3.1 OVERVIEW OF EXISTING INFRASTRUCTURE

SRK Consulting's investigation into the potential to supplement the LRWSS (*SRK, 2009*) includes a description of the existing infrastructure which is summarised in this section. **Figure 3.1** shows a schematic layout of the components.

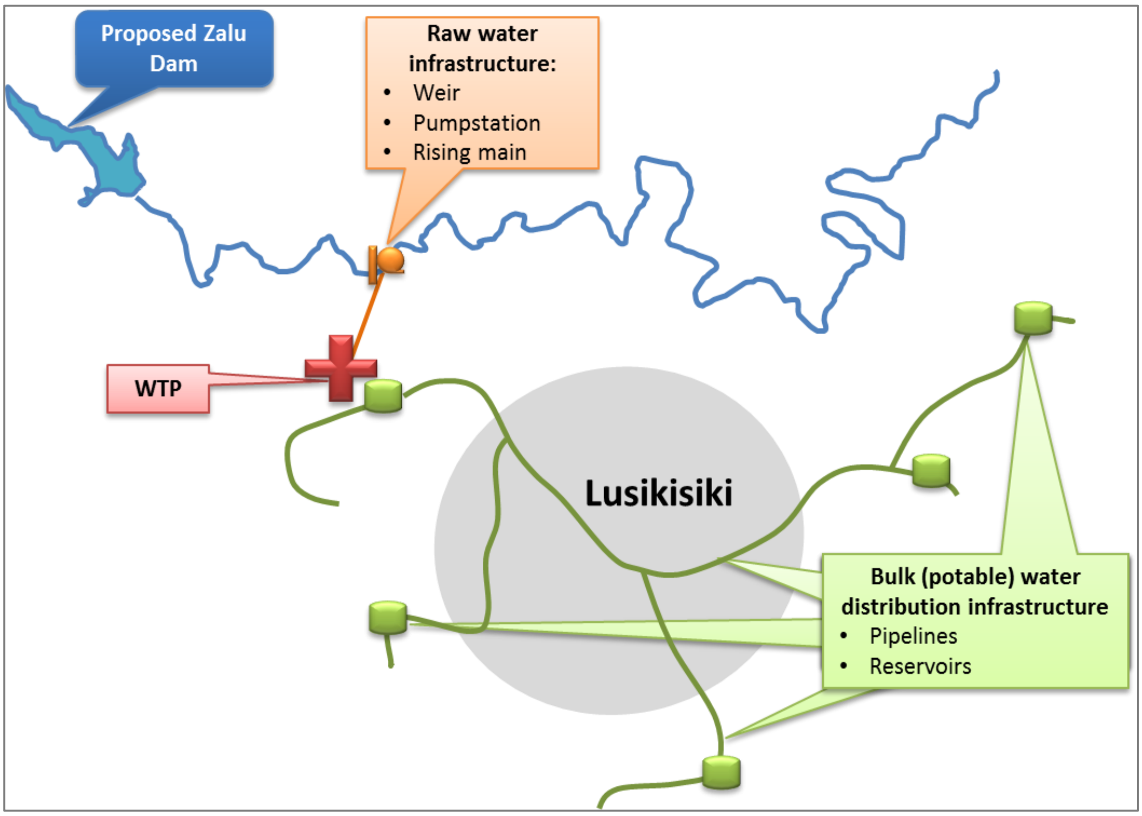

Figure 3.1: Schematic layout of the Water Distribution Infrastructure

The design capacity of the existing water (raw and potable) distribution infrastructure is 2 760 m^3/day (which equates to 1.0 million m^3/a).

3.2 EXISTING RAW WATER INFRASTRUCTURE

3.2.1 Abstraction weir

The DWA's flow gauging weir T6H004 on the Xura River is used as the abstraction weir for the LRWSS. The weir is situated underneath the bridge where the main road between Flagstaff and Lusikisiki, the R61, crosses the Xura River. The weir is a typical DWA crump gauging structure and the weir's minimum crest level is 527.646 masl. The weir consists of two portions of 5.677 m and 5.647 m respectively, which are the lengths of the two bridge spans. The intake structure at the weir consists of a metal grid with a 500 mm diameter pipe and a 300 mm diameter valve.

The as-built data of the weir was sourced from the DWA's Eastern Cape Regional Office. The weir, shown in **Figures 3.2,** is owned and maintained by the DWA.

Figure 3.2: Different views just downstream of gauging weir T6H004

3.2.2 Raw water pump station and rising main

Raw water is gravity fed to the raw water pump station by means of a 300 mm diameter pipe.

The raw water pump station functions on two centrifugal pumps (with an extra one on standby), with a combined capacity and head of 32 ℓ/s and 60 m respectively.

Figure 3.3: Raw water pump station

The water is pumped from the pump station to the Water Treatment Plant (WTP), which lies north-west of the town of Lusikisiki. The rising main is a 650 m long 200 mm ND asbestos cement (AC) pipe. The raw water is pumped directly into the Lusikisiki WTP at the chemical dosing point.

3.3 LUSIKISIKI WATER TREATMENT PLANT

The Lusikisiki WTP is about 6 km north-west of Lusikisiki town centre, next to the R61.

In previous studies (*SRK, 2009* and *UWP Engineers, 2001*) the treatment capacity at the Lusikisiki WTP is stated as 32 ℓ/s (2.76 Mℓ/day). However, during the site visit on 2 August 2011, the operator provided information demonstrating that the current raw water inflow into the WTP was approximately 43 ℓ/s (3.72 Mℓ/day). For comparison, this figure corresponds to UWP Engineers' estimate (*UWP Engineers, 2001*) of the water requirement of 42 ℓ/s in 2001.

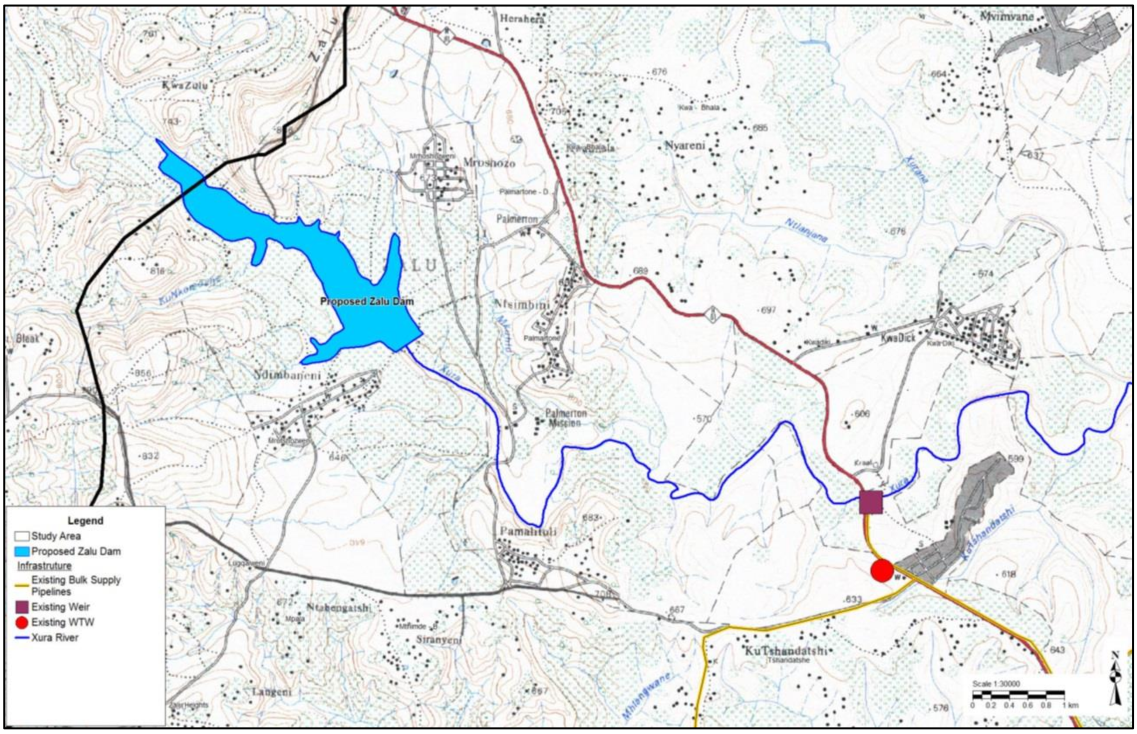

Figure 3.4: Locality of Lusikisiki WTP

The WTP comprises the following treatment processes and ancillary works, shown schematically in **Figure 3.6** below:

- Chemical dosing (Coagulant, polyelectrolyte);
- Mixing and Flocculation;
- Sedimentation;
- Pressurised sand filtration;
- Disinfection (Chlorination);
- Sludge pond; and
- Backwash water storage dams.

The clear water pump station, located within the WTP, also has two operational pumps and one standby pump. With its 32 ℓ/s capacity and 80 m head, the pump station delivers the treated water to a 1300 m³ bulk storage reservoir.

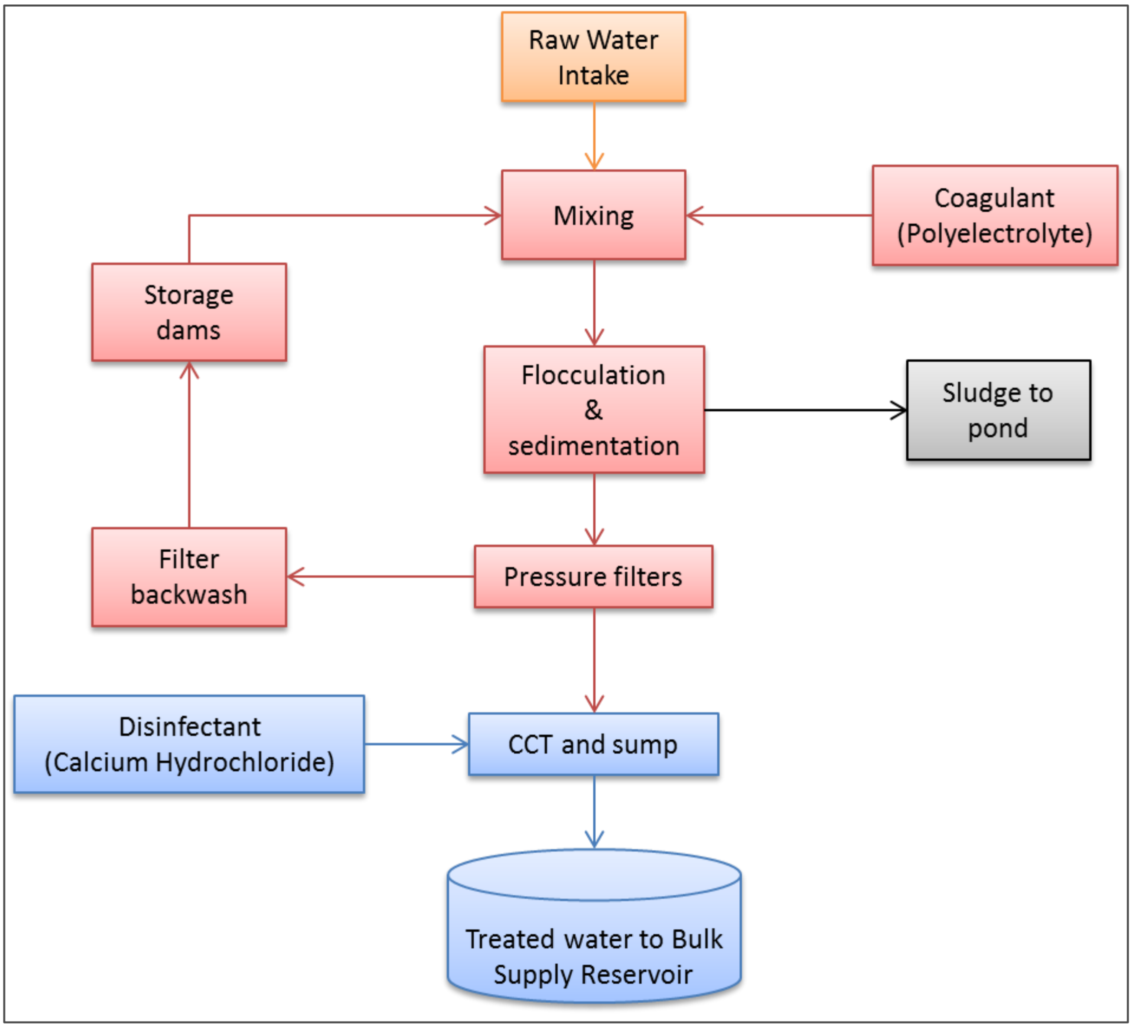

Figure 3.5: WTP process flow diagram

The Lusikisiki WTP was visited on 2 August 2011 and again on 13 December 2013, with the objective of providing an on-site assessment of the following aspects:

- Hydraulic and treatment capacity of the unit processes, theoretically calculated from as-built drawings;
- The condition of the concrete structures;
- The condition of the mechanical and electrical equipment; and
- Plant upgrade and/or extension possibilities, including integration into the upgraded scheme, or de-commissioning of the existing WTP.

3.3.1 Assessment of the Lusikisiki treatment plant

Due to the absence of as-built drawings and information, it was not possible to calculate the capacity of the plant per process unit. It was however observed that:

- All the pumps at the WTP were in working order;
- The mechanical and electrical equipment was generally well maintained;
- The site was generally well maintained, including the fencing around the site.

a) Chemical dosing and mixing

The raw water entering the plant is dosed with a coagulant (polyelectrolyte). Immediately after the dosing point the water is subjected to high levels of turbulence, which provides rapid hydraulic mixing of the coagulant.

The exposed aggregate that is evident on the concrete of the mixing and dosing channels, as shown in **Figure 3.6**, is the result of aggression (leaching of cement paste from the concrete matrix) caused by the low alkalinity of the raw water. The severe exposed aggregate at the dosing point, may also have been due to dosing with an aggressive coagulant in the past, e.g. Ferric Chloride.

Figure 3.6: Chemical dosing point at the WTP

The dosing rate of coagulant/flocculants could not be ascertained, but the mixing of coagulant/flocculent seemed to be adequate at the time of the site visit.

Figure 3.7: Chemical dosing room

The coagulant is stored in the administration building. There is significant amount of available space in the chemical store and dosing area, because the original design allowed for the chemical make-up and storage of large volumes of chemicals. The polyelectrolytes currently being used require very small quantities (in comparison with traditional coagulants like Alum or Ferric) and therefore the space required for storage and dosage is far less. **Figure 3.7** shows the chemical dosing room in the administration building, including the dosing pumps.

b) Flocculation

The flocculation channels form a long inlet channel down the side of the sedimentation tank, as shown in **Figures 3.8** and **3.9**.

There is also some exposed aggregate evident on the concrete of the flocculation channel. The floc-formation seemed to be adequate at the time of the site visit, but there was some scum build-up in the flocculation channels, as depicted in **Figure 3.9**, which should be periodically removed.

Figure 3.8: Flocculation channel at the WTP

Figure 3.9: Flocculation channel – the right image reveals significant build-up

c) Sedimentation

Suspended solids are removed in horizontal flow sedimentation tanks. There was no scum on the sedimentation tanks and the sludge blanket was at an appropriate height, indicating that the sludge withdrawal is regulated correctly. The operation of a sedimentation tank may also be influenced by wind and thermal effects, but there was no visual confirmation of these impacts during the site visit. The sedimentation tanks are shown in **Figure 3.10**.

Figure 3.10: Various views of the sedimentation tank

d) Filtration

The plant uses silica sand media pressure filters as shown in **Figure 3.11**.

Figure 3.11: Pressure filters

At the time of the site visit, the operator confirmed that all of the filters were in working order and visually it was assessed that all equipment was well maintained. Since the filters could not be easily opened (closed system to allow for pressure filtration), the state of the filter media is, however, unknown.

The filters are backwashed with air, followed by water utilising the blower and the pumps shown in **Figure 3.12**. The blower and backwash pumps were in working order at the time of the site visit, but it is evident that at least some corrosion protection is required.

Figure 3.12: Filter backwash blower (left) and filter backwash pumps (right)

e) Disinfection

The Chlorine Contact Tank (CCT) is directly under the administration building. The CCT comprises serpentine channels providing disinfection contact time. It was not possible as part of this study to determine whether sufficient contact time is being provided. Since the plant is operating over the design capacity by about 30%, the chlorine dosage needs to be increased above the design dosage to ensure that a higher chlorine concentration is used for the reduced hydraulic retention time (C_t = concentration x time).

The treatment plant uses Granular Chlorine (Calcium Hypochlorite or commonly known as HTH). At the first site visit the granules were dissolved in a container and dosed by means of the manual adjustment of a tap. At the later site visit, the chlorine granules were thrown directly into the CCT.

Both these methods of chlorine dosing do not provide the actual dosing rate. The current method of putting undiluted granules into the CCT will not provide a consistent disinfection. Furthermore the driving head on the tank gets less as the tank empties, which means the dosage varies as the tank level changes.

Figure 3.13: Chlorine dosing equipment: dosing tank (left) and dosing tap (right)

Since disinfection is potentially the most important unit process at a treatment plant, the method of chlorine dosing is inadequate and unacceptable.

The chlorine dosing and state of equipment is shown in **Figure 3.13**.

f) *Treated water distribution*

The water from the CCT flows into a storage tank, also situated under the administration building.

The treated water distribution pumps are situated in a pump sump below the administration building, shown in **Figure 3.14**.

Figure 3.14: Treated water distribution pump set

g) Sludge handling

The sludge from the sedimentation tanks is discharged through valves situated along the length of the sedimentation tanks, shown in **Figure 3.15**.

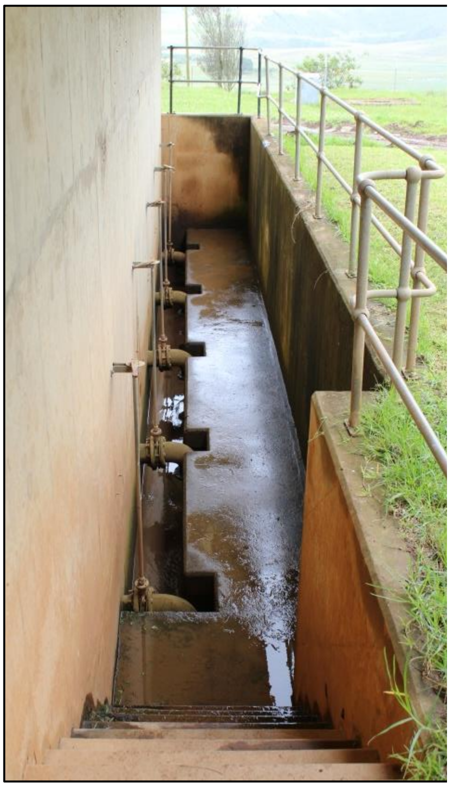

Figure 3.15: Sludge outlet valves on sedimentation tanks

At the time of the first site visit, sludge that was withdrawn from the sedimentation tanks flowed in an open channel to a sludge pond, probably due to a blocked pipe. The sludge dam in 2011 and in 2013 is shown in **Figure 3.16**.

There is no redundancy and therefore emptying of the sludge pond will entail bypassing directly to the water course. Furthermore the further handling of the sludge pond sludge, i.e. in terms of drying the sludge and ultimate re-use or disposal is not incorporated into the existing design of the treatment plant.

Figure 3.16: The sludge dam in 2011 (left) and 2013 (right)

There is no redundancy and therefore emptying of the sludge pond will entail bypassing directly to the water course. Furthermore the further handling of the sludge pond sludge, i.e. in terms of drying the sludge and ultimate re-use or disposal is not incorporated into the existing design of the treatment plant.

h) *Backwash handling*

The backwash water is deposited into storage dams. The storage dams provide for settling, balancing and recycling of the backwash water.

The storage dams are concrete lined and also have an HDPE lining over the top portion of the dam, to reduce the erosion effect of wave action and the concrete aggression. Refer to **Figure 3.17**.

Figure 3.17: The storage dams lined (left) and being emptied (right)

The water from the storage dams can be recycled back into the head of works by gravity, which reduces the water losses in the treatment process. Alternatively, the water can be bypassed into the sedimentation sludge channels for disposal.

There are four storage dams which allows them to be sequentially filled and bypassed, this allows the storage dams to be maintained or emptied.

i) *Administration building*

There is a large administration building at the treatment works that provides offices for the operators, general storage, a laboratory, chemical dosing pumps and storage, the treated water distribution pumps and underneath the building the CCT and storage tank (see **Figure 3.18**).

Figure 3.18: Administration building with inlet, chemical dosing and rapid mix

3.3.2 Water quality sampling: August 2011

Surface water grab-samples were taken at the inlet to the Lusikisiki WTP during a visit on 2 August 2011. The purpose of taking these samples was to test the quality of the river water and comparing it to that of the treated water.

The water samples were tested by **Waterlab** in Pretoria, which is a SANAS accredited laboratory according to ISO/IEC 17025:2005 standards. **Table 3.1** lists the test results.

Table 3.1: Surface water quality test results at the WTP

Determinant	Units	Raw Water (Xura River)	SANS Class 1*	Treated Water	Compliance with SANS Class 1
Physical and aesthetic determinants					
Colour Unfiltered	mg/ℓ Pt	416	< 20	40	Not compliant
Colour Filtered	mg/ℓ Pt	355	< 20	13	Compliant
Conductivity at 25°C	mS/m	17.5	< 150	17.3	Compliant
Dissolved solids	mg/ℓ	123	< 1 000	136	Compliant
pH value at 25°C	pH units	7.4	5,0 – 9,5	6.4	Compliant
Turbidity	NTU	43	< 1	5.1	Not compliant

Determinant	Units	Raw Water (Xura River)	SANS Class 1*	Treated Water	Compliance with SANS Class 1
Chemical-determinants (Macro)					
(Nitrate and nitrite) as N	mg/ℓ	0.8	< 10	-	
Total Alkalinity	mg/ℓ as $CaCO_3$	44	>50	36	Not compliant
Micro-determinants					
Iron as Fe	µg/ℓ	962	< 200	96	Compliant
Manganese as Mn	µg/ℓ	<25	< 100	< 25	Compliant
Chemical-determinants (Organic determinants)					
Dissolved organic carbon as C	mg/ℓ	1.1	< 10	1.5	Compliant

**SANS 241-1:2011*

From the test results it is found that the constituents of concern are colour, turbidity, iron and low alkalinity. These constituents do not directly represent any health risks, but colour, iron and turbidity influence the aesthetic quality of the water. Furthermore low turbidity is required for effective disinfection. Alkalinity levels below 50 mg/ℓ may lead to corrosion of mechanical equipment and distribution networks / pipelines and will lead to concrete aggression.

COLOUR: Based on testing the treated water colour before and after filtration through laboratory filter paper (e.g. Whatman filter paper), it is evident that additional colour is removed by the filter paper (difference between the filtered and unfiltered colour test). This is an indication that the sand filtration step at the WTP is not operating optimally.

TURBIDITY: The expected turbidity for this type of treatment plant would easily be below 1 NTU. Although we cannot comment about the quality and quantity of sand in the pressure filters, it is documented that the WTP is operating at least 30% over the design capacity (operating at 3.63 Mℓ/day versus 2.76 Mℓ/day design capacity).

The surface water quality test results are contained in **Appendix C**.

3.3.3 Conclusions and recommendations

When the site visit was conducted, the WTP was generally in a well maintained condition, but the following aspects will require attention:

- Dosing system in terms of increasing the alkalinity and Calcium Carbonate Precipitation Potential (CCPP) of the raw water, in order to minimise the concrete aggression of the raw water and the negative impact thereof on the concrete structures.

- The chlorine dosing system is inadequate for the size of treatment plant.
- Sludge handling will need to be improved. The use of an unlined sludge pond is not ideal.

The lack of as-built drawings seriously impairs the understanding of the designed operation of the treatment plant.

The existing WTP can be modified and extended for future requirements of the upgraded scheme. The existing WTP was constructed in modular units for future extension requirements. However, future extensions to the plant are subjected to land availability, future domestic water demands and hydraulic requirements. Issues like land ownership and rights has not been assessed as part of this feasibility study, but visually there is sufficient land around the existing Lusikisiki WTP to expand the plant. The extension of the WTP is further discussed in **Section 5**.

3.4 BULK WATER DISTRIBUTION INFRASTRUCTURE

The availability of data in terms of the existing water supply infrastructure is very limited, and no “as built” drawings, or information, could be sourced, although several attempts were made. A map of the existing infrastructure was however obtained from UWP Consulting Engineers, and a copy thereof is attached in **Appendix A**. The data on the UWP Map, together with the information that is reported in the *Investigating the potential to supplement the Lusikisiki Rural Water Supply Scheme* (SRK, 2009), and site visits to some of the existing reservoirs were used to assess the system, as discussed in the following sections.

The general condition of the distribution infrastructure is in a state of disrepair. Besides dilapidated village reservoirs, most of the distribution pipes are made of asbestos cement, which have been discontinued due to associated health risks. The reservoirs need to be cleaned twice a month when a 150 mm think layer of mud develops on the reservoir floor.

The villages are served by stand pipes generally located near the service reservoirs. The level of service received by the villages is below the basic level, defined as RDP level of 25 ℓ/p/d and access within 200 m.

3.4.1 Bulk supply and village reservoirs

A bulk supply reservoir of 1300 m³ stores the treated water at the WTP. This bulk storage reservoir gravity-feeds two more bulk storage reservoirs, with capacities of 1200 m³ and 1100 m³. Together, these three storage reservoirs supply 24 village reservoirs, with capacities ranging from 20 to 90 m³, except for Village Reservoirs 07 and 09. These village reservoirs then supply the surrounding rural villages. Two other 90 m³ village reservoirs are also directly fed via gravity flow from the WTP.

The conditions of the existing reservoirs that were visited are discussed in further detail in **Appendix D**. The reservoir numbers that are referred to correspond to those on the UWP map (refer to **Appendix A** for a copy of the map). The following general observations were made during the visit:

- All the village reservoirs, and their appurtenant works, are generally in a poor condition.
- The concrete of the in-situ cast village reservoirs is degraded and cracked.
- Most of the village reservoirs have leaks, some of which are quite severe.
- There is no water supply to some of the reservoirs due to the high demand currently placed on the existing bulk supply infrastructure.
- There seems to be no access control and therefore theft and vandalism at the reservoirs are uncontrolled.
- Steel components are stolen to be sold as scrap metal.
- The functionality and integrity of the existing village reservoirs are two concerns.

A summary of the existing bulk storage and village reservoirs is given in **Table 3.2**, and the assessments of the existing storage reservoirs that were visited are discussed in more detail, with images, in **Appendix D**.

Table 3.2: Summary of existing bulk supply and village reservoirs

Reservoir Description & Number	Capacity Reported on UWP Map (m^3)	Revised Capacity based on Site Visits (m^3)	Accepted Capacity* (m^3)	Comments
Bulk Supply Reservoir A	1 300	-	1 300	Visited
Bulk Supply Reservoir B	1 200	-	1 200	Visited, and there is a ***second newly constructed empty reservoir (apparently never used)*** next to the old 1 200 m^3 reservoir
Bulk Supply Reservoir C	500	-	500	Not visited
Village Reservoir – 01	90	-	90	Not visited
Village Reservoir – 02	90	-	90	Not visited
Village Reservoir – 03	90	-	90	Not visited
Village Reservoir – 04	90	-	90	Not visited
Village Reservoir – 05	90	-	90	Visited
Village Reservoir – 06	50	-	50	Not visited
Village Reservoir – 07	90	574	574	Visited, and there are two inter connected reservoirs at this site with a total storage capacity of 574 m^3 reservoir
Village Reservoir – 08	90	-	90	Not visited
Village Reservoir – 09	180	251	251	Visited, there are two reservoirs at this site of which the larger one has an estimated capacity of 161 m^3.
Village Reservoir – 10	90	-	90	Visited
Village Reservoir – 11	50	-	50	Visited
Village Reservoir – 12	50	-	50	Not visited
Village Reservoir – 13	50	-	50	Not visited
Village Reservoir – 14	50	-	50	Not visited
Village Reservoir – 15	50	-	50	Not visited
Village Reservoir – 16	90	-	90	Not visited
Village Reservoir – 17	90	61	61	Visited, this reservoir has an estimated capacity of 61 m^3, and not 90 m^3 as shown on the UWP Map.
Village Reservoir – 18	50	-	50	Not visited
Village Reservoir – 19	140	-	140	Not visited
Village Reservoir – 20	50	-	50	Visited
Village Reservoir – 21	50	-	50	Visited
Village Reservoir – 22	50	-	50	Not visited
Village Reservoir – 23	50	-	50	Not visited
Village Reservoir – 24	90	-	90	Not visited
Total Existing Storage Capacity	**4 860**	**-**	**5 386**	-

** Accepted capacity for the purposes of this study*

The total known available storage capacity of all the existing reservoirs is 5 386 m^3, which is about two times the design capacity of the existing bulk supply network of 2 760 m^3/d.

4 FUTURE RAW WATER INFRASTRUCTURE REQUIREMENTS

4.1 ASSESSMENT OF FUTURE RAW WATER INFRASTRUCTURE

The existing abstraction weir on the Xura River was assessed in terms of the available head at the weir and whether this head will be sufficient for increased abstraction at the weir once water is released from the proposed Zalu Dam. In the absence of as-built data it was assumed that the existing raw water pumping station's sump floor, and the river bed upstream of the weir, is on the same level. The minimum head at the weir is 1.14 m, which is the difference between the weir crest level and river bed level. If losses over the 300 mm ND 220 m long gravity raw water pipe are taken into account then the estimated water depth in the existing sump is about 1.03 m, which is more than two times the diameter of the suction pipe of 200mm ND. Both scenarios 1 and 2, for a supply of 5.4 and 7.2 million m^3/a from Zalu Dam respectively (defined in **Section 2.3**), were assessed in terms of the available head at the weir.

For **Scenario 1** the required suction pipe diameter will be 450 mm ND, if the water depth in the existing sump of the raw water pumping station is 1.03 m then the existing sump and weir will suffice since 1.03 m is larger than 0.9 m, which is two times the suction pipe diameter.

For **Scenario 2** the required suction pipe diameter will be 550 mm ND, if the water depth in the existing sump of the raw water pumping station is 1.03 m then the existing sump and weir will not suffice since 1.03 m is less than 1.1 m, which is two times the suction pipe diameter, and either the weir will have to be raised by 70 mm or the sump will have to be made 70 mm deeper.

The raw pumping station will have to be upgraded to accommodate the future water from Zalu Dam. The required pump station capacity and the daily energy are shown in **Table 4.1**.

Table 4.1: Summary of future pumping station requirements

Scenario	Required Pump Station Capacities (ℓ/s)	Daily Energy Requirements for Pumping (kWh/day)	
		2040	2060
Scenario 1	171.2	14 652	14 652
Scenario 2	228.3	14 652	20 262

The following is recommended:

- The construction of a new raw water pumping station, and utilization of the existing structure, if possible, is recommended.
- Investigate the structural integrity of the existing pump station structure. If a new pumping station is constructed then it is advisable to ensure that the sump depth is sufficient.

Table 4.2: Estimated capital costs for the pump station

Bulk Supply Infrastructure Component	Estimated Capital Costs	
	Scenario 1	Scenario 2
Pumping Stations	R 25 326 259	R 33 071 590

The pumping station will have to be refurbished every 10 years at a cost of 50% of the construction cost of a new pumping station.

5 PROPOSED FUTURE WATER TREATMENT PLANT

To assess the Lusikisiki WTP for future use, including receiving water from the proposed Zalu Dam, the following aspects were considered:

- The unit processes and plant layout of the existing WTP;
- Optimal abstraction positions for surface and groundwater relative to the WTP and the supply point/s (command reservoir/s);
- Available area for the extension and/or upgrading of the existing WTP;
- Available area for a new WTP, if required;
- Modular future expansion of the extended/upgraded/new WTP to cater for increased demand and deteriorating water quality up to 2040;
- Appropriate water treatment technologies for this rural area, and
- Operational and maintenance aspects of the WTP.

The upgrading of the WTP will involve the selection of water treatment processes that take into account the expected future water quality. Due to the uncertainty of the future water quality, a phased approach will probably be required to account for changes of water quality over time. The phased approach will require the plant to be upgraded and/or retrofitted periodically.

5.1 WATER TREATMENT PLANT REQUIREMENTS

There are various factors that need to be considered when formulating an upgraded Water Treatment Plant; these factors are listed and briefly described below.

5.1.1 Water requirements

The plant will have to treat as much water as is being used in the system per day, i.e. equivalent to the projected demand of 14.8 Mℓ/day, which corresponds to 171 ℓ/s.

If irrigation is not developed, the amount supplied will increase to 19.7 Mℓ/day, in which case the WTP will have to support a capacity of 228 ℓ/s.

In addition, the WTP will have to be designed to accommodate possible upgrades and retrofitting, in case of water quality deterioration or increased supply.

5.1.2 Condition and capacity of the current system

The potential to upgrade the current system needs to be considered, as well as an evaluation of the aspects in the system that would need to be changed. A few factors to consider are the following:

- Gravity flow through the treatment plant;
- Higher rate sedimentation processes to reduce the footprint of the horizontal flow treatment process;
- The filters should be rapid gravity sand filters or even micro/ultrafiltration membranes, as opposed to steel pressure filters;
- Far higher sludge quantities will be produced, which will require improved sludge handling facilities, e.g. sludge drying beds;
- Chemical dosing will need to be accurately monitored;
- Energy efficiency of the selected treatment process; and
- Backup power generation.

5.2 OPTIMISATION OF FUTURE EXPANSION OF THE WATER TREATMENT PLANT

Two options regarding the upgrading of the WTP were identified:

- **Option W1** involves the refurbishment of the existing 2.76 Mℓ/day WTP, and the construction of a new 12.03 Mℓ/day WTP adjacent to the existing works.
- **Option W2** involves the decommissioning of the existing 2.76 Mℓ/day WTP and the construction of a completely new 14.79 Mℓ/day WTP at the existing WTP site, or at Zalu Dam. These options are distinguished for the difference in associated cost.

The Unit Reference Values (URVs) of the two WTP Options were compared taking both the capital and operating cost of each into account.

The construction cost of a new WTP, based on recent tenders for other projects in 2012, was taken as R4.12 million for each Mℓ/day to be treated plus 20% for Preliminary and General Costs. The construction cost for the refurbishment of an existing WTP was assumed to be 50% of the cost of a new WTP, which amounts to R2.06 million for each Mℓ/day to be treated plus 20% for Preliminary and General Costs. The estimated construction cost for the WTP options is given in **Table 5.1**.

Table 5.1: Estimated construction cost for the WTP options W1 and W2 (2012 Rand)

Description	Unit	Quantity	Rate	Amount
Option W1				
Upgrading of the Existing WTP	Mℓ/day	2.76	R 2 060 000	R 5 685 600
Construction of a New WTP	Mℓ/day	12.03	R 4 120 000	R 49 563 600
Sub Total	-	-	-	**R 55 249 200**
Preliminary and General (% of Sub Total)	%	20	R 55 249 200	R 11 049 840
Total (excl. VAT)	-	-	-	**R 66 299 040**
VAT (% of Total)	%	14	R 66 299 040	R 9 281 866
Total (incl. VAT)	-	-	-	**R 75 580 906**
Option W2				
Construction of a New WTP	Mℓ/day	14.79	R 4 120 000	R 60-934 800
Sub Total	-	-	-	**R 60 934 800**
Preliminary and General (% of Sub Total)	%	20	R 60 934 800	R 12 186 960
Total (excl. VAT)	-	-	-	**R 73 121 760**
VAT (% of Total)	%	14	R 73 121 760	R 10 237 046
Total (incl. VAT)	-	-	-	**R 83 358 806**

Table 5.2: Refurbishment costs of various components of the bulk infrastructure

Component	Frequency of refurbishment	Scenario 1	Scenario 2
		Refurbishment cost	Refurbishment cost
Water treatment works	15 years	R 41 679 403	R 55 600 718

The URVs were calculated for WTP Options W1 and W2 for discount rates of 6%, 8% and 10% respectively over a period of 48 years from 2012 to 2060 for the treatment of raw water from Zalu Dam. For the purposes of the URV calculations it was assumed that the new WTP will have to be re-furbished every 15 years in 2027, 2042 and 2057, and that the refurbishment cost is 50% of the construction cost of the new 14.79 Mℓ/day WTP. The calculated URVs for Option W1 and W2 are summarised in **Table 5.3**.

Table 5.3: Comparison between the URVs for WTP options

Discount Rate	URV for WTP Option W1 (R/m^3)	URV for WTP Option W2 (R/m^3)
6% per annum	R 0.67	R 0.70
8% per annum	R 0.57	R 0.60
10% per annum	R 0.51	R 0.54
Average URVs	**R 0.58**	**R 0.61**

Given the marginal differences in the URVs and the absence of as-built drawings as well as information for the existing WTP it is difficult to recommend the most feasible option, even though it can be deduced from the URVs that **WTP Option W1** is the preferred option.

5.3 Assessment of Parameters for the Water Treatment Plant

The surface water quality results described in **Section 2.4** show that the surface water is generally of a good standard. However, aspects such as water colour, turbidity and alkalinity caused some concern. Possible treatment measures for these problems are explained below.

5.3.1 Colour

Since the most probable cause of the presence of colour in the water is an inefficient sand filtration process, it is expected that an optimally designed, operated and maintained sand filter will be sufficient to reduce the colour to below the required limits.

5.3.2 Turbidity

The high turbidity results are a cause for concern that can generally be explained by one of two elements:

- Insufficient sand in the pressure filter vessel; and
- Flows higher than the design flow.

It is expected that an optimally designed, operated and maintained sand filter will be sufficient to remove the turbidity to below the required limits.

For a larger treatment plant (±20 Mℓ/d), it is recommended that Rapid Gravity Sand Filters (RGSF) be used, which allow the quality of the filter media and the backwash to be observed on a daily basis.

5.3.3 Alkalinity

Although low alkalinity is not harmful to humans and livestock it does increase the potential for corrosion and concrete aggression, which has an associated maintenance cost. Furthermore due to the low concentration of calcium and magnesium, linked to the low alkalinity, the water will be termed 'soft', indicating a low concentration of divalent ions. 'Soft' water has low scaling potential, but it is difficult to wash soap off (lathers well).

If corrosion or concrete aggression in the network (and at connections) is a potential problem, then the alkalinity needs to be increased. This is achieved through the dosing of a hydroxide (e.g. lime or sodium hydroxide).

Alternatively concrete tanks and reservoirs can be constructed with water retaining concrete or other surface coats to resist the aggression.

5.3.4 Future water quality trends

As stated in **Section 2.4.4** the construction of the Zalu Dam will have a significant impact on the water that needs to be treated. The multi-level off take provided for in the design will allow for the selection of the best quality water to meet both the level of water in the dam and treatment objectives. The following are some of the factors that will have an impact on the raw water entering the treatment plant:

- Extracting water from low levels within a dam results in water that has a low dissolved oxygen concentration and potentially higher iron and manganese concentrations. This potential problem can be addressed by providing an aeration step (which will both increase the oxygen levels in the water, as well as oxidising the iron and manganese). In addition to the aeration step, the ability to dose a stronger oxidant at the start of the process (e.g. ozone or chlorine) provides flexibility for high concentrations of iron and manganese that need to be oxidised quickly.
- The decomposition of the vegetation that is left within the dam basin (***to be confirmed during the EIA phase***), will increase the dissolved organic carbon (DOC) entering the treatment works. It is not expected that the DOC will increase beyond

the limit of 10mg/l; if it does, then using Powdered Activated Carbon (PAC) intermittently during periods of high DOC can be considered. If DOC concentrations do present a problem in future, then the oxidant and disinfectant needs to be carefully selected, since chlorine combined with high DOC creates Disinfection By-Products (DBPs), which are suspected carcinogens (and would thus cause long term health problems).

- The nutrient load within an impoundment (from wastewater, fertiliser run-off, natural decay of the organic matter left in the basin, etc.) is a key determinant of the concentration of algae that will be present. Algae are problematic since they float on water and therefore settlement processes do not remove the algae. Although they are mostly removed by sand filters, they tend to blind the filter leading to very short filter runs. Although some algae contain toxins (neurotoxins, hepatotoxins) that can be harmful to susceptible individuals, this is only for high dose contact (e.g. with raw water), which would not be the case after treatment. Effective treatment of high concentrations of algae would be to use dissolved air flotation (DAF), which uses fine bubble aeration to float the algae to the surface. Lower concentrations of algae can generally be dealt with through the use of a strong oxidant.
- Algae also impart tastes and odours to the water. These tastes and odours are objectionable to the consumers of the water, which results in a high number of complaints. Taste and odour can generally be removed using PAC (also effective in removing DOC). Often an oxidant like ozone is used in conjunction with PAC to increase the effectiveness of the PAC.

5.4 Groundwater Treatment

The transfer of small quantities of borehole water to a central WTP will be expensive and therefore treatment of the borehole water on site is recommended. Stand-alone treatment systems for borehole supplies are available, and will provide effective treatment for the relative good quality of borehole water. These systems do however require technical operation and maintenance, which may not be present at a decentralised point. The management of these systems will need to include arrangements for operation and maintenance. The treatment requirements for each borehole are described in **Section 2.4.2**.

Since the water from the various sources (Zalu Dam and boreholes) will form part of the future distribution scheme, it will inevitably all blend, at least partially, at certain points along the network. Thus it is recommended that the water from each of the boreholes is treated on site before any blending does occur.

Table 5.4 lists all the proposed boreholes, and estimates the proposed blending ratios.

Table 5.4: Required groundwater treatment and recommended on-site treatment

Borehole Number	Blended with water from	Blend ratio	Contaminant to decrease	Treatment Method
EC/T60/051	EC/T60/052	EC/T60/051: 0.98 ℓ/s EC/T60/052: 0.95 ℓ/s	Iron	Oxidation, coagulation, clarification
EC/T60/052	EC/T60/051		Bacteria	Disinfection
EC/T60/053	CS-3, CS-6	EC/T60/053: 0.95 ℓ/s CS-3: 1.90 ℓ/s CS-6: 1.90 ℓ/s	Bacteria	Disinfection
EC/T60/054	EC/T60/055, EC/T60/072	EC/T60/054: 7.61 ℓ/s EC/T60/055: 0.66 ℓ/s EC/T60/072: 1.59 ℓ/s	-	-
EC/T60/055	EC/T60/054, EC/T60/072		-	-
EC/T60/061	Treated surface water	EC/T60/061: 2.22 ℓ/s surface water: 10.25 ℓ/s	Iron	Oxidation, coagulation, clarification
			Bacteria	Disinfection
			Chloride	Disinfection
EC/T60/064	Treated surface water	EC/T60/064: 0.63 ℓ/s surface water: 20.71 ℓ/s	Iron	Oxidation, coagulation, clarification
			Bacteria	Disinfection
EC/T60/072	EC/T60/054, EC/T60/055	see EC/T60/054	Coliforms	Disinfection
EC/T60/078	Treated surface water, treated borehole water	EC/T60/078: 0.95 ℓ/s	-	-
CS-1	EC/T60/053, CS-3, CS-6	CS-1: 0.95 ℓ/s EC/T60/053, CS-3 & CS-6: 1.04 ℓ/s	-	-
CS-2	EC/T60/051, EC/T60/052	CS-2: 1.27 ℓ/s EC/T60/051 & EC/T60/052: 1.90 ℓ/s	Bacteria	Disinfection
CS-3	EC/T60/053, CS-6	see EC/T60/053	Bacteria	Disinfection
CS-4	Treated surface water	CS-4: 1.90 ℓ/s surface water: 2.86 ℓ/s	Bacteria	Disinfection
CS-5	Treated surface water, EC/T60/054, EC/T60/055, EC/T60/072	[no info]	Bacteria	Disinfection
CS-6	EC/T60/053, CS-3	see EC/T60/053	Bacteria	Disinfection
CS-7	Partly blended with treated surface water	CS-7: 1.58 ℓ/s	Iron	Oxidation, coagulation, clarification

Borehole Number	Blended with water from	Blend ratio	Contaminant to decrease	Treatment Method
			Bacteria	Disinfection
			Chloride	Reverse osmosis
CS-8	Treated surface water	CS-8: 0.95 ℓ/s surface water: 7.67 ℓ/s	Iron	Oxidation, coagulation, clarification
			Chloride	Reverse osmosis

6 PROPOSED BULK INFRASTRUCTURE

The ageing supply infrastructure around Lusikisiki and the ever increasing water needs of the surrounding communities call for an infrastructure upgrade.

6.1 OPTIMISATION OF THE UPGRADE/EXPANSION OF THE FUTURE BULK DISTRIBUTION SYSTEM

6.1.1 Bulk supply pipelines

To address the need for the required infrastructure two proposed bulk supply pipeline alternatives, as outlined below, were assessed:

- Bulk supply pipeline Option P1: refurbishment and extension of bulk distribution system; and
- Bulk supply pipeline Option P2: replacement of bulk distribution system.

Bulk supply pipeline Option P1 encompasses refurbishing the existing domestic bulk supply system and building a new extended domestic bulk supply system parallel to the existing system. Bulk supply pipeline Option P2, is to decommission the existing bulk supply system and build a completely new extended system in its place, which will follow the same routes as the original system as well as spread out further to cover a broader range than the original system. The supplies required for each system are summarised in **Table 6.1**.

Table 6.1: Domestic bulk requirements for the two bulk supply pipeline options

Bulk Supply System	Bulk Supply		Water Resource
	(million m^3/a)	(Mℓ/day)	
Option P1			
Refurbished Existing system	1.0	2.8	Zalu Dam
Proposed Extended Bulk Supply System	4.4	12.0	Zalu Dam
	0.95	2.6	Ground Water
TOTAL Option P1	**6.35**	**17.4**	**Total Scheme**
Option P2			
Proposed Extended Bulk Supply System	5.4	14.8	Zalu Dam
	0.95	2.6	Ground Water
TOTAL Option P2	**6.35**	**17.4**	**Total Scheme**

Analysing the two options, using standard commercially available pipe diameters, it is recognised that the system for 12 Mℓ/day, can also convey 14.8 Mℓ/day. Therefore, **Option P2,** a totally new extended Bulk Distribution Infrastructure along the same routes of the existing system, and beyond, as well as the decommissioning of the existing Bulk Supply System, is recommended.

6.1.2 Bulk and village reservoirs

In this section the refurbishment/upgrade and new bulk and village reservoirs are considered. The following two options were analysed:

- **Reservoirs Option R1:** The refurbishment of the existing storage reservoirs, with additional new storage reservoirs.
- **Reservoirs Option R2:** New bulk and village reservoirs and the total decommissioning of the existing reservoirs

The required storage volumes were taken as two times the domestic water requirements, which conforms to the current sizing in which the volumes of the existing storage reservoirs are approximately two times the capacity of the existing bulk supply scheme. The required storage for bulk and village reservoirs for Scenarios 1 and 2 (5.4 and 7.2 million m^3/a supply from Zalu Dam respectively) are summarised in **Table 6.2** (details of individual reservoir storage volumes shown in **Appendix E**).

Table 6.2: Summary of required storage volumes for bulk and village reservoirs

Scenario	Required reservoir volumes (m^3)
Scenario 1 (5.4 million m^3/a supply)	78 521
Scenario 2 (7.2 million m^3/a supply)	106 575

Cost estimates were done for both options as shown in **Table 6.3** (details of individual reservoir storage volumes shown in **Appendix E**).

Table 6.3: Summary of the cost estimate for Option R2: all reservoirs to be replaced with new reservoirs

Costs	Scenario 1	Scenario 2
Bulk Supply and Village Reservoirs (subtotal 1)	R 130 344 364	R 176 914 989
Additional Sum to Compensate for the Remoteness (25% of subtotal 1)	R 32 586 091	R 44 228 747
Total Estimated Costs	**R 162 930 455**	**R 221 143 737**

Cost estimates for **Option R1** are outlined in **Table 6.4** for both scenarios. It was assumed that the refurbishment costs are 50% of the construction cost of a new concrete reservoir.

Table 6.4: Cost estimate for Option R1

Option R1						
Total Existing Storage Volume (m^3)	Refurbishment Cost per m^3	Total Refurbish-ment Cost	Additional Required Storage Volume (m^3)	New Reservoir Cost per m^3	Total Cost for Additional Storage	Total Cost of Reservoirs
Scenario 1: 5.4 million m^3/a						
5 335	R 1 038	R 5 535 063	73 186	R 2 075	R151 860 950	R 157 396 013
Scenario 2: 7.2 million m^3/a						
5 335	R 1 038	R 5 535 063	106 575	R 2 075	R 221 143 125	R 226 678 188

Note: The refurbishment cost of R1 038 per m^3 is 1.25 times R 1 660/2 in order to compensate for the remoteness, and the construction cost of R 2 075 per m^3 is 1.25 times R 1 660 also in order to compensate for the remoteness.

From **Tables 6.4** and **6.5** it can be deduced that the total saving in terms of capital costs of implementing Option R1 is R 5.5 million (excl. P&Gs and VAT), for both Scenario 1 and Scenario 2.

However, a saving of R 5.5 million is marginal compared to the total cost of the entire scheme. If DWA does indeed consider **Option R1**, the refurbishment of existing reservoirs plus additional new reservoirs, then it is recommended that due diligence in terms of the structural integrity of the existing reservoirs be performed.

6.2 Bulk Distribution Infrastructure Preliminary Design and Costing

6.2.1 Pipelines

The proposed bulk supply pipeline routes were drawn on the 1:50 000 topographical maps of the supply area. Preliminary pipe diameters, based on the most probable demands in 2040, were calculated for both scenarios. The proposed pipeline routes were modelled with the WADISO Model in order to determine the following:

- Recommended bulk supply pipe diameters; and
- Pumping requirements.

A layout of the proposed new bulk supply system is attached in **Appendix B** of this report.

The required storage volumes of the proposed storage reservoirs were also taken into account in the WADISO model. The required new bulk supply pipelines for **Scenarios 1** and **2** (i.e. for domestic supplies of 5.4 and 7.2 million m^3/a respectively) are summarised in **Table 6.5**.

Table 6.5: Summary of required bulk supply pipelines and estimated costs

Pipe Description and Outside Diameter	Required Pipe Lengths (m)		All Inclusive Cost (R/m)	Total Estimated Costs for Supply and Laying of Pipes	
	Scenario 1	Scenario 2		Scenario 1	Scenario 2
Class 16 uPVC – 63mm OD	10 413	9 486	481	R 5 011 410	R 4 565 239
Class 16 uPVC – 75mm OD	6 362	5 742	481	R 3 061 871	R 2 763 453
Class 16 uPVC – 90mm OD	39 338	35 528	481	R 18 931 234	R 17 098 079
Class 16 uPVC – 110mm OD	2 916	7 825	481	R 1 403 522	R 3 765 973
Class 16 uPVC – 125mm OD	0	12	481	R 0	R 5 948
Class 16 uPVC – 160mm OD	68 827	64 596	551	R 37 941 095	R 35 608 579
Class 16 uPVC – 180mm OD	3 882	2 104	647	R 2 513 712	R 1 362 631
Class 16 uPVC – 200mm OD	24 378	26 351	647	R 15 784 540	R 17 062 200
Class 16 uPVC – 225mm OD	6 828	6 110	647	R 4 421 305	R 3 956 322
Class 16 uPVC – 250mm OD	7 422	7 591	700	R 5 195 176	R 5 313 581
Class 16 uPVC – 280mm OD	4 497	7 146	700	R 3 147 921	R 5 002 088
Class 16 uPVC – 315mm OD	3 408	2 384	700	R 2 385 852	R 1 668 499
Total Length of uPVC Pipe	**178 271**	**174 875**	-	-	-
Steel Pipe - 400 mm OD	3 166	6 574	1 750	R 5 540 272	R 11 504 902
Steel Pipe - 450mm OD	971	967	1 750	R 1 699 548	R 1 692 967
Total Length of Steel Pipe	**4 137**	**7 541**	-	-	-
Subtotal 1 for Bulk Supply Pipelines				**R 107 037 458**	**R 111 370 464**
Additional Sum to Compensate for the Topography* (20% of subtotal 1)				R 21 407 492	R 22 274 093
Subtotal 2 for Bulk Supply Pipelines				**R 128 444 949**	**R 133 644 557**
Additional Sum to Compensate for Remoteness# (25% of subtotal 2)				R 32 111 237	R 33 411 139
Estimated Totals for Bulk Supply Pipelines				**R 160 556 187**	**R 167 055 697**

** Compensation for extreme topography changes*

 # Compensation for rural area, without any large commercial/industrial centres close by

6.2.2 Pumping stations

The cost of the pumping stations was assumed to be as follows:

- R25 000 per kW for Mechanical and Electrical installations;
- 30% of the Mechanical and Electrical for the Civil Works, and
- 30% of Mechanical, Electrical and Civil Works for Contingencies.

The cost of R 25 000 per kW is based upon recent tenders that were received and awarded in 2012 for the construction of pump stations. The energy requirements are also based upon assumed pump efficiencies of 75%. The estimated pumping and energy requirements for 24 hours per day, as well as the capital costs of the pumping stations for the bulk supply system for both **Scenario 1** and **2** for water supplied from Zalu Dam are summarised in **Tables 6.6**.

Table 6.6: Summary of pumping and energy requirements

Pump Number as per the WADISO Model	Pumping Requirements for Scenario 1			Pumping Requirements for Scenario 2		
	Flow (ℓ/s)	Head (m)	Power Requirement (kW)	Flow (ℓ/s)	Head (m)	Power Requirement (kW)
120	3.0	105	4.1	5.0	115	7.5
210	4.7	133	8.2	3.0	65	2.6
268	6.0	120	9.4	6.0	170	13.3
270	40.0	120	62.8	52.0	115	78.2
272	7.0	160	14.6	7.0	29	2.7
279	200.0	180	470.9	250.0	200	654.0
447	3.0	60	2.3	1.0	26	0.3
472	5.5	120	8.6	5.0	100	6.5
507	6.0	135	10.6	15.0	43	8.4
611	4.500	133	7.8	5.00	140	9.2
Total power requirements for bulk supply system (kW)			**599.4**			**782.8**
Total daily energy requirements for bulk supply system (kWh/day)			**14 385.6**			**18 786.2**

Table 6.7: Estimated capital costs of pumping stations

Pump Number as per the WADISO Model	Estimated Capital Costs of Pumping Stations					
	Power Requirement (kW)	Mechanical & Electrical (R25 000/kW)	Civil Works (30% of M & E)	Subtotal	Contingen-cies (30% of Sub Total)	Total
Scenario 1						
120	4.1	R 103 005	R 30 901	R 133 906	R 40 172	R 174 078
210	8.2	R 204 408	R 61 322	R 265 730	R 79 719	R 345 449
268	9.4	R 235 440	R 70 632	R 306 072	R 91 822	R 397 894
270	62.8	R 1 569 600	R 470 880	R 2 040 480	R 612 144	R 2 652 624
272	14.7	R 366 240	R 109 872	R 476 112	R 142 834	R 618 946
279	470.9	R 11 772 000	R 3 531 600	R 15 303 600	R 4 591 080	R 19 894 680
447	2.3	R 58 860	R 17 658	R 76 518	R 22 955	R 99 473
472	8.6	R 215 820	R 64 746	R 280 566	R 84 170	R 364 736
507	10.6	R 264 870	R 79 461	R 344 331	R 103 299	R 447 630
611	7.8	R 195 709	R 58 713	R 254 422	R 76 327	R 330 749
Total Estimated Capital Cost of Pumping Stations for Scenario 1						**R 25 326 259**
Scenario 2						
120	7.52	R 188 025	R 56 407	R 244 432	R 73 330	R 317 762
210	2.55	R 63 765	R 19 129	R 82 894	R 24 868	R 107 763
268	13.34	R 333 540	R 100 062	R 433 602	R 130 081	R 563 683
270	78.22	R 1 955 460	R 586 638	R 2 542 098	R 762 629	R 3 304 727
272	2.66	R 66 381	R 19 914	R 86 295	R 25 889	R 112 184
279	654.00	R 16 350 000	R 4 905 000	R 21 255 000	R 6 376 500	R 27 631 500
447	0.34	R 8 502	R 2 551	R 11 053	R 3 316	R 14 368
472	6.54	R 163 500	R 49 050	R 212 550	R 63 765	R 276 315
507	8.44	R 210 915	R 63 274	R 274 189	R 82 257	R 356 446
611	9.16	R 228 900	R 68 670	R 297 570	R 89 271	R 386 841
Total Estimated Capital Cost of Pumping Stations for Scenario 2						**R 33 071 590**

Eskom's Ruraflex Tariffs for Local Authorities for 2012/2013 were used to estimate the average energy cost per kWh. It was assumed that the Transmission Zone is not more than 300 km, and that the voltage is in the range of 500 V to 22 kV. The relevant tariffs that were used to arrive at the average rate per kWh are summarised in **Tables 6.8** and **6.9**.

Table 6.8: Eskom Ruraflex Tariffs (Local Authorities) for 2012/2013

Transmission Zone	Voltage	Active Energy Charges (R/kWh) (excl. VAT)					
		High Demand Season (June to August)			Low Demand Season (September to May)		
		Peak	Standard	Off Peak	Peak	Standard	Off Peak
≤ 300 km	≥ 500 V & ≤ 22 kV	3.2960	0.8454	0.4449	0.9082	0.5502	0.3805

Table 6.9: Peak periods, standard & off-peak periods

Period	Times
Peak	Weekdays from 07h00 to 10h00 and from 18h00 to 20h00
Standard	Weekdays from 06h00 to 07h00 and from 10h00 to 18h00 as well as from 20h00 to 22h00
Off Peak	Weekdays from 22h00 to 06h00, Saturdays & Sundays

Weighted averages were calculated in order to derive an average annual price of R0.64/kWh, this calculation is outlined in **Table 6.10**. The average annual energy costs from 2012 to 2060 are summarised in **Table 6.11**.

Table 6.10: Outline of average energy price calculation

Period	Peak	Average	Off-Peak
Season	High Demand Season from June to August (92 days)		
Hours per Week	25	55	88
Total hours per week	168		
Tariff per kWh	R 3.30	R 0.85	R 0.45
Weighted average during high demand season	R 1.01 per kWh for a period of 92 days		
Season	Low Demand Season from September to May (273 days)		
Hours per Week	25	55	88
Total Hours per Week	168		
Tariff per kWh	R 0.91	R 0.55	R 0.38
Weighted average during low demand season	R 0.51 per kWh for a period of 92 days		
Weighted average for high and low demand seasons	R 0.64 per kWh for a period of 365 days		

The energy requirements in **Table 6.11** below reflect the costs of pumping from surface and groundwater sources from 2012 to 2060.

Table 6.11: Estimated annual energy requirement and cost for surface and ground water pumping (showing every 5 years)

Year	Scenario 1		Scenario 2	
	Annual Energy Requirement (kWh)	Annual Energy Cost	Annual Energy Requirement (kWh)	Annual Energy Cost
2012	3 408 005	R 2 181 123	3 408 005	R 2 181 123
2015	3 545 610	R 2 269 190	3 545 610	R 2 269 190
2020	3 808 775	R 2 437 616	3 808 775	R 2 437 616
2025	4 121 580	R 2 637 811	4 121 580	R 2 637 811
2030	4 478 185	R 2 866 038	4 478 185	R 2 866 038
2035	4 884 430	R 3 126 035	4 884 430	R 3 126 035
2040	5 347 980	R 3 422 707	5 347 980	R 3 422 707
2045	5 347 980	R 3 422 707	5 798 547	R 3 711 070
2050	5 347 980	R 3 422 707	6 287 773	R 4 024 175
2055	5 347 980	R 3 422 707	6 818 975	R 4 364 144
2060	5 347 980	R 3 422 707	7 395 756	R 4 733 284
Total Cost of Energy (2012 to 2060)		**R 147 399 957**	-	**R 160 444 878**

6.2.3 URV's

The URV calculations were based upon the reported capital costs, operations and maintenance costs, refurbishment costs as well as energy costs at discount rates of 6%, 8% and 10% per annum respectively over a period of 48 years from 2012 to 2060. Decisions will be based on the URVs for the 8% discount rate, and the URVs for the 6% and 10% discount rates provides some form of sensitivity analysis. Although the design horizon is until 2040, the URVs were calculated from 2012 to 2060, because if the envisaged irrigation is not implemented and the scheme is designed for the sustainable yield of 7.2 million m^3/a from Zalu Dam and groundwater sources, then the scheme will be able supply the domestic demand for the most probable growth scenario until 2060. The URVs for **Scenarios 1** and **2** are summarised in **Table 6.12**.

Table 6.12: URVs from 2012 to 2060

Discount Rate per Annum	URVs	
	Scenario 1	Scenario 2
6%	R 3.31	R 3.75
8%	R 3.02	R 3.43
10%	R 2.84	R 3.22
Average URV	**R 3.06**	**R 3.46**

6.3 SUMMARY OF CAPITAL AND O&M COSTS

The estimated capital costs are summarised in **Table 6.13** for both **Scenarios 1** and **2**.

The annual operation and maintenance cost was taken as 2.5% of the capital cost as per the VAPS Guidelines. The estimated O&M cost is summarised in **Table 6.13**.

Certain components of the infrastructure require refurbishment at regular intervals. The refurbishment cost is assumed to be 50% of the capital cost of a new respective component. The refurbishment costs for the pumping stations and boreholes are shown in **Table 6.14**. These costs are inclusive of a 20% P&G cost.

Table 6.13: Estimated capital costs for bulk supply system

Bulk Supply Infrastructure Component	Estimated Capital Costs	
	Scenario 1	Scenario 2
Bulk Supply Pipelines	R 160 556 187	R 167 055 697
Bulk Supply and Village Reservoirs	R 162 930 455	R 221 143 737
Pumping Stations	R 25 326 259	R 33 071 590
Borehole Development	R 9 147 600	R 9 147 600
Water Treatment Plant	R 55 249 200	R 75 602 000
Sub Total	**R 413 209 700**	**R 511 706 223**
Preliminary and General (20% of Sub Total)	R 82 641 940	R 102 341 245
Total (Excl. VAT)	**R 495 851 641**	**R 614 047 468**
VAT (14% of Total)	R 69 419 230	R 85 966 646
Total (Incl. VAT)	**R 565 270 870**	**R 692 236 213**
Annual Estimated O & M Cost (2.5% of Total)	***R 14 131 772***	***R 17 305 905***

Table 6.14: Refurbishment intervals and cost

Component	Frequency of refurbishment	Refurbishment cost	
		Scenario 1	Scenario 2
Pumping station	Every 10 years	R 17 215 162	R22 620 967
Boreholes	Every 10 years	R 6 256 958	R 6 256 958
Water Treatment Plant	Every 15 years	R 41 679 403	R 55 600 718

7 CONCLUSIONS AND RECOMMENDATIONS

7.1 SUMMARY OF RAW AND POTABLE BULK DISTRIBUTION INFRASTRUCTURE

The existing infrastructure is designed for a capacity of 2.76 Mℓ/day, which equates to a supply of 1.01 million m^3/a from the Xura River. The details of the existing infrastructure are summarised in **Table 7.1** below.

Table 7.1: Summary of the identified existing bulk infrastructure

Storage/treatment facility		
Item	**Capacity**	**Quantity**
Water Treatment Plant (WTP)	2.76 Mℓ/d	1
Bulk supply reservoir	1300 m^3	1
Bulk supply reservoir	1200 m^3	1
Bulk supply reservoir	1100 m^3	1
Village reservoir	140 m^3	1
Village reservoir	90 m^3	9
Village reservoir	50 m^3	11
Village reservoir	61	1
Village reservoir	251	
Village reservoir	574	
Village reservoirs of which the capacities are unknown	--	2
Pipes		
Type	**Diameter**	**Length**
Raw water gravity main	300 mm	220 m
Raw water rising main (AC pipe)	200 mm	650 m
Clear water rising main (AC pipe)	200 mm	200 m
Clear water gravity main	varied & unknown	71.3 km
Pump stations		
Station	**Capacity**	**Head**
Raw water pumping station (two duty pumps and one standby)	32 ℓ/s for 24 hrs/d	60 m
Clear Water Pumping Station (two duty pumps and one standby)	32 ℓ/s for 24 hrs/d	80 m
Other		
Item		**Quantity**
Raw water abstraction weir		1
Booster pumping station		1
Flow meters		58
Stand pipes		20
Village reticulation networks		5
Control valves in the bulk supply network (types unknown)		31

7.2 RAW AND CLEAR WATER PUMPING STATIONS

The raw pumping station, as well as the clear water pumping station, will have to be upgraded to the capacities as summarised in **Table 7.2** for future supplies from Zalu Dam. The total daily energy requirements for pumping of the supplies from Zalu Dam, and Groundwater sources are summarised in **Table 7.2**.

Table 7.2: Summary of future pumping station requirements

Description	Scenario 1	Scenario 2
Required Pump Station Capacities (ℓ/s)		
Total required pump station capacities for 24 hours of pumping per day, for both raw and clear water pumping stations	171.2	228.3
Daily Energy Requirements for Pumping (kWh/day)		
Total daily energy requirement in 2040	14 652	14 652
Total daily energy requirement in 2060	14 652	20 262

The following is recommended:

- The construction of a new raw water pumping station, and utilization of the existing structure if possible, is recommended.
- The construction of a new clear water pumping station, and utilization of the existing structure if possible, is recommended.

7.3 WATER TREATMENT PLANT

The existing WTP was found to be in a well maintained condition, but the dosing systems and sludge handling systems require attention. Further the raw water from the Xura River is currently treated adequately, except for colour, turbidity and alkalinity. The lack of any as-built information seriously impairs the understanding of the operation of the existing WTP.

It was established that the existing WTP can, due to the modular units, be modified and extended for future requirements of the upgraded scheme. However, future extensions to the plant are subjected to land availability, future domestic water demands and system hydraulic requirements.

The expansion and upgrade of the existing WTP was investigated in relation to a complete new plant. The refurbishment of existing 2.8 Mℓ/day WTP at Xura, and the construction of a new 12 Mℓ/day WTP at Xura is the most favourable WTP Option, although the difference in terms of the URVs is only marginal.

A phased implementation approach for the WTP is recommended in terms of the current treatment requirements for the initial phases. Future treatment requirements for the design horizon/s of 2040 and/or 2060 need to take into account the expected change in water quality due to the dam.

For the new and/or upgraded WTP it is expected that an optimally designed, operated and maintained sand filter will be sufficient to remove the colour and turbidity to levels below the required limits. Corrosion and concrete aggression in the network could be a potential problem due to low alkalinity of the water; the alkalinity could however be increased through dosing of a hydroxide. Alternatively concrete tanks and reservoirs can be constructed with a surface coat to provide protection from the aggression of the water.

The following are recommended with regard to surface water treatment based on the expected future water quality:

- The refurbishment of the existing WTP, and the construction of a new WTP for the treatment of water supplied from Zalu Dam.
- The expected water quality from the Zalu Dam should be modelled based on the available information.
- Additional water quality testing should be undertaken to allow for the optimal design of the future WTP.
- The ability to dose lime and PAC should be included in the future treatment plant upgrade.
- The availability of land around the Lusikisiki WTP should be confirmed, prior to planning commencing.
- Although the Lusikisiki WTP can be upgraded, it is expected that the treatment technology would be slightly different, e.g. concrete RGSF instead of steel pressure filters. Therefore it is not likely that a modular solution at the existing plant will be possible (modular going forward, but not duplicating the existing).

7.4 GROUNDWATER TREATMENT OPTIONS

In terms of the groundwater, Iron and Chloride are the key concerns, but Bacteria and Coliforms are also concerns at some of the boreholes. Out of the 17 identified potential production boreholes the water from four of the boreholes is Class 1 and will not require any treatment. The water from the remaining thirteen boreholes will however require some treatment. Treatment of the borehole water at the central WTP was considered, but due to the sparse distribution of the boreholes this will not be feasible. On-site treatment is thus recommended at each one of the boreholes where treatment is required. Treatment must ensure that the Iron, Chloride, Bacteria and Coliform concentrations comply with the maximum permissible concentrations. **Table 7.3** displays the number of boreholes where each type of treatment in required. As shown, many boreholes will require more than one type of treatment.

Table 7.3: Summary of on-site treatment requirements at the boreholes

Required Treatment	Number of the Boreholes where Treatment is Required	Annual Supply from these Boreholes (m^3)	Required Treatment Capacity per day (Mℓ/day)
No Treatment Required	4	320 000	0.88
Class 2 Iron to Class 1 Iron	4	240 000	0.66
Class 2 Bacteria to Class 1 Bacteria	9	420 000	1.15
Class 2 Chloride to Class 1 Chloride	3	130 000	0.36
Class 4 Iron to Class 1 Iron	1	20 000	0.06
Class 4 Bacteria to Class 1 Bacteria	1	20 000	0.06
Class 4 Coliforms to Class 1 Coliforms	1	50 000	0.14

The following is recommended:

- Conjunctive use of surface and groundwater from Zalu Dam and the 17 identified potential production boreholes.
- On-site treatment of the borehole water at those boreholes where treatment is required.

7.5 Bulk Distribution Infrastructure

Due to these uncertainties in the allocation of the water from the proposed Zalu Dam, the assessment of the recommended bulk supply options was performed for two scenarios:

- **Scenario 1** for an annual supply of 5.4 million m³/a from the proposed Zalu Dam and 0.95 million m³/a from groundwater sources, solely for domestic use.
- **Scenario 2** for an annual supply of 7.2 million m³/a from the proposed Zalu Dam and 0.95 million m³/a from groundwater sources for domestic use, should irrigation not be implemented.

7.5.1 Pipelines

It was found that a new bulk supply system that runs parallel to the existing bulk supply pipelines, and beyond, will not be the best option for the following reasons:

- The required capacity of a new scheme is much higher than the capacity of the existing scheme, and therefore the same pipe diameters will be required for a new scheme to run parallel to the existing system.
- The poor and neglected state of the existing scheme.
- AC pipes that are deemed to be a health risk and their impacts on community health in the area.

It is recommended that new bulk supply pipelines be constructed and that the existing AC bulk supply pipes be decommissioned. The required lengths of the proposed new bulk supply pipelines are summarised in **Table 7.4**.

Table 7.4: Summary of required new bulk supply pipe lengths

Pipe Description	Required Total Pipe Lengths (m)	
	Scenario 1	Scenario 2
Class 16 uPVC Pipe for 63 mm to 315 mm OD	178 271	174 875
Steel Pipe for 400 mm to 450 mm OD	4 137	7 541

7.5.2 Bulk and village reservoirs

The existing bulk supply and village reservoirs are in a poor state. The village reservoirs that were visited are in a state of neglect and are vandalised. Some of these reservoirs are completely dry while others are overflowing. All the bulk supply reservoirs were visited and were found to be in more acceptable condition than the village reservoirs. The total storage capacity of the existing reservoirs is unsure, due to the lack of as-built information, but the estimated total storage capacity of the existing reservoirs is about 5 335 m^3. For the proposed new bulk supply scheme the required storage volume was assumed to be twice the daily capacity of the scheme. The total required storage volumes for the proposed new bulk supply system are summarised in **Table 7.5**.

Table 7.5: Summary of bulk and village reservoir volumes

Description	Required Total Reservoir Volumes (m^3)	
	Scenario 1	Scenario 2
Bulk and Village Reservoirs	78 521	106 575

The option to retain and refurbish the existing storage reservoirs was investigated. The estimated saving in terms of capital costs will however only be a mere R 5.5 million (excluding P&Gs and VAT) at 2012 prices, compared to the estimated cost of the entire proposed bulk and village storage reservoirs. It is however recommended that due diligence be performed as far as the structural integrity of the existing reservoirs is concerned in order to establish whether the retaining and refurbishment of the existing reservoirs will be a feasible option.

The following recommendations for the bulk distribution infrastructure are made:

- The decommissioning of the existing bulk supply system's AC pipes is recommended.
- The construction of a new bulk supply pipe network, along the same routes of the existing pipelines and beyond, is recommended.
- The construction of new storage reservoirs, and the refurbishment of the existing reservoirs where and if possible, is recommended.

7.6 Summary of the Cost for the Bulk Distribution Infrastructure

Table 7.6 summarises the capital costs of expansion, upgrades and new infrastructure required.

Table 7.6: Estimated capital costs for the preferred bulk distribution option

Bulk Supply Infrastructure Component	Estimated Capital Costs	
	Scenario 1	Scenario 2
Bulk Supply Pipelines	R 160 556 187	R 167 055 697
Bulk Supply and Village Reservoirs	R 162 930 455	R 221 143 737
Pumping Stations	R 25 326 259	R 33 071 590
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Water Treatment Plant	R 55 249 200	R 75 602 000
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VAT (14% of Total)	R 69 419 230	R 85 966 646
Total (Incl. VAT)	**R 565 270 870**	**R 692 236 213**

The annual operation and maintenance cost was assumed to be 2.5% of the capital cost for the construction of a totally new scheme, as per the VAPS Guidelines. The following was assumed in terms of refurbishment costs:

- The WTP will have to be refurbished every 15 years at a cost of 50% of the construction cost of a new WTP.
- Each borehole will have to be refurbished every 10 years at a cost of 50% of the borehole development cost.
- Each pumping station will have to be refurbished every 10 years at a cost of 50% of the construction cost of a new pumping station.

The average weighted energy cost, at 2012/13 Eskom Ruraflex Tariffs, was estimated to be R0.64 per kWh, and the URV calculations were based upon this tariff.

7.7 Water Quality

The quality of intake water from the Xura River Weir is generally of good quality, but parameters such as total Iron and total Coliform were found to be high during the SRK 2009 Study. The constituents of concern that were tested from the water samples are colour, turbidity, iron and low alkalinity. These constituents do not represent any direct risks, but they do influence the aesthetic quality of the water. In terms of the groundwater quality Bacteria, Iron and Chloride are the key concerns.

The impoundment of the surface water from the Xura River in the proposed Zalu Dam will result in changes of the physical, chemical and biological properties of the water if compared to the current free flowing water in the river. A multi-level dam outlet will however allow for flexibility to select water from various levels, depending on the water quality in the dam. Aeration of the water that is released into the Xura River for abstraction down-stream at the weir will also improve the quality of the water that is released from the dam.

The quality of the surface water could however deteriorate in future due to increased population densities and agricultural/industrial growth in the Xura River catchment.

Further surface water quality monitoring is recommended in order to assess the seasonal variations of the water quality upstream of the proposed Zalu Dam, for all the listed water quality parameters in this report. The recommended sampling frequencies are as follows:

- Every two weeks for surface water upstream of the proposed Zalu Dam;
- Every six month at each borehole, and
- Every two weeks for the WTP effluent.

It is also recommended that detailed water quality modelling be performed for the proposed Zalu Dam during the detail design stage in order to gain a better understanding of the anticipated water quality changes of the impounded surface water in the dam.

8 REFERENCES

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DWA P WMA 12/T60/00/4111 (2013)	DWA Report No. P WMA 12/T60/00/4111: Feasibility Study for Augmentation of the Lusisiki Regional Water Supply Scheme: Domestic Water Requirements – Final Report, 2013.
DWA P WMA 12/T60/00/4211 (2013)	DWA Report No. P WMA 12/T60/00/4111: Feasibility Study for Augmentation of the Lusisiki Regional Water Supply Scheme: Irrigation Potential Assessment Report – Draft, 2013.
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SABS (2011)	South African National Standard SANS 241-1:2011, 2011.
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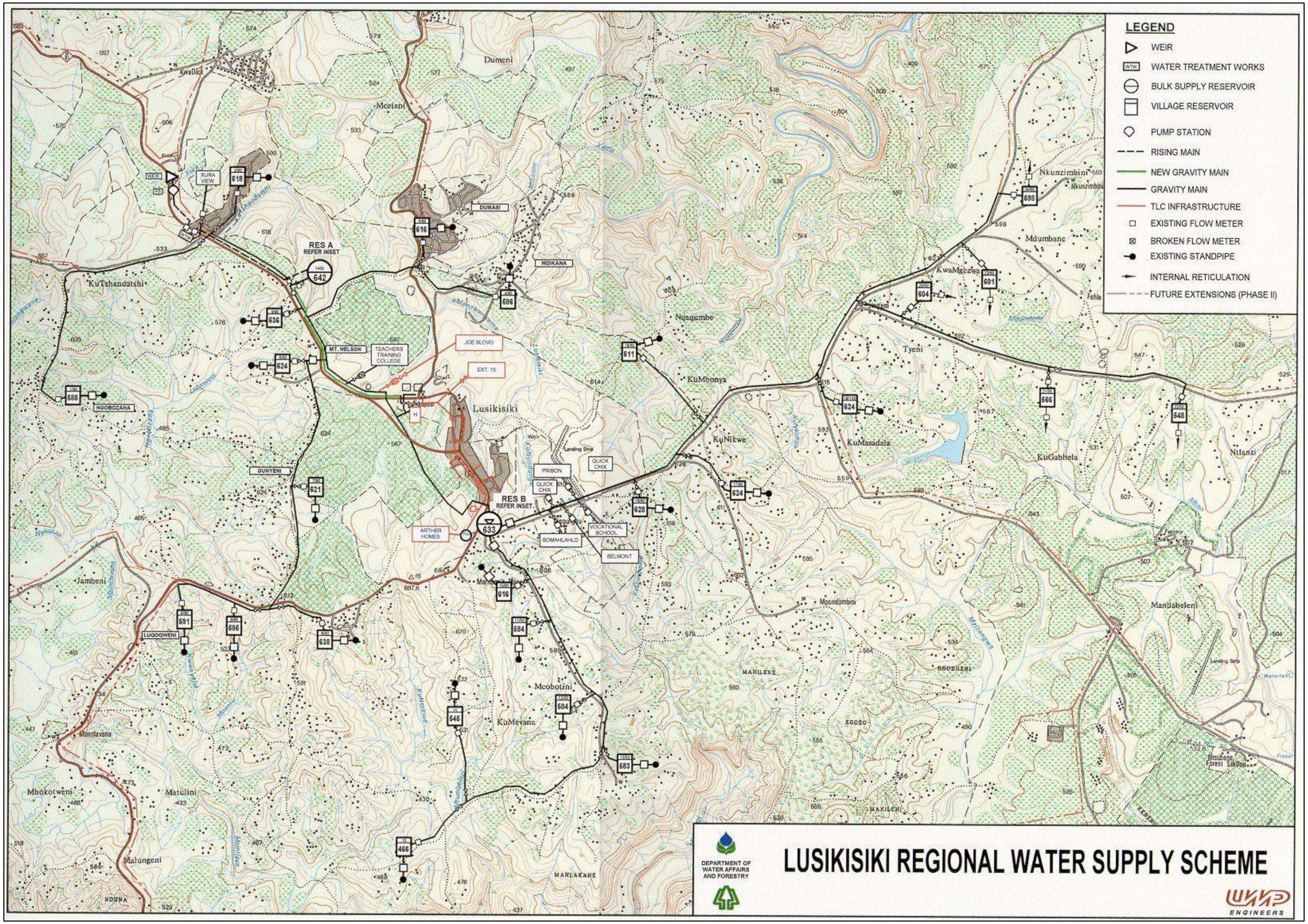
UWP Engineers (2001)	Eastern Pondoland Basin Study – Basin Study Main Report, 2001.
VAPS (1996)	DWA Report No. PC 000/00/14394: Vaal Augmentation Planning Study, Guidelines for the Preliminary Sizing, costing and Engineering Economic Evaluation of Planning Options, 1996.
WRC (1998)	WRC Report Number TT 101/98, Quality of Domestic Water Supplies Volume1: Assessment Guide, 1998.

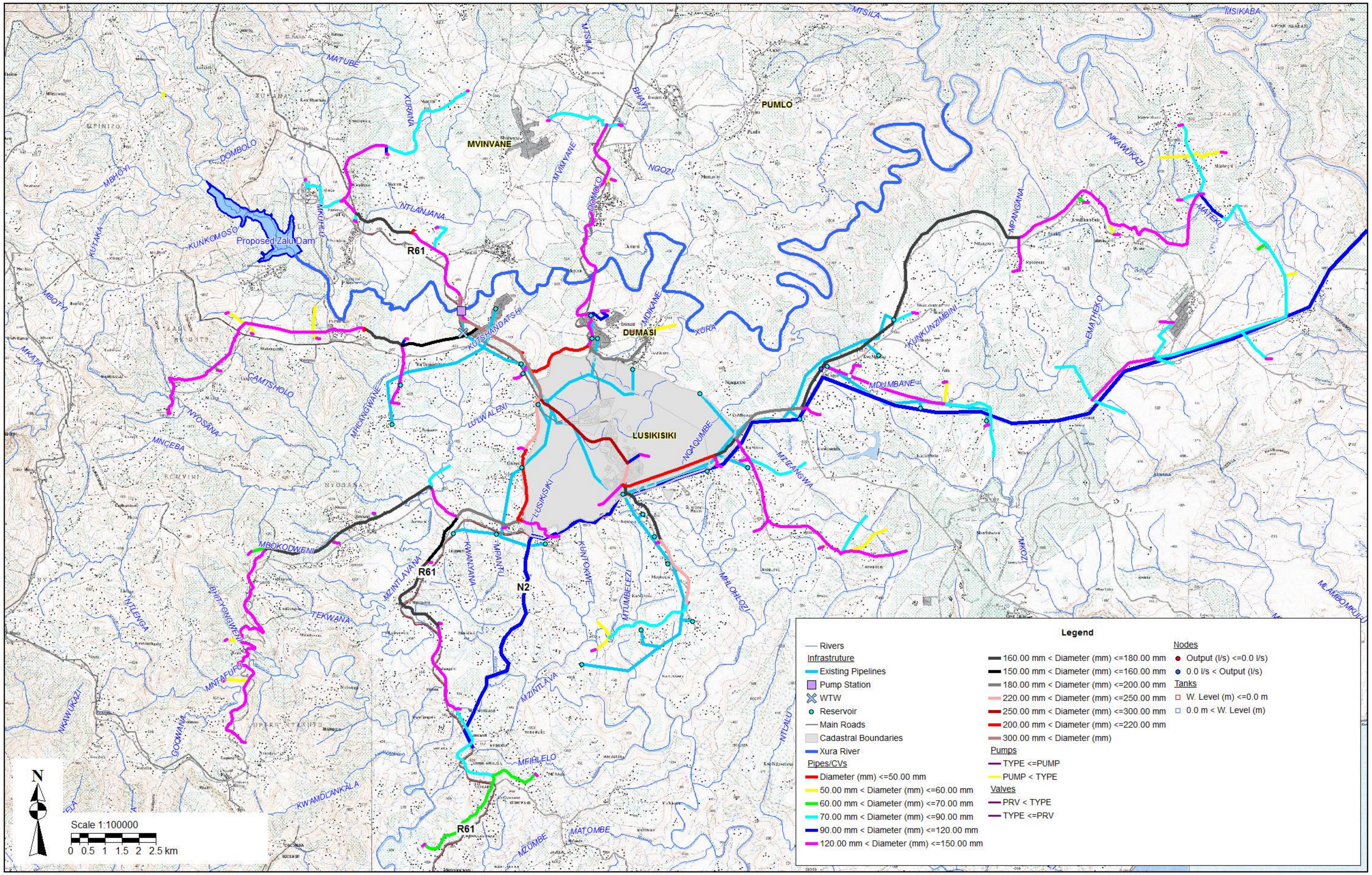
Appendix A

UWP's Map of the Existing Bulk Supply Infrastructure

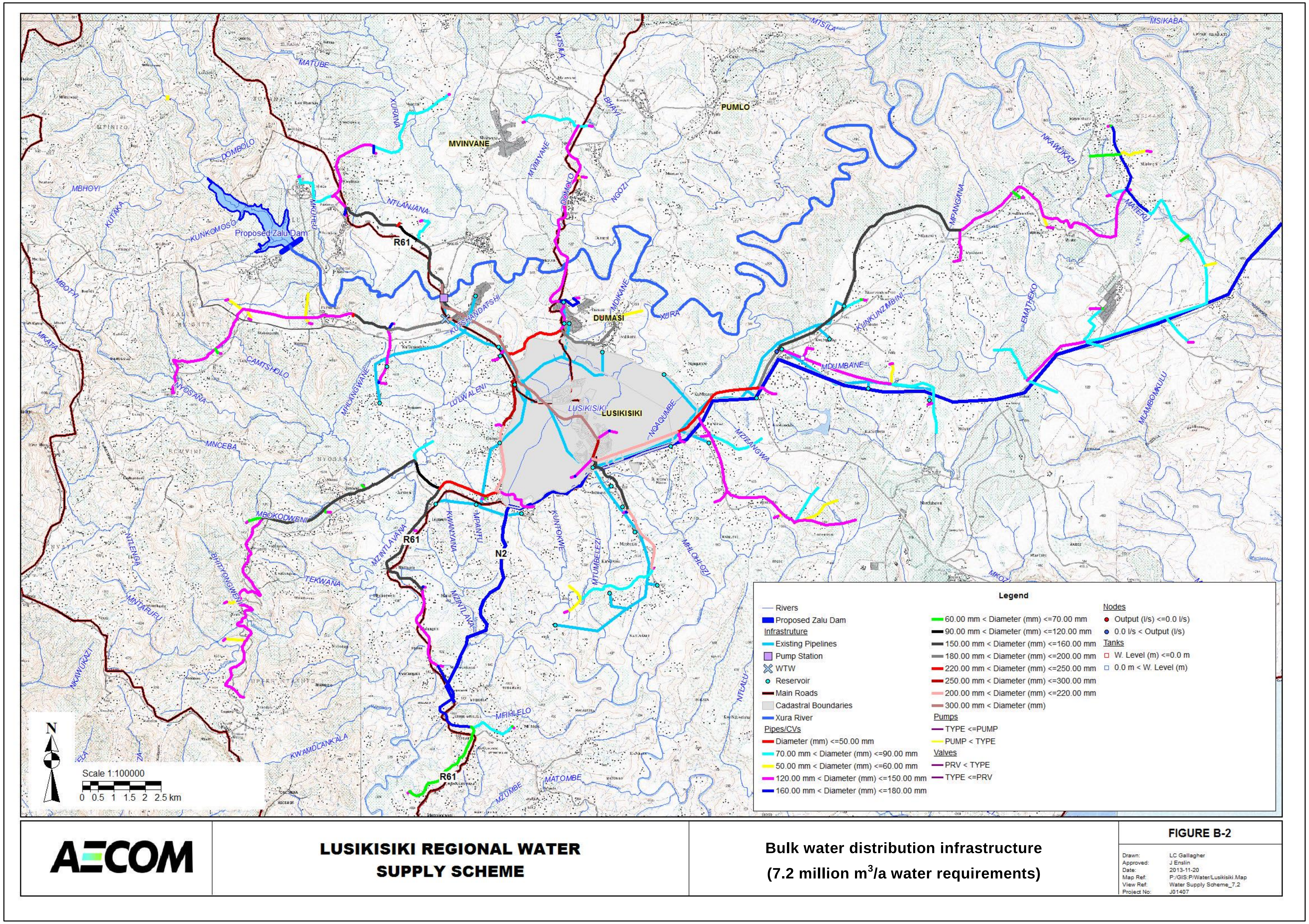

LEGEND
WEIR
WATER TREATMENT WORKS
BULK SUPPLY RESERVOIR
VILLAGE RESERVOIR
PUMP STATION
RISING MAIN
NEW GRAVITY MAIN
GRAVITY MAIN
TLC INFRASTRUCTURE
EXISTING FLOW METER
BROKEN FLOW METER
EXISTING STANDPIPE
INTERNAL RETICULATION
FUTURE EXTENSIONS (PHASE II)
RES A
REFER INSET
RES B
REFER INSET
Lusikisiki
DEPARTMENT OF WATER AFFAIRS AND FORESTRY
LUSIKISIKI REGIONAL WATER SUPPLY SCHEME
ENGINEERS

Appendix B

Maps of proposed Bulk Distribution Infrastructure for the LRWSS



AECOM	**LUSIKISIKI REGIONAL WATER SUPPLY SCHEME**	**Bulk water distribution infrastructure (5.4 million m^3/a water requirements)**	**FIGURE B-1** Drawn: LC Gallagher Approved: J Enslin Date: 2013-11-20 Map Ref: P:/GISP/Water/Lusikisiki.Map View Ref: Uitleg 54 Project No: J01407


Legend
Rivers
Proposed Zalu Dam
Infrastruture
Existing Pipelines
Pump Station
WTW
Reservoir
Main Roads
Cadastral Boundaries
Xura River
Pipes/CVs
Diameter (mm) <=50.00 mm
70.00 mm < Diameter (mm) <=90.00 mm
50.00 mm < Diameter (mm) <=60.00 mm
120.00 mm < Diameter (mm) <=150.00 mm
160.00 mm < Diameter (mm) <=180.00 mm
60.00 mm < Diameter (mm) <=70.00 mm
90.00 mm < Diameter (mm) <=120.00 mm
150.00 mm < Diameter (mm) <=160.00 mm
180.00 mm < Diameter (mm) <=200.00 mm
220.00 mm < Diameter (mm) <=250.00 mm
250.00 mm < Diameter (mm) <=300.00 mm
200.00 mm < Diameter (mm) <=220.00 mm
300.00 mm < Diameter (mm)
Pumps
TYPE <=PUMP
PUMP < TYPE
Valves
PRV < TYPE
TYPE <=PRV
Nodes
Output (l/s) <=0.0 l/s
0.0 l/s < Output (l/s)
Tanks
W. Level (m) <=0.0 m
0.0 m < W. Level (m)
Scale 1:100000
0 0.5 1 1.5 2 2.5 km
N
LUSIKISIKI
DUMASI
MVINVANE
PUMLO
Proposed Zalu Dam
R61
N2
AECOM
LUSIKISIKI REGIONAL WATER SUPPLY SCHEME
Bulk water distribution infrastructure
(7.2 million m³/a water requirements)
FIGURE B-2
Drawn: LC Gallagher
Approved: J Enslin
Date: 2013-11-20
Map Ref: P:/GIS:P/Water/Lusikisiki.Map
View Ref: Water Supply Scheme_7,2
Project No: J01407

Appendix C

Surface Water Quality Test Results

WATERLAB (Pty) Ltd

Reg. No.: 1983/009165/07 V.A.T. No.: 4130107891

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sanas Testing Laboratory

SANAS Accredited Testing Laboratory
No. T0391

CERTIFICATE OF ANALYSES
GENERAL WATER QUALITY PARAMETERS

Date received: 2011 - 08 - 04 **Date completed:** 2011 - 08 – 24

Project number: 128 **Report number: 31917** **Order number: J01407**

Client name: BKS **Contact person: Mr. G. Clifford**

Address: P.O. Box 3173 Pretoria 0001 **e-mail: gernac@bks.co.za**

Telephone: 012 421 3500 **Facsimile: -** **Mobile: 083 630 5181**

Analyses in mg/ℓ (Unless specified otherwise)	Method Identification	Sample Identification	
		Raw	Treated/Final
Sample Number		11724	11725
pH – Value at 25°C	WLAB001	7.4	6.4
Electrical Conductivity in mS/m at 25°C	WLAB002	17.5	17.3
Total Dissolved Solids at 180°C *	WLAB003	123	136
Suspended Solids at 105°C *	WLAB004	9.6	<1.0
Colour in PtCo Units (Filtered)*	WLAB006	355	13
Colour in PtCo Units (Unfiltered)*	WLAB006	416	40
Turbidity in N.T.U	WLAB005	43	5.1
Total Alkalinity as $CaCO_3$	WLAB007	44	36
Nitrate & Nitrite as N *	WLAB046	0.8	---
Dissolved Organic Carbon as C [s]	---	1.1	1.5
Iron as Fe	WLAB015	0.962	0.096
Manganese as Mn	WLAB015	<0.025	<0.025

*** = Not SANAS Accredited**
Tests marked "Not SANAS Accredited" in this report are not included in the SANAS Schedule of Accreditation for this Laboratory.

[s] = Analyses performed by a Sub-Contracted Laboratory

Technical Signatory: A. van de Wetering

Appendix D

Assessment of some of the existing reservoirs

<u>The following existing storage reservoirs, which are discussed in this Appendix, were visited and assessed:</u>

- Village Reservoir 5 at Dumasi
- Village Reservoir 7 near Gunyeni
- Village Reservoir 9 near Luququeni
- Village Reservoir 10 near Kwanyuswa
- Village Reservoir 11 near Mcobotini
- Village Reservoir 17 near Goso
- Village Reservoir 20 near Mgezwa
- Village Reservoir 21 in the Tea Plantation near Falha
- Village Reservoir 22 near Mtanzi
- Bulk Supply Reservoir A near Mbila
- Bulk Supply Reservoir B near Dubana B

<u>Village Reservoir 5 at Dumasi</u>: The UWP Map shows one 90 m^3 Village Reservoir at Dumasi, which is an in- situ casted reservoir. This reservoir appears to have a serious leak, the reservoir as well as its appurtenant works is in a poor condition and it is partially fenced. Images of this reservoir are shown in **Figures D1** to **D5** below.

Figure D1: Cracks on the Existing Village Reservoir 5 at Dumasi

Figure D2: The Existing Village Reservoir 5 at Dumasi

Figure D3: Leaking from the Existing Village Reservoir 5 at Dumasi

Figure D4: Severity of the Leakage from the Existing Village Reservoir 5 at Dumasi

Figure D5: Runoff of Leaking Water from the Existing Village Reservoir 5 at Dumasi

Village Reservoir 7 near Gunyeni: The UWP Map shows one 90 m^3 reservoir near Gunyeni, but two interconnected circular reservoirs were found at this location. The one reservoir is a precast reservoir and the other an in situ cast concrete reservoir. The circumference and height of the first reservoir is 24.5 m and 2.5 m respectively. The diameter is therefore about 7.8 m and the storage volume is about 119.5 m^3. The circumference and height of the second reservoir is 53.4 m and 2 m respectively. The diameter is therefore about 17 m and the storage volume is about 454 m^3. The total available storage at this reservoir site is therefore about 573.5 m^3, which is much higher than the 90 m^3 as indicated on the UWP Map. The valves at these two reservoirs are in a poor condition, these reservoirs do however still have a fence. Images of these two reservoirs are shown in **Figures D6** to **D10** below.

Figure D6: Valve at the Existing Village Reservoirs at Gunyeni

Figure D7: Flow Meter at the Existing Village Reservoirs at Gunyeni

Figure D8: The two Existing Village Reservoirs at Gunyeni

Figure D9: The Old In-situ Casted Village Reservoir at Gunyeni

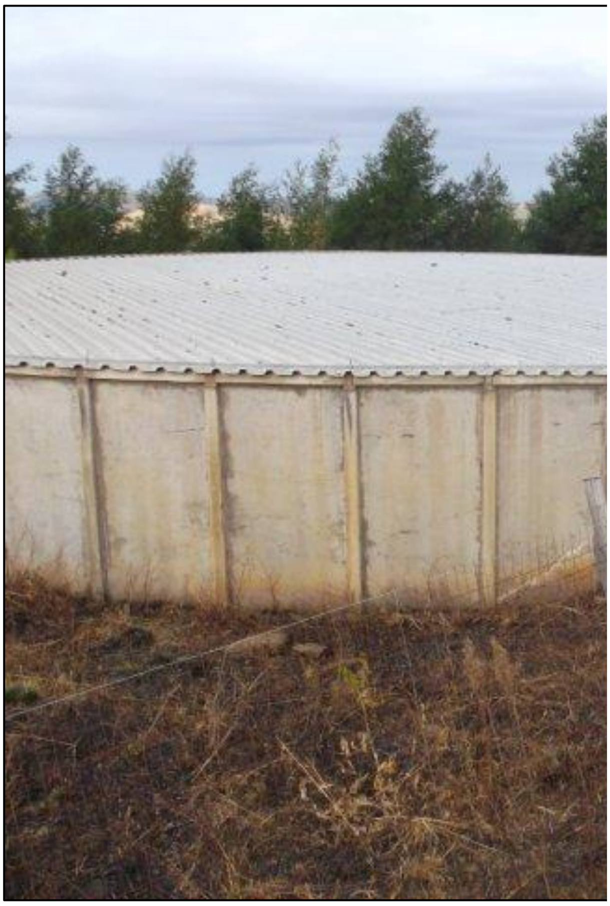

Figure D10: The Newer Pre-cast Village Reservoir at Gunyeni

Village Reservoir 9 near Luqhoqhweni: The UWP Map shows two 90 m^3 reservoirs near Luqhoqhweni, both these reservoirs are in-situ casted concrete reservoirs. The circumference and height of one of these reservoirs is 45 m and 2.1 m respectively. The diameter of this reservoir is therefore about 14.32 m and the storage volume is about 161.1 m^3, which is much higher than the 90 m^3 as indicated on the UWP Map. Both reservoirs and their appurtenant works are in a poor condition and there are no fences around these two reservoirs. Images of these reservoirs are shown in **Figures D11** to **D16** below.

Figure D11: First In-situ Casted Village Reservoir near Luqhoqhweni

Figure D12: First In-situ Casted Village Reservoir near Luqhoqhweni from a different angle

Figure D13: First In-situ Casted Village Reservoir near Luqhoqhweni from a Short Distance Away

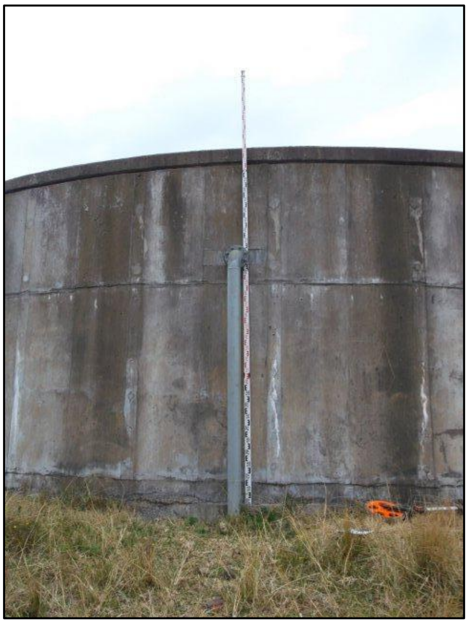

Figure D14: Second In-situ Casted Village Reservoir near Luqhoqhweni

Figure D15: Second In-situ Casted Village Reservoir near Luqhoqhweni from a different angle

Figure D16: Second In-situ Casted Village Reservoir near Luqhoqhweni from a Short Distance away

Village Reservoir 10 near Kwanyuswa: The UWP Map shows one 90 m^3 reservoir near Kwanyuswa, this reservoir is an in-situ casted concrete reservoir. This reservoir and its appurtenant works are in a poor condition and there are no fences around this reservoir. Images of this reservoir are shown in **Figures D17** and **D18** below.

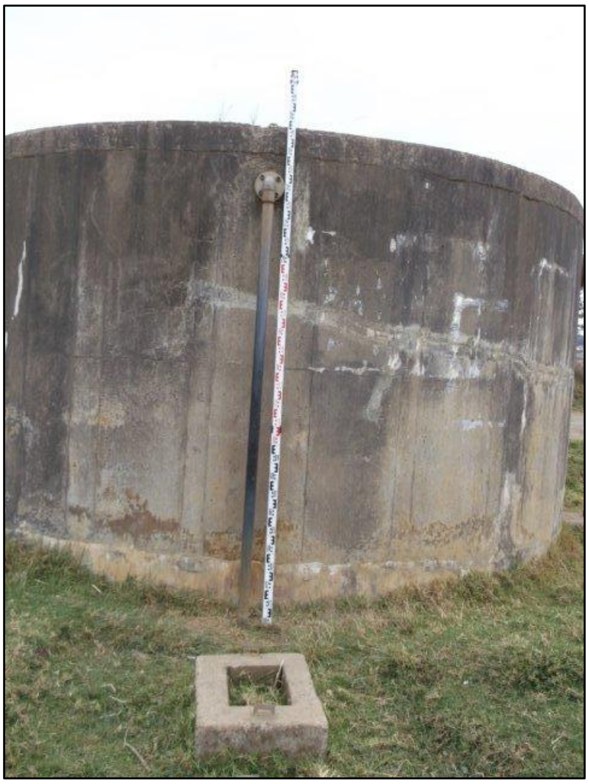

Figure D17: In-situ Casted Village Reservoir 10 near Kwanyuswa

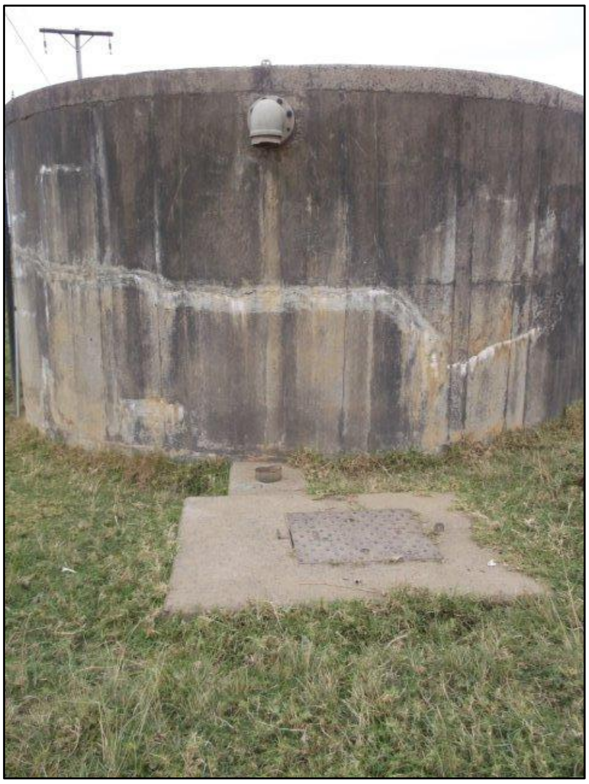

Figure D18: In-situ Casted Village Reservoir 10 near Kwanyuswa from a different angle

Village Reservoir 11 near Mcobotini: The UWP Map shows one 50 m^3 reservoir near Mcobotini, this reservoir is an in-situ casted concrete reservoir. This reservoir and its appurtenant works are in a poor condition and there are no fences around this reservoir. It also seems that no water is supplied to this reservoir anymore.

Images of this reservoir are shown in **Figures D19** to **D21** below.

Figure D19: In-situ Casted Village Reservoir 11 near Mcobotini from a Short Distance

Figure D20: In-situ Casted Village Reservoir 11 near Mcobotini

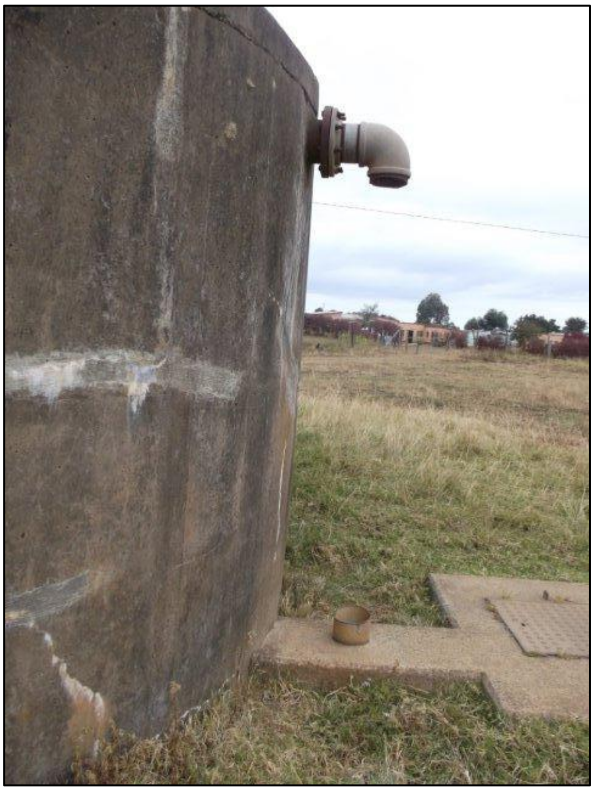

Figure D21: In-situ Casted Village Reservoir 11 near Mcobotini from a different angle

Village Reservoir 17 near Goso: The UWP Map shows a 90 m^3 reservoir near Goso, this reservoir is an in-situ casted concrete reservoir. The circumference and height of one of this reservoir is 27.6 m and 2.7 m respectively. The diameter of this reservoir is therefore about

8.78 m and the storage volume is about 60.5 m^3, which is less than the 90 m^3 as indicated on the UWP Map. This reservoir and its appurtenant works are in a poor condition, and there are no fences around this reservoir. Images of this reservoir are shown in **Figures D22** to **D24** below.

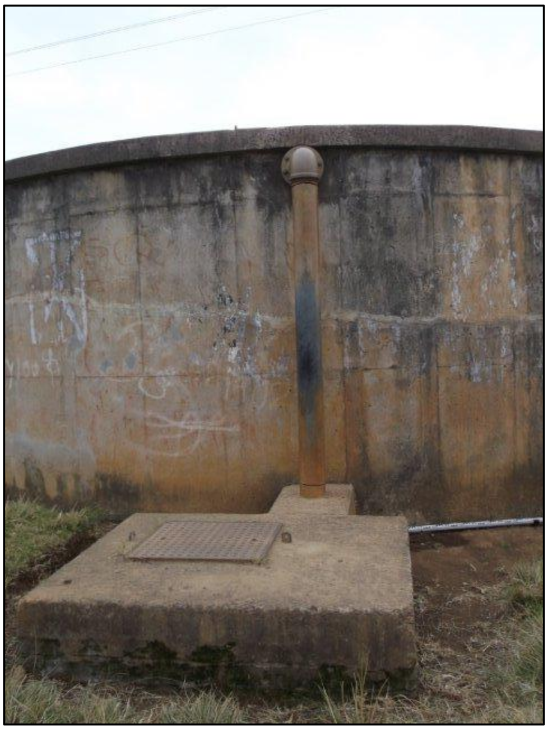

Figure D22: In-situ Casted Village Reservoir 17 near Goso

Figure D23: Vandalised State of Village Reservoir 17 near Goso

Figure D24: Flow meter at Village Reservoir 17 near Goso

<u>Village Reservoir 20 near Mgezwa</u>: The UWP Map shows a 50 m^3 reservoir near Mgezwa, this reservoir is an in-situ casted concrete reservoir. This reservoir and its appurtenant works are in a poor condition, and there are no fences around this reservoir. Images of this reservoir are shown in **Figures D25** to **D27** below.

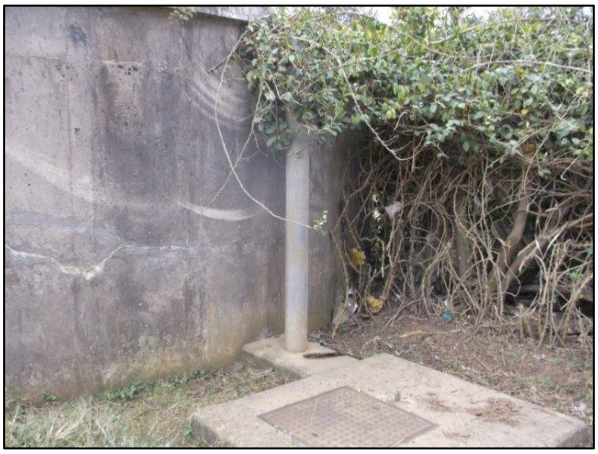

Figure D25: Village Reservoir 20 near Mgezwa

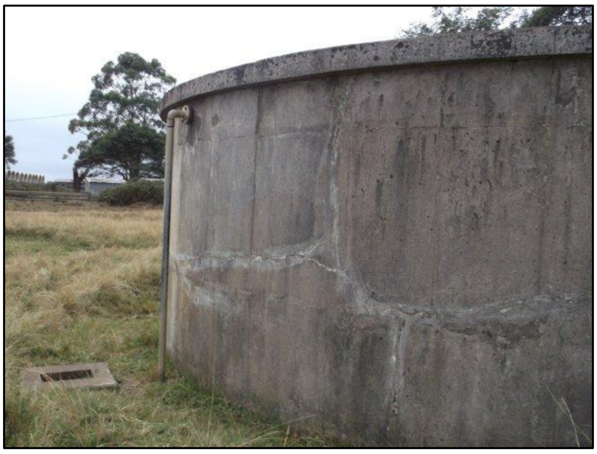

Figure D26: Village Reservoir 20 near Mgezwa from a different angle

Figure D27: Valve Chamber at Village Reservoir 20 near Mgezwa

Village Reservoir 21 in the Tea Plantation near Falha: The UWP Map shows a 50 m^3 reservoir in the tea plantation near Falha, this reservoir is an in-situ casted concrete reservoir. This reservoir and its appurtenant works are in a poor condition, and there are no fences around this reservoir. This reservoir seems to be overflowing. Images of this reservoir are shown in **Figures D28** to **D30** below.

Figure D28: Village Reservoir 21 in Tea Plantation near Falha

Figure D29: Flooded Valve Chamber in Tea Plantation of Village Reservoir 21 near Falha

Figure D30: Village Reservoir 21 in Tea Plantation near Falha from a different angle

Village Reservoir 22 near Mtanzi: The UWP Map shows a 50 m^3 reservoir near Mtanzi, this reservoir is an in-situ casted concrete reservoir. This reservoir and its appurtenant works are in a poor condition, and there are no fences around this reservoir. This reservoir seems to be leaking through cracks in its wall. Images of this reservoir are shown in **Figures D31** to **D33** below.

Figure D31: Village Reservoir 22 near Mtanzi

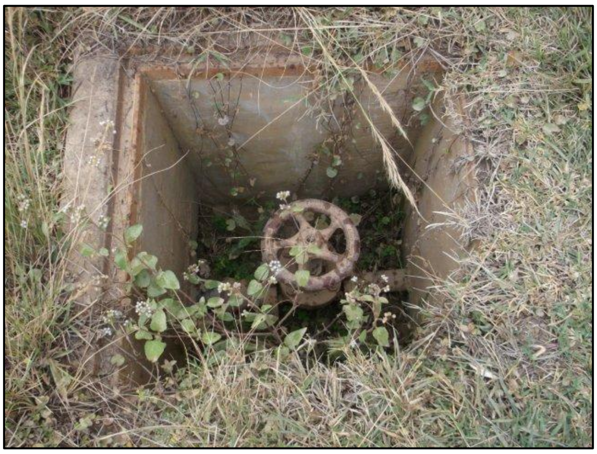

Figure D32: Valve Chamber at Village Reservoir 21 near Mtanzi

Figure D33: Leaking at Village Reservoir 21 near Mtanzi

Bulk Supply Reservoir A near Mbila: The UWP Map shows a 1400 m^3 reservoir near Mbila, this reservoir is a large in-situ casted concrete reservoir. This reservoir and its appurtenant works are in a better condition than the village reservoirs, but not in a perfect condition. There is telemetry at this reservoir that seems to still be operational. Images of this reservoir are shown in **Figures D34** to **D41** below.

Figure D34: Bulk Supply Reservoir A near Mbila

Figure D35: One of the Valve Chambers at Bulk Supply Reservoir A near Mbila

Figure D36: Another one of the Valve Chambers at Bulk Supply Reservoir A near Mbila

Figure D37: Bulk Supply Reservoir A from a different angle near Mbila

Figure D38: Bulk Supply Reservoir A from a distance near Mbila

Figure D39: Missing Steel Covers at Bulk Supply Reservoir A near Mbila

Figure D40: Evidence of the Telemetry at Bulk Supply Reservoir A near Mbila

Figure D41: Result of theft at Bulk Supply Reservoir A near Mbila

Bulk Supply Reservoir B near Dubana B: The UWP Map shows one 1050 m^3 reservoir at Dubana B. There are however two bulk supply reservoirs at Dubana B, of which the older one is an in-situ casted concrete reservoir with an AC roof. This is assumed to be the 1050 m^3 bulk supply reservoir. The new in-situ casted concrete reservoir was completed in 2010, but is not being used. The new reservoir is in a good condition, but the old reservoir is in a poor condition. It was deduced that there is telemetry at these reservoirs and it seems to be operational, given the antenna at these reservoirs. Images of these reservoirs are shown in **Figures D42** to **D49** below.

Figure D42: New Bulk Supply Reservoir at Dubana B

Figure D43: Roof of New Bulk Supply Reservoir at Dubana B and Old Reservoir in the Background

Figure D44: Telemetry Antenna at Dubana B and Old Reservoir in the Background

Figure D45: Inside of the Old Reservoir at Dubana B

Figure D46: Outside of the Old Reservoir at Dubana B and New Reservoir in the Background

Figure D47: Incomplete or Vandalised Valve Chamber at Dubana B Bulk Supply Reservoirs

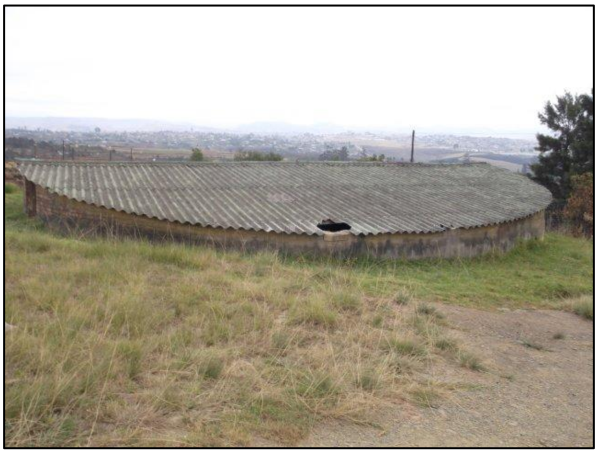

Figure D48: Old Bulk Supply Reservoir at Dubana B

Figure D49: Inside of the New Bulk Supply Reservoir at Dubana B

Appendix E

Requirements for Some of the Village Reservoirs

Reservoir Description	Required Reservoir Volumes (m^3)		All Inclusive Cost (R/m^3)	Total Estimated Costs for Bulk Supply and Village Reservoirs	
	Scenario 1	Scenario 2		Scenario 1	Scenario 2
Nyembezini Village Reservoir	58	77	1 660	R 96 546	R 127 769
Kwa-Bhala Village Reservoir	1 223	1 654	1 660	R 2 030 451	R 2 745 727
Palmerton-D Village Reservoir	73	115	1 660	R 121 657	R 191 653
Palmerton Village Reservoir	726	972	1 660	R 1 205 883	R 1 613 408
Mrhoshozveni Village Reservoir	217	291	1 660	R 359 622	R 482 393
Kwadiki Village Reservoir	170	251	1 660	R 282 395	R 417 204
Kwa-Diki Main Reservoir	2 714	3 619	1 660	R 4 505 808	R 6 007 739
Bomveni Village Reservoir	814	1 106	1 660	R 1 351 795	R 1 835 700
Zalu Heights Village Reservoir	445	597	1 660	R 738 338	R 991 513
Mpala Village Reservoir	196	275	1 660	R 325 941	R 456 317
Lugqalweni Village Reservoir	50	71	1 660	R 82 794	R 117 339
Mtimde-B Village Reservoir	238	314	1 660	R 395 525	R 521 506
Jambeni-C Village Reservoir	1 197	1 578	1 660	R 1 986 550	R 2 619 001
Tsandatshe Main Reservoir	3 269	4 358	1 660	R 5 425 744	R 7 234 324
Mvimvane Village Reservoir	356	475	1 660	R 591 741	R 788 516
Qawukeni Village Reservoir	266	362	1 660	R 441 715	R 600 774
Bazana Village Reservoir	291	393	1 660	R 482 785	R 651 882
Kanana Village Reservoir	931	1 247	1 660	R 1 545 492	R 2 069 334
Main Reservoir B1	8 370	11 160	1 660	R 13 894 411	R 18 525 888
Mdikane Village Reservoir	3 723	5 007	1 660	R 6 180 691	R 8 311 495
Mbila Village Reservoir	1 618	2 199	1 660	R 2 686 342	R 3 650 539
Mtambalala Village Reservoir	328	452	1 660	R 544 608	R 750 968
Ntongane Village Reservoir	75	96	1 660	R 125 060	R 159 711
Luqhoqhweni Village Reservoir	645	884	1 660	R 1 070 960	R 1 466 734
Ganata Village Reservoir	1 034	1 407	1 660	R 1 716 896	R 2 336 084
Mzintlana Village Reservoir	717	954	1 660	R 1 190 273	R 1 584 073
Main Reservoir B2	4 922	8 467	1 660	R 8 170 659	R 14 054 576
Upper Tafufu-A Village Reservoir	774	1 060	R 1 660	R 1 285 459	R 1 760 081
Upper Ntafufu-A Village Reservoir	204	251	R 1 660	R 338 979	R 417 204
Nyathi Village Reservoir	29	43	R 1 660	R 47 610	R 71 707
Ishilito Village Reservoir	399	532	R 1 660	R 662 354	R 882 387
Jambeni-A Village Reservoir	431	565	R 1 660	R 715 966	R 938 710
Jambeni Village Reservoir	380	509	R 1 660	R 631 189	R 844 839
Main Reservoir C	4 249	5 160	R 1 660	R 7 053 207	R 8 565 729
Nzintlana Village Reservoir	472	654	R 1 660	R 784 118	R 1 085 384
Ntsimbini Village Reservoir	784	1 060	R 1 660	R 1 301 887	R 1 760 081
Gobozana Village Reservoir	2 207	3 142	R 1 660	R 3 663 389	R 5 215 056

Reservoir Description	Required Reservoir Volumes (m^3)		All Inclusive Cost (R/m^3)	Total Estimated Costs for Bulk Supply and Village Reservoirs	
	Scenario 1	Scenario 2		Scenario 1	Scenario 2
Lusisiki Village Reservoir	1 058	1 400	R 1 660	R 1 756 822	R 2 323 307
Cabekwana Main Reservoir	1 716	2 288	R 1 660	R 2 849 115	R 3 798 810
Goso-D Village Reservoir	317	432	R 1 660	R 526 303	R 717 070
Goso-C Village Reservoir	281	393	R 1 660	R 466 137	R 651 882
Goso Village Reservoir	1 555	2 105	R 1 660	R 2 581 518	R 3 494 088
Mtshayaza Village Reservoir	1 375	1 822	R 1 660	R 2 283 005	R 3 024 732
Dubana-B Main Reservoir	8 909	11 878	R 1 660	R 14 788 544	R 19 718 055
Dubana-A Village Reservoir	1 960	2 670	R 1 660	R 3 254 391	R 4 432 798
Main Reservoir A	5 444	7 259	R 1 660	R 9 037 045	R 12 049 387
Dubhana Village Reservoir	276	101	R 1 660	R 457 924	R 166 882
Dubane Village Reservoir	717	972	R 1 660	R 1 190 273	R 1 613 408
Mcobotini Village Reservoir	942	1 272	R 1 660	R 1 563 946	R 2 112 098
Kwanyuswa Village Reservoir	1 046	1 418	R 1 660	R 1 736 801	R 2 353 294
Tungwana Village Reservoir	40	53	R 1 660	R 65 788	R 88 004
Matheko Village Reservoir	501	707	R 1 660	R 831 992	R 1 173 388
Malangeni Village Reservoir	814	1 067	R 1 660	R 1 351 379	R 1 770 903
Nkunzimbini Village Reservoir	524	707	R 1 660	R 869 011	R 1 173 388
Mtanzi Village Reservoir	835	1 106	R 1 660	R 1 385 590	R 1 835 700
Fahla Village Reservoir	108	151	R 1 660	R 179 634	R 250 323
Mgezwa Village Reservoir	1 236	1 696	R 1 660	R 2 052 581	R 2 816 130
Main Reservoir D	2 669	3 559	R 1 660	R 4 431 024	R 5 908 029
Msikana-F Village Reservoir	524	707	1 660	R 869 011	R 1 173 388
Msikana-H Village Reservoir	33	47	1 660	R 55 214	R 78 226
Mzimtsha Village Reservoir	196	267	1 660	R 325 941	R 443 280
Main Reservoir E	386	515	1 660	R 641 494	R 855 321
Lambasi Village Reservoir	452	616	1 660	R 749 654	R 1 022 151
Mpisi - C Village Reservoir	1 618	2 199	1 660	R 9 387	R 17 601
Total Required Storage Volumes	**78 521**	**106 575**	-	-	-
Sub Total 1 for Bulk Supply and Village Reservoirs				**R 130 344 364**	**R 176 914 989**
Additional Sum to Compensate for the Remoteness (25% of Sub Total 1)				R 32 586 091	R 44 228 747
Estimated Totals for Bulk Supply and Village Reservoirs				**R 162 930 455**	**R 221 143 737**